Annual Report - 2020

भाकृअनुप
ICAR

भा.कृ.अनु.प.–भारतीय बागवानी अनुसंधान संस्थान
हेसरघट्टा लेक पोस्ट, बेंगलूरू – ५६००८९

भा.कृ.अनु.प.-भा.बा.अनु.सं.
ICAR-IIHR

ICAR - Indian Institute of Horticultural Research
Hesaraghatta Lake Post, Bengaluru – 560089

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COVER PAGE ILLUSTRATION
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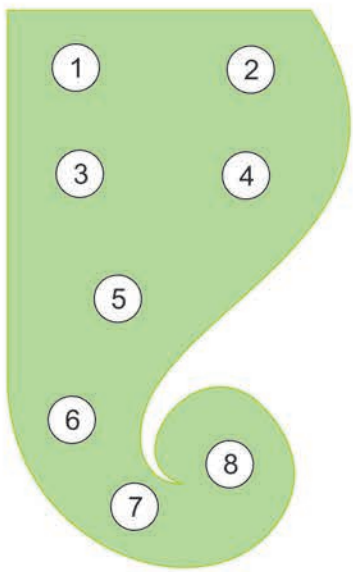

BACK COVER:
ARKA logo superimposed on ICAR-IIHR field photo of tuberose
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Innovative Technologies Released by ICAR-IIHR in 2020

ARKA SHYAMA
ICEBOX SEGMENT
WATERMELON VARIETY

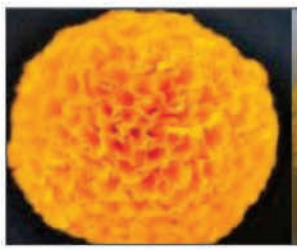
ARKA SUPREME
HIGH YIELDING
AVOCADO VARIETY

ARKA CHANDRA
PUMMELO VARIETY

ARKA ANANTHA
PUMMELO VARIETY

ARKA TEJASVI, ARKA TANVI & ARKA GAGAN
CHILLI HYBRIDS RESISTANT TO CHILLI LEAF CURL VIRUS

ARKA NUTHAN & ARKA SHREYAS
BOTTLE GOURD HYBRIDS RESISTANT
TO GUMMY STEM BLIGHT



ARKA SHUBHA & ARKA BHANU
HIGH YIELDING, CAROTENOID
RICH MARIGOLD HYBRIDS

ARKA RED
GERBERA VARIETY

CHINA ASTER MUTANTS
ARKA ADVIKA & ARKA NIRALI

READY-TO-SERVE
POMEGRANATE JUICE

ARKA HERBIWASH HERBAL
PRODUCT TO
REMOVE PESTICIDES
& MICROBES IN FRUITS &
VEGETABLES

IRON FORTIFIED
ELM OYSTER
MUSHROOM

ARKA SASYA POSHAK
RAS
LIQUID NUTRIENT
FORMULATION FOR
SOILLESS VEGETABLE
CULTIVATION

SOLAR POWER OPERATED
TRICYCLE CART FOR READY
TO HARVEST FRESH
MUSHROOM VENDING

Contents

PREFACE

The ICAR-Indian Institute of Horticultural Research with main station at Bengaluru and two regional centers at Bhubaneswar and Chettalli, has endeavored for the past 54 years to make a strong impact on various stakeholders involved in the horticultural sector. The Institute has identified 18 promising varieties in fruit, vegetable and flower crops, and 14 technologies related to crop management, diagnostic kits, insect lures, farm machinery and value addition. The release of five high yielding chilli hybrids with resistance to ChLCV and four carotenoid rich marigold hybrids for improving the income of farmers are notable achievements. The Arka Herbiwash, Solar powered Vending Vans for fruits and vegetables & ready-to-harvest mushrooms, and probiotic fruit juices of mango, pineapple and pomegranate are the most relevant technologies for the present pandemic situation. Arka Herbiwash is an eco-friendly formulation capable of removing 80-100% of surface pesticide residues and microbes. The Solar powered vending cart became handy in moving the produce from producer to consumers with minimum post-harvest losses.

Though the COVID pandemic partially affected our extension activities during 2020, we have successfully demonstrated 116 technologies, conducted 35 trainings and 38 farmer–scientist interface meetings for 2742 stakeholders, and participated in 15 exhibitions. The technology demonstrations in all North eastern states of India comprised of 148 ICAR-IIHR varieties/ technologies in 75 crops covering an area of 348.3 acres in 41 districts. On-farm trials were conducted in 33 farmers' fields covering 38.5 acres with ICAR-IIHR varieties of okra and onion (Arka Nikita and Arka Kalyan respectively) and tuberose (Arka Prajwal) under the Tribal Sub-Project (TSP) program. Besides, an awareness program on ICAR-IIHR technologies was organized for 550 tribal beneficiaries at Pavagada, Tumakuru district and for 320 tribal farmers of 16 villages at Konanakere village, Kollegala taluk, Chamarajanagar district. A Seed Vending Machine was installed at Hirehalli under the TSP program. A sale counter was opened at Sanjay Nagar, Bengaluru to facilitate input availability to stakeholders, especially for the urban Bengaluru citizens.

We have generated a revenue of Rs.26,69,560/- through commercialization of technologies and Rs.77,88,903/- from professional services (CPC). The ITMU and BPD units have facilitated licensing of 58 technologies related to post-harvest technology, farm implements and machinery, seed and planting material and crop protection technologies. The revenue generated from Agrinnovate India Limited through commercialization of these technologies was Rs.90,85,500/-. The Institute has

generated revenue worth Rs.26,07,450/-through sale of mushroom spawn. ICAR-IIHR has been granted two patents and another two are pending.

The National Horticultural Fair with the theme 'Horticulture: Making Farming an Enterprise', was held during 5-8 February, 2020. It has drawn huge response for the second consecutive year with footfall of more than 70,000 stakeholders representing 26 states. The fair was inaugurated by Dr. Trilochan Mohapatra, Secretary DARE and DG, ICAR. The fair included live demonstrations on crop varieties, fruit-based integrated farming systems, vegetable cultivation in protected and soilless conditions, peri-urban horticulture and terrace gardening. The 'ICAR-IIHR Seed Portal' was launched for online sale of vegetable and flower seeds to stakeholders in distant and remote areas and subsequently it was connected to YONO SBI app. A trilingual mobile app 'Arka Bagwani' in English, Hindi and Kannada with information on varieties/ technologies, success stories, seed and planting material, and various schemes of the GOI was released.

The COVID-19 pandemic has created unprecedented damage to mankind and the economy of several growth sectors including agriculture. However, ICAR-IIHR has contributed it's might by promoting the Seed Village Concept that ensured three-fold increase in profits of small and marginal farmers. The Breeder Seed and Truthful Label seed production programs were organized at both ICAR-IIHR campus and in farmers' field under the Seed Village Concept, to produce 11557.985 kg of seeds of 67 vegetable varieties/ hybrids. The e-Horticulture WhatsApp group at the Institute and BESST-HORT Society helped farmers, by linking producers to buyers. Despite severe restrictions due to COVID pandemic, our scientists ensured participation in off-line and online meetings with stakeholders, winning awards and honors, publishing in high impact journals and obtaining external project funds as in previous years. I am proud to present the Annual Report of 2020 of ICAR-IIHR and thank my staff for their research contributions and services in this regard. I am thankful to Dr. Trilochan Mohapatra, Secretary DARE and DG, ICAR, and Dr. A.K. Singh, DDG (Horticultural Sciences), ICAR, and Dr. V.K. Pandey and Dr. B.K. Pandey, ADG's (Horticultural Sciences), ICAR, for their continued support and guidance.

Bengaluru
June 2021

M.R. DINESH
Director

Introduction

The ICAR-Indian Institute of Horticultural Research, an ISO 9001:2015 certified premier Institute conducts basic, strategic, anticipatory and applied research on all aspects of fruits, vegetables, ornamentals, medicinal and aromatic plants and mushrooms. The Institute was the first horticultural research Institute in the country established by the Indian Council of Agricultural Research (ICAR), New Delhi, on September 5, 1967, which was initially established at the ICAR headquarters at New Delhi, and subsequently shifted to Bengaluru in Karnataka on February 1, 1968. Dr. G.S. Randhawa was the Founder Director, whose vision and dynamism helped the Institute grow rapidly. The Institute took over the erstwhile National Horatorium of the Government of Karnataka, spread over an area of 24.7 ha at Hesaraghatta, and later on acquired an additional 238 ha of land from the surrounding village of Ivarkandapura. The Institute expanded the ambit of its research activities to the length and breadth of the country by establishing experimental stations at Lucknow, Nagpur, Ranchi, Godhra, Chettalli and Gonikoppal. Over the years, the experimental stations at Lucknow, Nagpur, Ranchi, and Godhra have grown in size and have attained the status of independent Institutes. The ICAR-IIHR, Bengaluru has two Central Horticultural Experiment Stations located at Bhubaneswar in Odisha and Chettalli in Karnataka, and two Krishi Vigyan Kendras located at Gonikoppal and Hirehalli. The Institute houses Project Coordinating Unit of All India Coordinated Research Project on Fruits at its main campus.

Vision

Increasing research efforts to reorient and refine approaches for developing eco-friendly sustainable and widely adoptable technologies contributing towards increased food and nutritional security, quality and higher output, so that horticulture can become an enterprise and the farmer an entrepreneur.

Objectives

To address the food and nutritional security, the following objectives are envisaged:

- To serve as a national repository of horticultural crop germplasm and horticultural database
- To develop improved varieties/ hybrids through conventional breeding and through Marker Assisted Selection for biotic and abiotic stress tolerance in various horticultural crops
- Effective utilization of natural resources and enhancement of input use efficiency and plant health management
- Production of quality seed and planting material of horticultural crops
- Post-harvest management, value addition and horticultural waste utilization
- Dissemination of the technologies for improving on-farm production and productivity and to act as a specialized center for HRD in horticulture.

Mandate

- Basic, strategic and applied research to enhance sustainable productivity, quality and utilization of horticultural crops
- Repository of horticultural genetic resources and scientific information
- Transfer of technology, capacity building and impact assessment of technologies
- Human resource development and education

Mission

To bring about improvement in fruit, vegetable, ornamental and medicinal crops through genetic manipulation, refinements in pre- and post-harvest technology through precision horticulture, mechanization and other modern approaches.

Main Station, Hesaraghatta, Bengaluru

The main station is located at Hesaraghatta, 25 km north of Bengaluru city. The Institute houses laboratory complexes, experimental farms, administrative block and staff quarters located at the Hesaraghatta campus spread over 263 ha land. Recently the Institute has also taken over 24 acres of land of IVRI at Yelahanka, Bengaluru, and about 2 acres in the UHS, Bengaluru campus. The experimental farm located at Hirehalli has a total area of 68 acres involved in breeder seed and foundation seed production of ICAR-IIHR released vegetable varieties, and research work on fruit crops, particularly maintenance of jack fruit germplasm and a few flower crops in collaboration with ICAR-IIHR, Hesaraghatta, and Bengaluru. In 2013, the station acquired an additional 26 acres of adjoining area for research purpose.

Growth

The physical growth of the Institute can be viewed in two phases. In the initial years up to 1990, wherein emphasis

was laid on development of land and infrastructure. The blueprint of the entire farm area for carrying out experimental trials and laboratories for research and administrative office buildings was prepared. The entire arable land was divided into well-defined experimental blocks for carrying out field experiments and independent laboratory buildings for all the major scientific divisions. Currently, research activities are being carried out by eight crop divisions having state of art equipment like electron microscope, ultracentrifuge, LC-MS/MS, GC- MS/MS, ICP-OES, HPLC, GLC, SFE, AAS, Rapid microbial identification systems, RT-PCR, etc., field facilities such as polyhouses, net houses, growth chambers, mist chambers, Gamma chamber, temperature gradient chambers and phenomics facility. Facilities like cold storage chambers, gene banks, seed processing and nursery units and communication channels like, local area network with video conferencing facilities, etc., are available. The Institute has also created cryopreservation facilities for long-term preservation of germplasm of various crops. A referral laboratory for food safety has been established in the year 2017, for analysis and certification of food contaminants in stakeholder's samples. Apart from this, the Institute houses an ultra-modern library, committee rooms, auditorium, food court, training hostel, bank, post office, dispensary, essential quarters and facilities for the students for research in horticultural sciences.

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

The Station was established in 1972 at Chettalli, with Citrus Experiment Sub-station at Gonikoppal. In the year 1992, the Citrus Experiment Sub-station at Gonikoppal was converted into a full-fledged KVK and all the research work along with the research laboratories of the erstwhile substation were shifted to Chettalli. The station occupies an area of 92 ha. The mandated crop of the center is Coorg mandarin with major emphasis on citrus dieback disease. The Station also works on underutilized fruit crops like, pummello, avocado, mangosteen, karonda, rambutan *etc*. The Station has a well-developed nursery unit for production and distribution of true-to-type disease-free citrus and other planting materials and *Trichoderma* cultures. Transfer of Technology under the Tribal Sub-plan project is also being taken up at this Station.

Central Horticultural Experiment Station (CHES), Bhubaneswar, Odisha

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

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

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

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

The KVK, situated in Kodagu district of Karnataka was established in the year 1954 by the Karnataka State Government as Citrus Research Station and was transferred to ICAR-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 Substation was converted into a full-fledged KVK occupying an area of 17.5 ha.

AICRP on Fruits

The Institute houses the Project Coordinating Cell of All India Coordinated Research Project (AICRP) on Fruits. The AICRP on Tropical Fruits and Sub-Tropical Fruits were amalgamated and named as AICRP on Fruits from August 21, 2013. The project has objective 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, banana, grapes, guava, litchi, jackfruit, mango, papaya and sapota. There are 23 centres throughout the country working on mango, 16 on guava, 13 on banana, 12 on citrus, 9 on papaya, 8 each on litchi and grapes, 5 on jackfruit, 4 on sapota. At present, there are 50 centres, including 30 SAU based centres, 14 ICAR-Institute-based centres, four CAU-based centre and one private unit and one under the Government of Arunachal Pradesh.

The main station at Hesaraghatta, Bengaluru, under the leadership of the Director, ICAR-IIHR, implements and

monitors all the activities of the Institute. Considering the importance given to horticultural research and development in the country, ICAR-IIHR has the mandate to serve various stake-holders of horticultural sector and for carrying out this mandate, the Institute has established various service-oriented units as follows: Prioritization, Monitoring and Evaluation Cell (PME); Institute Technology Management Unit (ITMU) and Consultancy and Processing Committee including Horti-business incubation facility; Agricultural Technology Information Centre (ATIC); Agricultural Knowledge Management Unit (AKMU); Regional Centre (South), ICAR-National Agricultural Education Accreditation Board (NAEAB); Vigilance Cell; P. G. Education; Library and Women's cell.

Accomplishments of ICAR-IIHR

Research work carried out during the last five decades has paid rich dividends in terms of release of 289 varieties and hybrids and development of a number of sustainable productions, protection and post-harvest management technologies. The Institute maintains a wealth of varied collection of germplasm (13778) in various horticultural crops reflecting considerable genetic biodiversity including potential sources of resistance to various biotic and abiotic stresses and also those with high nutritional, health care and medicinal values and quality traits. The main station at Hesaraghatta, Bengaluru, holds 12658 germplasm comprising of 1873 in fruits, 9193 in vegetables, 882 in ornamentals, 506 in medicinal plants apart from 93 in mushroom and 111 in betel vine. CHES, Chettalli, has 116 avocado collections. CHES, Bhubaneswar has germplasm collection of 187 in fruits and 817 in vegetables. The Institute has the largest ex situ field gene bank of mango comprising of 120 germplasm, besides *ex situ* field gene bank of over 125 collections of herbal and RET medicinal plants including tree species. Morphological characterization, molecular characterization and DNA fingerprinting have been carried out for majority of the accessions. About 600 genotypes including indigenous and exotic accessions of fruits, vegetable and ornamental crops have been evaluated for resistance to major insect pest and diseases and sources of resistance have been identified. The Institute has developed and standardized technologies for *in-vitro* conservation of fruits and medicinal species, cryo preservation of pollen apart from low-cost techniques for storage of vegetable seed germplasm. A pollen cryobank was established for the first time in the country at the Institute in 1983 in which nearly 675 collections of various horticultural crops are cryopreserved.

The Institute has so far developed over 289 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 36 varieties; three in papaya, seven in mango, five in guava, eleven in grapes, one each in annona, avocado, ber, litchi, lime and passion fruit and two each in pomegranate and pummelo. Two pummelo varieties, Arka Chandra and Arka Anantha, and in avocado, a high yielding variety, Arka Supreme were identified and released at Institute level this year. Arka Supreme has the advantages of being a regular bearer and high yielder, with high average fruit weight and superior fruit quality.

In vegetable crops, the Institute has so far developed and released 110 high yielding open pollinated varieties and 30 F1 hybrids of different vegetable crops resistant to pests and diseases. Three bottle gourd hybrids, Arka Ganga, Arka Shreyas and Arka Nutan, resistant to gummy stem blight (GSB), Arka Shyama, an icebox segment watermelon variety and Arka Bharath, an high yielding teasel gourd variety have been released from the institute. Five cytoplasmic-genic male sterile system based chilli F_1 hybrids, Arka Tejasvi, Arka Yashasvi, Arka Saanvi, Arka Tanvi and Arka Gagan which are resistant to Chilli Leaf Curl virus and suitable for varied market segments, have been identified. Arka Anamika of okra resistant to Yellow Vein Mosaic Virus and Arka Komal, a high yielding French bean have spread throughout the country. High yielding varieties of tomato (Arka Rakshak), onion (Arka Kalyan and Arka Niketan) have made significant impact. 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; Arka Apeksha and Arka Vishesh, two hybrids suitable for processing and Arka Aditya was identified at the national level zone VIII. Chilli hybrids, Arka Meghana, tolerant to thrips and viruses, Arka Harita and Arka Suphal, 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 Kirtiman, high yielding stringless varieties of French bean, Arka Suvidha, Arka Anoop and Arka Sukomal 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 106 improved varieties having high yield, attractive colour, novelty and improved shelf life in flower crops. One gerbera variety, Arka Red and four marigold

hybrids, Arka Shubha, Arka Vibha, Arka Abhi and Arka Bhanu, rich in carotenoids and superior in yield has been identified and released during current year. Many of the gladiolus varieties, China aster varieties and Tuberose cultivar Arka Prajwal has become highly popular among farmers in Eastern as well as other parts of the country. Crossandra varieties-Arka Kanaka, Arka Ambara and Arka Channa have also gained popularity among the farmers. In the field of medicinal and aromatic plants, the Institute has developed 10 varieties, two in *Diascoria floribunda* and *Solanum viarum* and six varieties in *Mucuna pruriens* having higher content of active principles and three varieties of aromatic plants, jasmine having higher percentage of essential oil.

In mushroom research, end to end technologies of Oyster, Milky And Shiitake Mushrooms has been developed. Iron fortified elm oyster mushroom was identified and the technology for production of mushroom millet cookies standardized. Value added products like Arka Mushroom rasam powder, Mushroom nutritive powder (chutney powder) have been developed through dehydrated mushrooms to enhance nutrition in daily diet. ICAR- IIHR was the first institution in the country to develop indigenous spawn production machinery, systems to integrate solar energy in spawn production and cultivation processes. Ready to fruit (RTF) bags is a novel concept initiated by ICAR-IIHR in 2013 to enable women to grow mushrooms at home and utilize it in their daily diet.

The Institute has concentrated on 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; technology for foliar nutrition of micro nutrients viz., mango special, banana special, citrus special and vegetable special for higher and quality yields; technology for soilless cultivation of brinjal, Arka Sasya Poshak Ras, a liquid nutrient formulation for soilless vegetable production; development of Arka Microbial Consortium, Arka Fermented Cocopeat and Arka Actino-plus for use in horticultural crop production; Arka Herbiwash**,** safe herbal product to wash fruits and vegetables with, in order to remove surface residues of pesticides, technology to boost seed yield in China aster; identification of causative factor for the formation of spongy tissue and jelly seed, (major physiological disorders in Alphonso and Amrapali mangoes respectively), and development of a nutrient formulation for management of spongy tissue in mango; technology for production of tomato, colored capsicum, cucumbers and melons under protected conditions; refinement in the technology for production of nursery seedlings using protrays.

The Institute has worked out management practices for control of major insects, nematodes and diseases using chemical pesticides which have been included in package of practices as recommendation for plant protection. Arka Viral Kit, Loop-Mediated Isothermal Amplification (LAMP) kit to diagnose Tomato Leaf Curl Bangalore virus (ToLCBV). Arka Cucurlure, a novel kairomone blend for effective trapping of male melon flies, *Zeugodacus cucurbitae* was developed at the Institute. Arka Neem Seed Powder Pellet, an eco-friendly product was developed for the control of diamond back moth and aphids on cabbage and cauliflower. Work on integrated pest management using botanicals, plant products, biocontrol measures, trap crops, pheromone traps, etc., is initiated and has developed several of sustainable technologies. IPM modules have been developed for control of fruit fly and stone weevil in mango, sapota seed borer, citrus leaf miner, borer in tomato, brinjal, chilli, DBM in cabbage and cauliflower, okra, onion, leguminous vegetables and various other vegetables. IDM strategies for major diseases of fruits, vegetables and ornamental crops, biointensive management of nematodes in fruits and vegetables, biological control of insect pest and diseases and microbial control of pest complex have also been successfully worked out.

ICAR-IIHR, Bengaluru has been recognized as the Center of Excellence in Post-Harvest Technology. The Institute has standardized the technology to extend the storage life of fruits and vegetables, protocol for MAP and shrink wrapping, value addition, preparation of osmo dehydrated products, fruit-based beverages. Arka Avocado Chutney and Arka Avocado Bread Spread is developed which can be regularly consumed due to the incredible health benefits it has due to the butter fruit. Beverages like Arka Haagalarasa, Ready-to-Serve Bitter Gourd Juice, Ready-to-Serve Probiotic Mango Beverage, Probiotic Pomegranate Juice, prepared using pomegranate arils and soy milk, Arka Probio Pineapple juice, Ready to Serve Pineapple Beverage, prepared using 70% pulp from cv. Kew and Queen, were developed at the Institute. First of its kind Jackfruit based beverages, biscuits and chocolates were developed. As a part of farm mechanization, the Institute has developed a number of machineries for cultivation, harvesting and processing of horticultural crops. Power operated Pomegranate Aril Extractor, Solar power operated tricycle cart for ready to harvest fresh mushroom vending, Solar Power Operated

Tricycle Cart for Fresh Fruits and Vegetables Vending. The Solar Powered Fruit and Vegetable Vending Van developed at the Institute came in handy to farmers/ vendors in moving the produce to the door steps of the consumers during the COVID-19 pandemic and lock-down times

The Institute has been identified as a Center of Excellence for Research in Biotechnology. State of-art infrastructures include, 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 regeneration protocol and CRISPR-Cas based gene editing protocols.

On the Social sciences front, the Institute has been working on economics of production of various horticultural crops, input use pattern and efficiency studies, economics of marketing, economics of post-harvest losses, market intelligence studies, impact assessment studies for ICAR-IIHR technologies, economics of farming systems, development of various statistical models. Computer applications on development of mobile and web applications in horticultural crops, participatory rural appraisal for understanding gaps in adoption and assessing the research needs, validation of technologies developed and technological interventions to refine the technologies, identification of training needs, use of innovative extension methodologies for transfer of technology etc., have also been carried out.

ICAR-IIHR has developed 'ICAR-IIHR Seed Portal' (https://seed.iihr.res.in) for the online sale of seeds of vegetable crop varieties released by the Institute. The portal was launched during the National Horticulture Fair 2020 by Dr. Trilochan Mohapatra, Secretary DARE and Director General, ICAR, New Delhi.

The Institute including its Regional Stations, CHES, Bhubaneswar, CHES, Chettalli, KVK, Gonikoppal, and KVK, Hirehalli, has organized more than 89 on campus trainings, 64 off-campus, and 38 farmer-scientist interaction meetings on various aspects of horticulture and trained more than 7146 personnel (farmers, farm women and private entrepreneurs). The Krishi Vigyan Kendras at Gonikoppal and Hirehalli are involved in transfer of technology and conduct of Front-Line Demonstrations and On Farm Testing. The Institute, Regional Stations and KVK's have also conducted 65 demonstrations, 5 On-Farm trials, 6 Front line demonstrations, & 18 and 3 under Scheduled Caste Sub-Plan (SCSP) and Tribal Sub-Plan (TSP), respectively, on innovative ICAR-IIHR technologies on farmers' fields to popularize the technologies. A total of 15 exhibitions were conducted and 7 demonstrations were taken up in North Eastern states of the country. More than 12 field days on ICAR-IIHR developed technologies and varieties have been organized both at the Institute and on farmers' fields. About 27 radio and 27 TV programs on various technologies and aspects have been given by the scientists of the Institute apart from producing video films on important aspects in horticulture. Popular literature in Kannada, Hindi and English languages in the form of extension bulletins and folders on various aspects of horticulture have been brought out and are being distributed to extension personnel and farmers. 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 undertaken on payment basis.

ICAR-IIHR, Bengaluru, takes up protection and commercialization of technologies developed by the Institute. The Institute Technology Management Unit (ITMU) established in 2006, shoulders the responsibility of commercialization of potential technologies and as a first step in this direction has registered a trade mark, 'ARKA' (with a logo) for sale of its technological products and also took up patenting/registering its technologies. So far, the Institute has obtained eight international and four national patents and filed 18 protocols of the technologies for patenting in India. More than 370 clients have been successful in dissemination of these technologies through commercialization across the country by marketing the products.

Physical and Financial

The Institute (including its regional stations) has a sanctioned strength of 560 staff members (157 scientific, 226 technical, 83 administrative and 94 supporting) as detailed in the table overleaf. The consolidated expenditure during 2020 including regional stations was Rs. 8197.93 lakhs. Revenue was generated through commercialization of technologies, consultancy services, analytical testing and sale of farm-produce and other means at the main Station and the CHES including the KVKs.

STAFF POSITION OF ICAR-IIHR, BENGALURU AS ON 01.06.2021

Sl. No.	Category	Sanctioned	In Position	Vacant
1	**Scientific**	154+1* (Including KVK)	136+1	18
2	**Technical**	226	133	93
3	**Administrative**	83	45	38
4	**Supporting**	94	57	37
	Total	**557+1***	**371+1**	**186**

* Director

UNIFIED BUDGET ALLOCATION 2020-21 (BE)

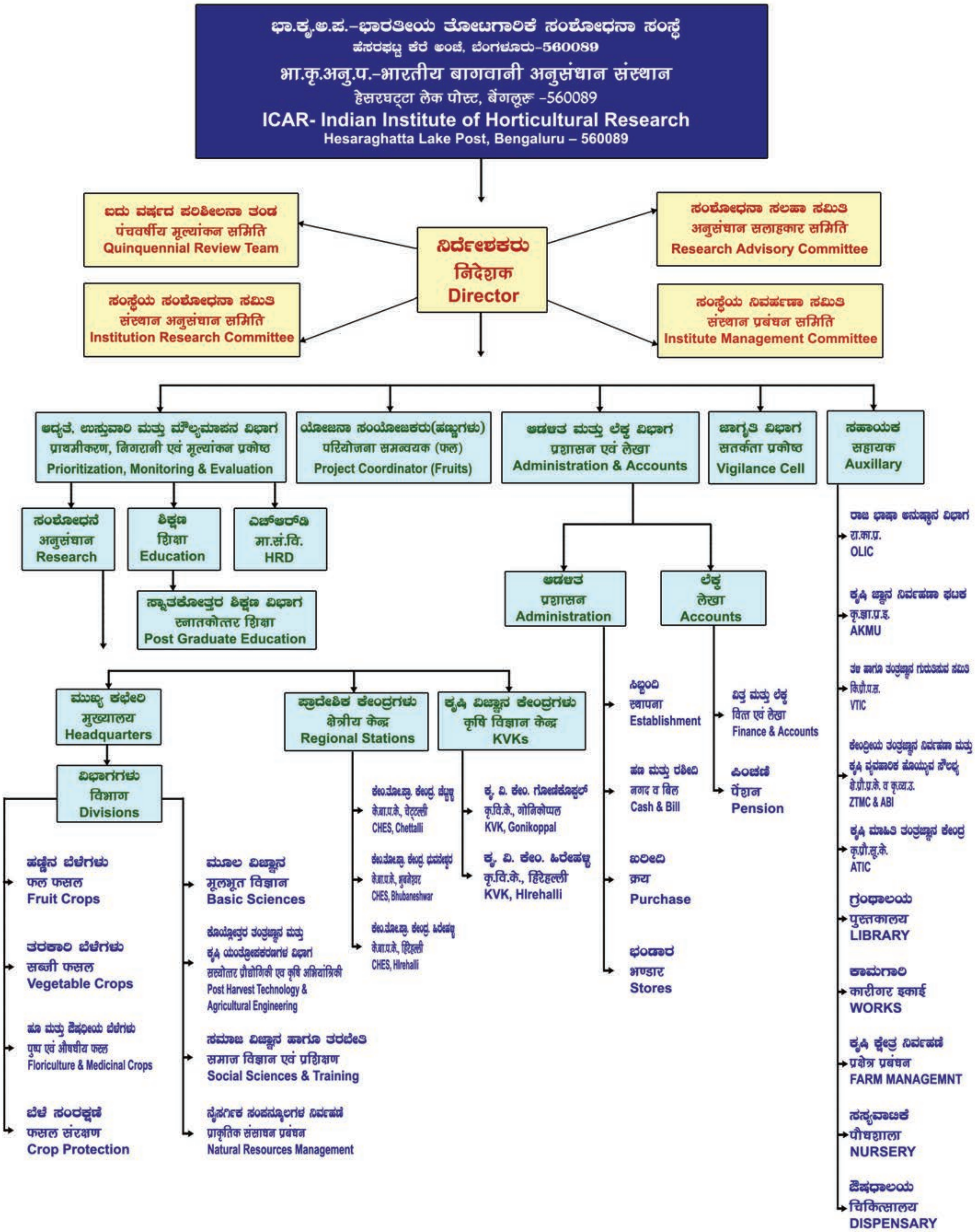
Rs. (Lakhs)

Sl. No.	Head	Other than NEH & TSP	NEH	TSP	SCSP	Grand Total
1	**Grants for creation of capital assets (CAPITAL)**	125.00	0	0	10.00	135.00
2	**Grants in aid - Salaries (REVENUE)**	5520.10	0	0	0	5520.10
3	**Grants in Aid - General (REVENUE)**					
	Pension & other retirement benefits	3637.08	0	0	0	3637.08
	Traveling allowance	15.90	0	0	0	15.90
	Research & Operational expenses	790.00	20.00	70.00	105.00	985.00
	Administrative expenses	710.82	0	0	0	710.82
	Miscellaneous expenses	5.00	0	0	0	5.00
	Total	**10803.90**	**20.00**	**70.00**	**115.00**	**11008.90**

EXPENDITURE UPTO 31 DECEMBER 2020 (UNIFIED BUDGET)

Rs. (Lakhs)

Sl. No.	Head	Other than NEH & TSP	NEH	TSP	SCSP	Grand Total
1	**Grants for creation of capital Assets (CAPITAL)**	74.10	0	0	0	74.10
2	**Grants in aid - Salaries (REVENUE)**	4506.21	0	0	0	4506.21
3	**Grants in aid - General (REVENUE)**					
	Pension & other retirement benefits	2689.67	0	0	0	2689.67
	Traveling allowance	8.12	0	0	0	8.12
	Research & Operational expenses	394.90	0.10	29.57	27.49	452.06
	Administrative expenses	464.80	0	0	0	464.80
	Miscellaneous expenses	2.97	0	0	0	2.97
	Total	**8140.77**	**0.1**	**29.57**	**27.49**	**8197.93**


ಭಾ.ಕೃ.ಅ.ಪ.-ಭಾರತೀಯ ತೋಟಗಾರಿಕೆ ಸಂಶೋಧನಾ ಸಂಸ್ಥೆ
ಹೆಸರಘಟ್ಟ ಕೆರೆ ಅಂಚೆ, ಬೆಂಗಳೂರು-560089
भा.कृ.अनु.प.-भारतीय बागवानी अनुसंधान संस्थान
हेसरघट्टा लेक पोस्ट, बेंगलूरू -560089
ICAR- Indian Institute of Horticultural Research
Hesaraghatta Lake Post, Bengaluru – 560089
ನಿರ್ದೇಶಕರು
निदेशक
Director
ಐದು ವರ್ಷದ ಪರಿಶೀಲನಾ ತಂಡ
पंचवर्षीय मूल्यांकन समिति
Quinquennial Review Team
ಸಂಶೋಧನಾ ಸಲಹಾ ಸಮಿತಿ
अनुसंधान सलाहकार समिति
Research Advisory Committee
ಸಂಸ್ಥೆಯ ಸಂಶೋಧನಾ ಸಮಿತಿ
संस्थान अनुसंधान समिति
Institution Research Committee
ಸಂಸ್ಥೆಯ ನಿರ್ವಹಣಾ ಸಮಿತಿ
संस्थान प्रबंधन समिति
Institute Management Committee
प्राथमीकरण, निगरानी एवं मूल्यांकन प्रकोष्ठ
Prioritization, Monitoring & Evaluation
परियोजना समन्वयक (फल)
Project Coordinator (Fruits)
ಆಡಳಿತ ಮತ್ತು ಲೆಕ್ಕ ವಿಭಾಗ
प्रशासन एवं लेखा
Administration & Accounts
ಜಾಗೃತಿ ವಿಭಾಗ
सतर्कता प्रकोष्ठ
Vigilance Cell
ಸಹಾಯಕ
सहायक
Auxillary
ಸಂಶೋಧನೆ
अनुसंधान
Research
ಶಿಕ್ಷಣ
शिक्षा
Education
मा.सं.वि.
HRD
ಸ್ನಾತಕೋತ್ತರ ಶಿಕ್ಷಣ ವಿಭಾಗ
स्नातकोत्तर शिक्षा
Post Graduate Education
ಆಡಳಿತ
प्रशासन
Administration
ಲೆಕ್ಕ
लेखा
Accounts
ಮುಖ್ಯ ಕಛೇರಿ
मुख्यालय
Headquarters
ಪ್ರಾದೇಶಿಕ ಕೇಂದ್ರಗಳು
क्षेत्रीय केन्द्र
Regional Stations
ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರಗಳು
कृषि विज्ञान केन्द्र
KVKs
ವಿಭಾಗಗಳು
विभाग
Divisions
ಹಣ್ಣಿನ ಬೆಳೆಗಳು
फल फसल
Fruit Crops
ತರಕಾರಿ ಬೆಳೆಗಳು
सब्जी फसल
Vegetable Crops
पुष्प एवं औषधीय फसल
Floriculture & Medicinal Crops
ಬೆಳೆ ಸಂರಕ್ಷಣೆ
फसल संरक्षण
Crop Protection
ಮೂಲ ವಿಜ್ಞಾನ
मूलभूत विज्ञान
Basic Sciences
सस्योत्तर प्रौद्योगिकी एवं कृषि अभियांत्रिकी
Post Harvest Technology & Agricultural Engineering
ಸಮಾಜ ವಿಜ್ಞಾನ ಹಾಗೂ ತರಬೇತಿ
समाज विज्ञान एवं प्रशिक्षण
Social Sciences & Training
प्राकृतिक संसाधन प्रबंधन
Natural Resources Management
CHES, Chettalli
CHES, Bhubaneshwar
CHES, Hirehalli
कृ.वि.के., गोनिकोप्पल
KVK, Gonikoppal
कृ.वि.के., हिरेहल्ली
KVK, Hirehalli
स्थापना
Establishment
Cash & Bill
क्रय
Purchase
भण्डार
Stores
वित्त एवं लेखा
Finance & Accounts
पेंशन
Pension
OLIC
AKMU
VTIC
ZTMC & ABI
ATIC
पुस्तकालय
LIBRARY
कारीगर इकाई
WORKS
प्रक्षेत्र प्रबंधन
FARM MANAGEMNT
पौधशाला
NURSERY
चिकित्सालय
DISPENSARY

१. कार्यकारी सारांश

भा.कृ.अनु.प.–भारतीय बागवानी अनुसंधान संस्थान का विजन फल, सब्जी, पुष्प और औषधीय फसलों में आनुवंशिक हेरफेर के माध्यम, पूर्व और बाद की फसल प्रौद्योगिकी में शोधन, सटीक बागवानी, मशीनीकरण और इस तरह के आधुनिक दृष्टिकोणों के माध्यम से सुधार है। वर्ष 2020 के दौरान भा.कृ.अनु.प.–भा.बा.अनु.सं. की प्रमुख उपलब्धियों का संक्षिप्त सारांश यहां दिया गया है।

पादप आनुवंशिक संसाधन

संस्थान, देश में उद्यानिकी फसलों के पादप आनुवंशिक संसाधनों के प्रबंधन के लिए एक महत्वपूर्ण नोडल केंद्र है, और कई बागवानी फसलों के लिए राष्ट्रीय सक्रिय जर्मप्लाज्म साइट (एनएजीएस) के रूप में पहचाना जाता है। जर्मप्लाज्म अन्वेषण और संग्रह पर दीर्घकालिक कार्यक्रम के हिस्से के रूप में, भा.कृ.अनु.प.–भा.बा.अनु.सं., बेंगलुरु में फल फसलों के जननद्रव्य को 27 प्राथमिक और 13 द्वितीयक जननद्रव्य और चेट्टल्ली में एवोकाडो जननद्रव्य के 53 संग्रह के साथ समृद्ध किया गया। वर्ष 2020 में सब्जी फसलों के जननद्रव्य संग्रह में सहजन के 77, खीरा के 60, छप्पन कद्दू के 33, भिंडी के 27, मिर्च के 24, करी पत्ता के 17, शिमलामिर्च के 16 और सेम फली के 16 संकलन को शामिल किया गया। इसके अतिरिक्त पुष्प फसलों में रजनीगंधा (1), ग्लेडियोलस (12), जरबेरा (16) और डहलिया (30) के 59 जननद्रव्य को शामिल किया गया।

कर्नाटक, केरल और तमिलनाडु से एकत्र 53 एवोकैडो एक्सेशन, भा.कृ.अनु.प.– भा.बा.अनु.सं. के केंद्र चेट्टल्ली में संरक्षित हैं। मिर्च में, अंडमान और निकोबार द्वीप समूह और उत्तर पूर्वी भारत से एकत्र किए गए *कैप्सिकम चाइनेंस* और *कैप्सिकम फ्रूटसेन* के दस जंगली प्रविष्टियों को वातावरण के अनुकूल बनाया और संग्रहित किया। बैंगन में, छह जंगली प्रजातियों *(सोलनम टॉरवम, सोलनम गिलो, सोलनम इंडिकम, सोलनम मैक्रोकार्पोन, सोलनम मैमोसुम* और *सोलनम सीफोरथियानम)* को बनाए रखा। भिन्डी में नौ जंगली प्रजातियों को नेट हाउस में प्रतिरोध प्रजनन कार्यक्रम में बनाए रखा और उपयोग किया जा रहा है। खीरा की तीन जंगली प्रजातियाँ यथा– *कुकुमिस हार्डिविकी, कुकुमिस मेटुलीफेरस* और कुकुमिस *हिस्ट्रिक्स* का संरक्षण और प्रजनन कार्यक्रम के लिए उपयोग किया गया। इसके अतिरिक्त, सब्जियों की फसलों यथा– मिर्च (140), बैंगन (42), फली सब्जियां (165), चौलाई (285), सहजन (86), खाद्य पत्तेदार सब्जियां (30), परवल(69) के जर्मप्लाज्म को अनुसंधान केंद्र भुवनेश्वर में बनाए रखा गया।

गुलाब की 13 प्रजातियों के गुण के अध्ययन से ज्ञात हुआ कि बैंगलोर स्थितियों के तहत केवल *रोसा मल्टीफ्लोरा* में फूल आते है। गेंदे की विभिन्न प्रजातियां यथा– *टैजिटस इरेक्टा, टैजिटस पटुला* और टैजिटस मिनुटा को गेंदे जर्मप्लाज्म में एकत्रित किया गया था। गुलदाउदी में, 100 जर्मप्लाज्म का संरक्षण और क्षेत्र जीन बैंक में उत्पादित किया गया। 28 जर्मप्लाज्म को शीतकक्ष में संरक्षित, उत्पादित और रखरखाव किया गया। बारह परिग्रहणों के लिए आईसी नंबर प्राप्त किए गए।

सेंटेला एशियाटिक के लगभग 28 और *जिमनेमा सिल्वेस्ट्रे* के 31 परिग्रहणों का क्षेत्र बैंक में संरक्षण किया गया। *एक्लिप्टा अल्बा* में 155 जर्मप्लाज्म, और *बैकोपा मोननेरी* में 71 जर्मप्लाज्म हमारे संग्रह में हैं। *एक्लिप्टा अल्बा* में 36 अभिग्रहण के लिए, एलोवेरा में 30 और *मुकुना प्रूयेंस* में आईसी नंबर प्राप्त किए गए थे। दो जंगली मशरूम सुसंस्कृत, शुद्ध किए गए और स्पॉन तैयार किया गयाावर्तमान में सत्यापन के लिए फलदायक परीक्षण के तहत हैं। ताजा पपीता में पराग (78%) की तुलना में *वास्कोनसेलिया कुंडिनमार्केन्सिस* के क्रायोप्रेसिवेड पराग की प्रारंभिक व्यवहार्यता 76% थी।

फसल सुधार

तीन आम संकर (आर3पी12, आर3पी16 और आर4पी18) बेहतर फल गुणवत्ता मानकों के लिए चुने गए। तीन पॉलिम्ब्रायोनिक किस्मों के पौधे के पत्ती के अस्थिर प्रोफाइल की तुलना उनके संबंधित मदर प्लांट से की गई। आम के उच्च और निम्न कुल घुलनशील पदार्थ के लिए पहचाने जाने वाले गैर–कोडिंग आरएनए क्रमशः 33191 और 24706 थेउच्च और निम्न के लिए अम्लता की किस्में क्रमशः 6393 और 16253 थीं। गैलिक एसिड और प्रोटोकैतेचुइक एसिड अल्फोंसो और आम्रपाली किस्मों के पराग और वर्तिकाग्र में प्रमुख फेनोलिक एसिड थे। सामान्य तौर पर, अल्फोंसो (अनियमित वाहक) की तुलना में तोतापुरी (नियमित वाहक) में फूलों के जीनों की अधिक अभिव्यक्ति थी, लेकिन अल्फोंसो में एक वर्ष पर अभिव्यक्ति तुलनीय थी।

अमरूद (*सीडियम फ्राइडरिचस्थेलियनम*) की जंगली प्रजातियाँ फ्यूसैरियम के दो आइसोलेट्स (कानपुर से जीडब्ल्यू–10

और गुंटूर से जी डब्ल्यू–जी) और रूट नॉट सूत्र कृमि के लिए प्रतिरोधी थीं। *पी. कैटेलियनम* (लेमन अमरूद) ने 6.18 डीएस एम–1 की उच्च लवणता को सहन किया। पपीते की क़िस्म अर्का प्रभात x *वी.कैलिफ्लोरा* (1016 एफ2 में से 93 संतानें) और क़िस्म अर्का प्रभात X *वी. कुंडिनमकैंसिस* (2328 में से 198 संतानें) ने पीआरएसवी के लक्षणों को व्यक्त नहीं किया। चकोतरा संकर आर11पी9 (3–2 x 19–1) को कम कड़वाहट और मिठास के लिए चुना गया है। अनार का चयन एक 4/2 (व्यक्तिगत पौधे चयन द्वारा विकसित भगवा की खुली परागण) गुणवत्ता मानकों के लिए आशाजनक पाया गया। जामुन में आंशिक जीनोम अनुक्रम डेटा का उपयोग करके कुल 17457 एसएसआर प्राइमरों को डिजाइन किया गया था।

टमाटर एफ1 संकरों में, एच–505 ताजा बाजार के लिए उपयुक्त है और पाँच एच1 संकर एच–501, एच–506, पीएच–1021, पीएच–1025 और पीएच–6321 अनिश्चितकालीन खंड के लिए उपयुक्त थे। पांच मिर्च एफ1 संकर (अर्का तेजस्वी, अर्का यशसवी, अर्का सांनवी, अर्का तन्वी और अर्का गगन) को उपज, फल की गुणवत्ता और मिर्च एल.सी.वी.की प्रतिरोध के लिए आशाजनक पाया गया। केएच2पीओ4 @ 10–3 एम के साथ उपचारित किए गए बीजों ने अंकुरण में उच्च जड़ / शूट अनुपात और उन्नति दिखाई। भिन्डी हाइब्रिड संकर ओकेएच–57 की उच्चतम फल उपज 29.14 टन/हे. है। लौकी की किस्म अर्का नूतन और अर्का श्रेयस बेलनाकार और क्लब आकार खंड में गमी स्टेम ब्लाइट (जीएसबी) प्रतिरोधी किस्में हैं। अर्का गंगा, प्रतिरोधी जनक से गमी स्टेम ब्लाइट के लिए प्रतिरोधी विकसित किया गया था। वाणिज्यिक खेती के लिए एक टीसेल गार्ड की किस्म अर्का नीलांचल गौरव (7.82 किलो/पौधा) की पहचान की गई थी।

फ्रेंच बीन के 38 जर्मप्लाज्म लाइनों के लक्षण वर्णन ने संकेत दिया कि प्रति पौधे की पैदावार 34 से 241 ग्राम तक थी, जबकि दो लाइनों (आईआईएचआर–17 और आईआईएचआर–33) ने रतुआ रोग के लिए क्षेत्र प्रतिरोध दिखाया। लोबिया की 33 जर्मप्लाज्म लाइनों के मूल्यांकन से, तीन लाइनों यथा– आईआईएचआर –15, आईआईएचआर –28 और आईआईएचआर –65 सर्कोस्पोरा लीफ स्पॉट और लोबिया मोज़ेक वायरस और दो लाइनों यथा– आईआईएचआर–37 और आईआईएचआर–91 ने एफिड्स के लिए क्षेत्र प्रतिरोध दिखाया। मटर के 50 जर्मप्लाज्म का मूल्यांकन किया गया, फली की उपज 23.5 (आईआईएचआर700) से 80 ग्राम प्रति पौधा (वीपी–8902) और परिग्रहण आईआईएचआर–13–4 ने रतुआ के लिए प्रतिरोध दिखाया। *बाकोपा मोननेरी* के 51 अभिगमों में उल्लेखनीय रूपात्मक रूपांतर देखा गया, और *एक्लप्टा अल्बा* के पुष्प जीव विज्ञान के अध्ययनों से पता चला कि यह आत्म और पार दोनों संगत है।

जामुन जीनोटाइप (21) का मूल्यांकन भौतिक–रासायनिक विशेषताओं के लिए किया गया था, उच्च फल का वजन, सेलेक्शन–20 (8.52 ग्राम)और कुल घुलनशील ठोस पदार्थ केएचए–14 (19.660 बी) में दर्ज किया गया था। तुमुकुरू में किसान के खेत से एक जामुन जीनोटाइप की पहचान की गई, जो वर्ष में दो बार (जून–जुलाई और नवंबर–दिसंबर) फल देता है। सब्जी कटहल में तीन प्रकार के प्रविष्टियों में औसत फलों का वजन 1650–3152 ग्रा., 62–80% नमी और कुल आहार फाइबर सामग्री 9–11 ग्राम प्रति 100 ग्राम ताजा वजन था। इमली की फली के संग्रह में संग्रह (एन–388) का मूल्यांकन किया गया और औसत लुगदी की वसूली 36.5% अनुमानित की गई थी। तेलंगाना के संग्रह में कर्नाटक (39.5%) और ओडिशा (39.4%) के बाद सबसे अधिक 40.5% की लुगदी की वसूली हुई। कर्नाटक में तुमकुरु के किसान एक्सेशन 'लक्ष्मणा' में बेहतर पैदावार (251.4 कि.ग्रा. फली/पेड़), 20% कुल अम्लता और 29.8% गूदा में कुल चीनी थी। बेल में, फल की पैदावार अधिकतम एक्सेशन 10/3 (73.5 कि.ग्रा./ पेड़, दक्षिण भारतीय प्रकार) और उसके बाद एक्सेशन 13/19 (67.3 कि.ग्रा./पेड़, उत्तर भारतीय प्रकार) में हुई। बेंगलुरु में किसान के खेत में रोज एप्पल के पांच अभिजात्य वृक्षों का स्वस्थानी मूल्यांकन में फलों के वजन (18.5–78 ग्रा.), फल का आकार (3.5 से.मी. x 3.6 से.मी. से 5.3 से.मी. x 6.5 से.मी.) और कुल घुलनशील ठोस पदार्थ (5 से 8.2^0 बी) पाया गया।

बैंगन के 68 जीनोटाइप्स में औसत फल उपज, आईआईएचआर –635 (0.40 कि.ग्रा./पौध) से आईआईएचआर–602 (2.75 कि.ग्रा./पौध) थी। प्राकृतिक क्षेत्र की स्थिति के तहत, बेल वाली सेम के 122 जर्मप्लाज्म का सेम के पीला मोजैक विषाणु रोग की प्रतिरोधी तीन जीनोटाइप, आईसी 556703, आईसी 556723 और आईसी 632639 की पहचान की गई । सेम की किस्म अर्का कृष्णा (बेल वाली) और अर्का विजय (झाड़ी नुमा) ने बेहतर स्थिरता दिखाई जिसे आगे थर्मो–इंडक्शन अध्ययन के लिए चुना गया। सेम के अर्का सौम्या, अर्का विस्तार और आईआईएचआर बी–डीबी 25 जीनोटाइप उच्च तापमान के लिए उच्च सेलुलर सहिष्णुता के साथ पहचाने गए। फ्रेंच बीन जर्मप्लाज्म के 18 प्रविष्टियों में, आईसी 632961 ने 255 ग्राम प्रति पौध की उच्चतम फली उपज, जिसमें गहरे हरे रंग और चपटी फली लक्षण और 18.20 से.मी. फली की लंबाई है।तुरई में, फलों की अधिकतम पैदावार आईआईएचआर –158 (230.3 कुं./हे.) में थी, इसके बाद अधिक उपज आईआईएचआर–164

(212.8 कुं./हे.) और आईआईएचआर– आरजी–131 बी (196.5 कुं./हे.) में थी।

एवीआरडीसी, ताइवान से एकत्रित करेले की आठ जर्मप्लाज्म लाइनों में आईआईएचआर –195 ने फलों की अधिकतम पैदावार (32.69 टन/हे.) और उच्चतम चैरेन्टीन सामग्री (1.86 माइक्रो ग्राम प्रति ग्राम शुष्क वजन) दर्ज की।एंटीडायबिटिक गुणों के लिए करेला के जर्मप्लाज्म चयनों में से, आईआईएचआर –191–9 में सबसे अधिक चैरेन्टीन सामग्री (1.134 माइक्रोग्राम प्रति ग्राम शुष्क वजन) और आईआईएचआर –180–4 में उच्चतम मोमॉर्डिन सामग्री (8.539 माइक्रोग्राम प्रति ग्राम शुष्क वजन) दर्ज की गई हैं।लौकी में जीनोटाइप बीजी–155 ने (48.53 टन/हे.) और उसके बाद बीजी–148 (38.45 टन/हे.) ने उच्च विपणन योग्य फल उपज दर्ज की। पेठे की एजी–21 प्रविष्टि में अधिकतम उपज (20.15 किलोग्राम/पौध) दर्ज की गई। करी पत्ता के जीनोटाइप एलएसआर/18/75, एलएसआर/18/8, एलएसआर/18/9 और एलएसआर/18/ 06–ए, ने क्रमशः 22.4, 21.4, 21.2 और 19.6 किग्रा./पौध ताजे पत्तों की उच्च पैदावार दर्ज की है। तमिलनाडु, कर्नाटक और ओडिशा से संग्रहित 20 करी पत्ती जर्मप्लाज्म लाइनों में आवश्यक तेल की उपज, 0.11 मि.ली. प्रति 100 ग्रा. (एलएसआर 18/162) से 0.63 मि.ली. प्रति 100 ग्रा. (एलएसआर/18/06–बी) थी।

उच्च उपज, सुगठित फूलों के साथ अच्छे निधानी आयु वाले गेंदे की चार एफ1 संकर (नर बंध्य पृष्ठभूमि जिसके परिणामस्वरूप नर बंध्य संकर होते हैं) की पहचान की गई। अर्का शुभा (एमओएच 1–2) ने बेहतर फूलों की गुणवत्ता के साथ अधिकतम उत्पादकता दर्ज की। गुलदाउदी में, जीनोटाइप आईआईएचआर 4–8, आईआईएचआर 2–16 और आईआईएचआर 2–13, गमलों तथा क्यारियों में खेती के लिये के लिए आशाजनक पाए गए। नवीन रंगो के लिए रजनीगंधा में पूर्व प्रजनन लाइनों का विकास किया गया। चाइना एस्टर के दो म्यूटेंट आईआईएचआर वी 1 और आईआईएचआर वी 2 को अद्वितीय फूलों के रंग, फूलों के प्रकार, निधानी आयु और कट फ्लावर के लिए उपयुक्त पाया गया। जरबेरा की चार लाइनों को संरक्षित खेती के लिए और दो लाइनों को खुले में खेती के लिए पहचाना गया। *सेंटेला एशियाटिका* के आईआईएचआर–सीए–17 और आईआईएचआर – सीए–18 ने क्रमशः 7368.7 और 6784.0 कि.ग्रा./हे. की उच्च बायोमास उपज दर्ज की, जबकि आईआईएचआर – सीए–23 में अधिकतम एशियाटिकोसाइड (3.96%) था। *बकोपा मोननेरी* में, आईसी– 284992 और आईसी– 410932 ने उच्च बैकोसाइडए सामग्री क्रमशः 2.54 और 2.48% दर्ज की। *एक्लिप्टा अल्बा* में, वेडेलोलैक्टोन, पत्तियों (2.84%), फूलों (0.034%), तना (0.008%) और जड़ों (0.0003%) में अनुमानित किया गया था। कालमेघ सेलेक्शन एपी सेल 1 में उच्चतम पत्ती एण्ड्रोग्राफोलाइड (5.53%) और उसके बाद एपी सेल 2 (5.16%) में दर्ज की गई।

फसलोत्पादन

बागवानी फसलोत्पादन के दृष्टिकोण में मुख्य विकास यहाँ संक्षेप में प्रस्तुत किए गए हैं।

आम में फल विकास के चरणों में पुष्पगुच्छ खिलने, मटर के दाने और कंचे के आकार के समय, ट्राईकॉन्टानॉल (3–5 पीपीएम) के तीन पर्ण छिड़काव द्वारा फलों को गिरने से बचाया जा सकता है। अमरूद में फसल चक्र के दौरान 60% वाष्पीकरण पुनरावृत्ति के बराबर ड्रिप सिंचाई, 11.48 किलो/मी.3 की उच्च जल उपयोग दक्षता के साथ, 23% सिंचाई पानी की बचत और 2.40 के लाभ लागत अनुपात के साथ दर्ज कराई है।अति उच्च घनत्व (2 x 1.5 मीटर) में प्रति हेक्टेयर उपज, उच्च घनत्व पद्धति (3 x 2.5 मीटर) से 26.9–37.5 % अधिक थी। अंगूर की किस्म रेड ग्लोब में,प्रूनिंग के बाद प्रति बेल 30 कैन की अवधारण और आगे की छंटाई के बाद प्रत्येक बेल पर 30 गुच्छों के साथ 13 पत्तियों को बनाए रखने पर औसत गुच्छा वजन (517 ग्रा.) बढ़ा।अंजीर में रूटस्टॉक के अध्ययन से पता चला है कि एक्सेल और कोनडारिया को ब्राउन तुर्की पर कलम बांधने से पौधों की वानस्पतिक शक्ति,शाखाओं में विभाजन और फल अधिक लगते हैं। मासिक अंतराल पर फूलों की अवधि (अप्रैल से जून) के दौरान जीए3 का 150–200 पीपीएम की दर से तीन पर्ण छिड़काव, सीताफल की किस्म अर्का नीलाचल विक्रम में फलों के लगने,उपज और फलों की गुणवत्ता के मापदंडों में सुधार के लिए प्रभावी था। भुवनेश्वर परिस्थितियों के तहत सीताफल में फूलों के मौसम को आगे बढ़ाने के लिए कृत्रिम पत्रपात (रासायनिक या मैनुअल) अप्रभावी था।

पपीते में, ग्राफ्टेड पौधों ने जमीन से 55 सेंटीमीटर की ऊंचाई पर रोपण के 3 महीने के भीतर कलियों का उत्पादन किया,जबकि अंकुरित पौधे वानस्पतिक चरण में ही वृद्धि करते रहें। चीकू में, एसिड लाईम का अंतर – फसल, उत्पादन और 1.86 लागत :अनुपात के साथ लाभदायक था। उन्नत परिपक्व अवस्था (एंथेसिस के 16 सप्ताह बाद) को उच्चतम फल गुणवत्ता विशेषताओं जैसे कि कुल घुलनशील ठोस पदार्थ, कुल घुलनशील ठोस पदार्थ/अम्ल अनुपात, शर्करा की मात्रा, शर्करा अम्ल अनुपात और एंटीऑक्सीडेंट संपत्ति के साथ चिह्नित किया गया था; इसलिए यह अनानास के लिए एक आदर्श फल तुड़ाई के चरण के रूप में माना

जाता था ताकि अधिकतम प्राप्य गुणवत्ता सुनिश्चित हो सके। कमलम फलों के पौधों का प्रदर्शन पौधों की वृद्धि और उपज के संदर्भ में संरक्षित स्थिति की तुलना में खुले खेती में बेहतर था। कें.बा.प.कें., भुवनेश्वर में एक फल–आधारित बहु–मंजिला प्रणाली (आम + कमलम फल + अनानास) विकसित की गई है।

टमाटर की किस्म अर्का सम्राट को बीएन 10–2 पर कलम बांधने से अर्का सम्राट द्वारा (122 टन/हे.), हवाई 7996 पर कलम बांधने (110.0 टन/हे.) की तुलना में अधिक उपज प्राप्त हुई थी। टमाटर के जंगली एक्सेशन एल ए– 2157 ने अधिकतम नत्रजन उपयोग दक्षता दर्ज की जिसके बाद आईआईएचआर– 1940 का स्थान था। मिर्च की किस्म अर्का हरिता को आईआईएचआर 3226 पर पर कलम बांधने से सबसे अधिक उपज (36.69 टन/हे.) प्राप्त हुई। एक्सेशन आईआईएचआर–बी–एचपी 130 को अत्यधिक प्रतिरोधी (95.65%) के रूप में पहचाना गया और शिमला मिर्च की किस्मों के लिए प्रतिरोधी मूलवृंत के रूप में इस्तेमाल किया गया था। तुरई की किस्म अर्का विक्रम में पोषक तत्वों की मात्रा (150:90:150 कि.ग्रा. नत्रजन: फास्फोरस:पोटाश/हे.) को पानी में घुलनशील उर्वरकों के माध्यम द्वारा देने से उच्च पैदावार (45.6 टन/हे.) प्राप्त हुई। एकीकृत पोषक तत्व प्रबंधन में गोबर की खाद,रासायनिक उर्वरकों और पौध संरक्षण रसायनों के उपयोग से तुरई की किस्म अर्का प्रसन में अधिक उपज (27.1 टन/हे.) प्राप्त हुई । बेल वाली सेम की किस्म अर्का सुकोमल में पानी में घुलनशील उर्वरकों के माध्यम से पोषक तत्वों के द्वि–साप्ताहिक अनुप्रयोग के परिणामस्वरूप अधिक पैदावार हुई। पालक में, गोबर की खाद के माध्यम से अनुशंसित नत्रजन के 100% प्रतिस्थापन से 21.7 टन/हे. की उच्चतम उपज दर्ज की; जबकि सुरक्षित सब्जी उत्पादन विधि में 11.8 टन/हे. उपज दर्ज की गई थी।

गुलाब में, नत्रजन और फास्फोरस अधिग्रहण दक्षता (31%) *आर. मल्टीफ्लोरा* रूटस्टॉक में अधिक थी, जबकि नटाल बरार में पोटाश अधिग्रहण दक्षता (33%) सबसे अधिक थी। पोषक तत्व उपयोग दक्षता (1.76 फूल डंठल प्रति ग्रा. पोषक तत्व), नटाल बरार मूलवृंत पर अर्का स्वदेश के कली लगाने से मिली थी। खुले खेत में कट फ्लावर की खेती (रुपए 2.58 प्रति रु. निवेश) की तुलना में फूलों की खेती (रुपए 3.66 प्रति रु. निवेश) शुद्ध लाभ के साथ अत्यधिक लाभदायक थी। रजनीगंधा की किस्म अर्का प्रजवल में 150:75:125 कि.ग्रा. नत्रजन: फास्फोरस:पोटाश/हे./वर्ष की दर से देने पर 1.0 सेमी व्यास के बल्बलेट से बल्ब का तेजी से गुणन कर प्रवर्धन चक्र को छोटा किया जा सकता है। क्रॉसेंड्रा की किस्म अर्का श्रेया में, वानस्पतिक वृद्धि के दौरान 1.0 वाष्पीकरण प्रतिपूर्ति (ईआर) पर ड्रिप सिंचाई और फूलों के चरणों के दौरान 1.2 ईआर पर ड्रिप सिंचाई + 75% उर्वरक की संस्तुत मात्रा (90:60:180 कि.ग्रा. नत्रजन:फास्फोरस:पोटाश/हे./वर्ष) देने पर फूल का उत्पादन (8.84 टन/हे.) प्राप्त हुआ। पुष्प फसलों के लिए पॉट कल्चर तकनीकों के मानकीकरण से पता चला कि गेंदे की किस्म अर्का परी को 6 " के प्लास्टिक गमलों में अर्का किण्वित कोकोपीट (एएफसी) + वर्मीकम्पोस्ट (1:1 वी/वी) और पोषक तत्व घोल (128:24: 144 पीपीएम नत्रजन:फास्फोरस:पोटाश) के साप्ताहिक अनुप्रयोग के सब्सट्रेट संयोजन के साथ उगाने पर सर्वाधिक फूलों की संख्या प्राप्त हुई है। क्रॉसेंड्रा की किस्म अर्का चेन्ना पर 6" के प्लास्टिक गमलों में रोपाई के एक महीने बाद 20 पीपीएम पैक्लोब्यूट्राजोल का पर्ण छिड़काव किया गया जिसके परिणामस्वरूप अधिकतम फूलों की संख्या प्राप्त हुई। अर्का किण्वित कोकोपीट (एएफसी) और जले हुए मिट्टी के गोले (एलईसीए) के साथ 3:1 अनुपात में सब्सट्रेट माध्यम ऊर्ध्वाधर उद्यान के लिए आदर्श माध्यम पाया गया।

धान के पुआल सब्सट्रेट पर मशरूम *मैक्रोसीबे गिगेंटिया* की उत्पादन तकनीक को मानकीकृत किया गया। मकई ठूंठ पाउडर के पूरक मिश्रण पर *हेरिसियम एरिनेसियस* का फ्रक्टिफिकेशन परीक्षण किया गया था। लौह संबल एल्म ओएस्टर मशरूम के उत्पादन के लिए प्रौद्योगिकी का मानकीकरण किया गया, जिससे लौह सामग्री 185.6% बढ़ गई। पोटेशियम सिलिकेट और ओ–सिलिकिक एसिड के 4 मि.ली. प्रति लीटर पर्ण छिड़काव ने शिमला मिर्च में उपज में काफी वृद्धि की। मृदा रहित खेती के संबंध में, अर्का किण्वित कोकोपीट पर लगाए गए बैगन के पौधों में, पौधों की अधिकतम ऊंचाई, पत्तियों की संख्या, कुल पौधे सूखे बायोमास,फलों की संख्या,फलों की लंबाई,फलों की मोटाई, फलों के वजन व उपज मृदा में खेती की तुलना में ज्यादा मिली। जैव जीवाणु रोधी सब्जियों के बीजों के उत्पादन के लिए राइजोबैक्टीरियल उपभेदों का उपयोग किया गया था। भिंडी में यह देखा गया कि नमी युक्त सेल बैक्टीरियल कंसोर्टियम के साथ फिल्म कोटिंग या एनहाइड्रोबायोटिक रूप से सूखे बैक्टीरिया कंसोर्टियम के साथ फिल्म कोटिंग उपज और पोषक तत्वों के लिए एक दूसरे के बराबर थे। गुलाब का मूलवृंत *आर. मल्टीफ्लोरा* और *आर. इंडिका* की प्रजाति पुष्कर और चैत्री ने खारापन और क्षारीयता की स्थिति में बेहतर प्रदर्शन किया। अर्का हर्बिवैश, पूर्णतया वानस्पतिक सूखे उत्पादों से तैयार किया गया है और इसमें कोई कृतिम रसायन या पदार्थ का उपयोग नहीं किया गया है। यह सब्जियों और फलों के धोने के लिए पूर्णतया सुरक्षित है।

फसल सुरक्षा

आम में चूर्ण आसिता पर कृत्रिम इनोक्यूलेशन अध्ययनों में, अल्फोंसो को सभी चरणों में चूर्ण आसिता के संक्रमण के लिए अतिसंवेदनशील पाया गया और रोग का प्रसार लज्जत बक्श की तुलना में तेजी से हुआ। चूर्ण आसिता प्रकोप के साथ सापेक्ष आर्द्रता (पूर्व 7 दिनों का औसत) के बीच एक सकारात्मक सहसंबंध (आर = 0.68), लेकिन तापमान के साथ एक नकारात्मक सहसंबंध (आर = −0.52) था। आम के फल छेदक *सिट्रिपिस्टिस यूट्राफेरा* की रोकथाम के लिए कीटनाशक और वनस्पति तत्व के एक स्प्रे मॉड्यूल का मानकीकरण किया गया है। ओलूर (21.5%) की तुलना में वैल्लिकोलंबन मूलवृंत (33.5% संचयी क्षति) पर कलम किए गए अल्फांसो में तना छेदक का संक्रमण अधिक था। *सिडियम कैटलियानम* ने *मेलोइडोगाइने इकागनीटा* के प्रति बिना किसी भी गॉल के प्रतिरक्षा प्रतिक्रिया दिखाई।

अमरूद के तना छेदक कीट के प्रबंधन के लिए कीटनाशक (लैम्ब्डा साइहलोथ्रिन 1 मि.ली. प्रति लीटर पर्ण छिड़काव) और आईआईएचआर नीम साबुन 10 ग्राम प्रति लीटर पर्ण छिड़काव प्रभावी और सुरक्षित था। पपीता में फैले एफिड्स और पीआरएसवी की जनसंख्या की गतिशीलता से पता चला है कि एफिड आबादी में अधिकतम और न्यूनतम तापमान और हवा की गति के साथ सकारात्मक सहसंबंध, और वर्षा और सापेक्ष आर्द्रता के साथ नकारात्मक सहसंबंध है। पपीते में आइएसआर / एसएआर के तंत्र का सागरिका, एक्टिनोप्लस, *बी. एमिलोलिक़ासिएन्स* और काओलिन के साथ उपचार करने से एंजाइमों पीओडी, एसओडी, पीएएल और पेरोक्सीडेज की गतिविधि में वृद्धि हुई और सैलिसिलिक एसिड का स्तर बढ़ गया।पपीते की किस्म अर्का प्रभात का रूपांतरण किस्पर / सीएस 9 के लिए ने ईआईएफ 4 ई जीन को लक्षित करने वाले पपीते की मध्यस्थता जीनोम संपादन का प्रयास किया है। लीची *(लीची चिनेंसिस)* और एवोकैडो *(पर्सिया एमेरिकाना)* में कीट परागण विविधता निर्धारित की गई थी। एवोकैडो के स्कैब और एंथ्रेक्नोज रोगों के विरुद्ध, सात प्रणालीगत कवकनाशी का मूल्यांकन कृत्रिम परिवेशीय में किया गया था।

फ्रूट चैफर बीटल, जिसे *प्रोएटेटिया अल्बोगुटाटा* (विगर्स) (कोलॉप्टेरा: स्कारेबिडे: सीटोनीनी) के रूप में पहचाना जाता है, अंजीर (*फाइकस कैरिका* एल.) पर दर्ज किया गया। अंजीर में तना छेदक के प्रतिरोध के लिए विविधता / मूलवृंत मूल्यांकन से पता चला कि पूना कम से कम अतिसंवेदनशील (7.40%) था और प्रतिरोधी माना जाता था। ट्राइकोडर्मा की इन विट्रो स्क्रीनिंग में जेएल 5, जीजे 16 बी, एलए और *बेसिलस सबटिलिस* को *अल्टरनेरिया* सोलानी (टमाटर के अगेती अंगमारी का कारक) के खिलाफ दोहरी परख के माध्यम से, रोगज़नक़ के निषेध पर वाष्पशील कार्बनिक यौगिकों (वीओसी) की भागीदारी दिखाई गई। टमाटर पिन वर्म *टुटा एब्सोलूटा* के एकीकृत प्रबंधन पर काम किया गया।एक स्टेप आर.टी.लैम्प का उपयोग अद्वितीय न्यूक्लिक एसिड प्रवर्धन परख के लिए किया गया था जिसे रिवर्स ट्रांसक्रिप्शन (आर.टी.) कहा गया जो चीवीएमवी की विशिष्ट और संवेदनशील पहचान के लिए विकसित किया गया था।

वेक्टर जनित वायरस के एकीकृत रोग प्रबंधन में वेक्टर आबादी और वायरस की घटनाओं का अध्ययन किया गया। पॉलीवायरस के प्रतिरोध के लिए मिर्च में पुनरावर्ती प्रतिरोध ईआईएफ 4 जीन के जीनोम संपादन का प्रयास किया गया था। एस जीआर एन ए, इआइ4एफई 428 आरएनए घुसपैठ वाले पौधों ने पॉटीवायरस का प्रतिरोध दिखाया है। बैंगन में, बीज उपचार (10 मि.ली.प्रति किलो बीज), नर्सरी उपचार (50 मि.ली. प्रति वर्ग मीटर), मृदा अनुप्रयोग (गोबर की खाद के 5 टन प्रति हे., 5 लीटर में समृद्ध) और मृदा ड्रेंचिंग (5 मिली प्रति लीटर), *बेसिलस मेगाटेरियम* –1% ए.एस. के साथ 30–दिन के अंतराल पर उपचार करने से मृदा एवं जड़ की सूत्रकृमि जनसंख्या काफी कम हो गई ।

खीरा में एकीकृत वायरस रोग प्रबंधन, मक्का के साथ बॉर्डर क्रॉपिंग की दो पंक्तियाँ, परावर्तक मल्च की स्थापना, नीली और पीली चिपचिपी ट्रैप, नीम का तेल 3 मि.ली. प्रति लीटर, अर्का माइक्रोबियल कंसोर्टियम 20.0 ग्राम प्रति लीटर, अर्का सब्जी विशेष 3 ग्राम प्रति लीटर, फिप्रोनिल 1 मि.ली. प्रति लीटर , थायोमेथोक्साम 0.5 ग्राम प्रति लीटर और डाइमेथोएट 2 मिली प्रति लीटर की दर से साप्ताहिक आधार पर छिड़काव करने से वायरस से फसल की (95% तक) रक्षा हुई इसके विपरीत सामान्य फसल में वायरस से फसल का नुकसान (60–90%) प्रतिशत हुआ। खीरा में एकीकृत सूत्रकृमि प्रबंधन के लिए, रोपण से 45 दिन पहले अफ्रीकी गेंदा की बुवाई + जैव उत्पादों *बी. सबटिलिस, बी. प्यूमिलस* और *बी. एमाइलोलिक़ैसिअन्स* (प्रत्येक 2.0 कि. ग्रा.) से संवर्धित नीम की खली (1.0 टन प्रति हेक्टेयर) + जैव कारकों से संवर्धित 10% नीम खली की ड्रेंचिंग, 30 दिनों में एक बार उपयोग करने पर *एम. इनगनिटा* की संख्या (जड़ों और मिट्टी में 70.8–76.1 % कम) सुझाव दिया गया है।पॉली हाउस के अंदर उगाई जाने वाले खरबूजा (अर्का सिरी)और खीरा में परागण के लिए दो देसी मधुमक्खियों की प्रजातियों *एपिस सिराना* और डंक रहित मधुमक्खी, *टेट्रागोनुला इरीडिपेनिस* के उपयोग की विधि का मानकीकरण किया गया है। *फाइटोप्थोरा मेलोनिस* की पहचान रोगज़नक़ के रूप में की जाती है,जो राइबोसोमल आंतरिक उत्कीर्ण

स्पेसर क्षेत्रों के डीएनए अनुक्रम विश्लेषण के साथ–साथ रूपात्मक, सांस्कृतिक और रोगजनक वर्णों के आधार पर परवल के कॉलर और रूट रोट का कारण बनता है। मोरिंगा में टी मोस्क्यूटो बग के प्रबंधन के लिए, नीले रंग के चिपचिपी ट्रैप (2.37±0.750.75) की तुलना में वयस्क *एच. एंटोनी* की उच्च संख्या को आकर्षित करने के लिए पीले रंग के चिपचिपे ट्रैप(7±2.26) उचित पाए गए। सीताफल के बीज से तैयार उत्पाद, करेला में एफिड्स (*एफिस क्रैसीवोरा*), *माइसस परसीके* और *स्कारोथ्रिप्स डोरसालिस,* और मिर्च और शिमला मिर्च के सफेद मक्खी (*बेमिसिया तबसी*) के विरुद्ध प्रभावी पाया गया है।

अनुक्रम विश्लेषण डेटा का उपयोग करते हुए, सजावटी फसलों में 23 में से 19 फाइटोफ्थोरा आइसोलेट *पी. निकोटियाना* के रूप में पहचाना गया है, जिसमें न्यूक्लियोटाइड की पहचान >98% है। क्रॉसैंड्रा की किस्म/लाइन एम4, *एम. इनकोगनीटा* के लिए प्रतिरोधी और अर्का अंबारा मध्यम प्रतिरोधी है। बायोकंट्रोल बैक्टीरिया, *बेसिलस प्यूमिलस* आईआईएचआर बीपी 2 के साथ ग्लेडियोलस कॉर्म (अर्का आयुष) के उपचार ने मूल गाँठ सूत्रकृमि की जनसंख्या को कम किया। मृदा के जैव जीवाणुओं से समृद्ध गोबर की खाद का अनुप्रयोग, *बी. एमाइलोलिक़्फ़ैसिएन्स* @ 5.0 टन प्रति हेक्टेयर रोपने से पहले, उसके पश्चात जैव कारकों से समृद्ध नीम की खली 2.0 लीटर प्रति वर्ग मीटर की दर से 3 महीने के अंतराल में मिट्टी में डालने से जरबेरा (अर्का अश्व) में *मेलोइडोगाइन इनकोगनीटा* की जनसंख्या मिट्टी में 69.4% घटी और स्पाइक उपज में 20.3% की वृद्धि हुई। पांच गेंदे की किस्में /लाइनों के रूट एक्सयूडेट ने 62.8–91.9% अंडे सेने को दबा दिया और *एम. इनकोगनीटा* की 38.9–69.7% मरण का कारण बना। एस्टर में *हिरिशमोनस फाइसिटिस* द्वारा एस्टेर येलो के संचरण की पुष्टि की गई। पॉलीहाउस में किवांच फलियां उगाना और बुवाई के 45 दिन बाद इसके अवशेषों को भूमि में मिलाने से मिट्टी में पौधे परजीवी सूत्रकृमि की संख्या को को 49.1–61.9% तक कम कर दिया।

फसल उपयोग और फार्म मशीनीकरण

गर्म पानी के उपचार के साथ संगरोध विकिरण उपचार (400 Gy) का एकीकरण (5–10 मिनट के लिए 52–55°C) से अल्फांसो की आंतरिक गुणवत्ता पर कोई प्रतिकूल प्रभाव नहीं पड़ा। आम के संकर अर्का उदय से प्रोटीन फोर्टीफाइड फ्रूट रोल, व्हे प्रोटीन कॉन्सेंट्रेट (WPC, 2 और 5%) का उपयोग करते हुए बिना चीनी के बनाया गया। अनार जीनोटाइप चयन ए4/ 2, दोनों – ताजे और निर्जलित अधिचोल के लिए उपयुक्त पाया गया। निर्जलित अधिचोल अच्छे स्वाद के साथ गहरे लाल रंग के होते हैं और 24% की वसूली करते हैं। प्रोबायोटिक अनानास के रस की तैयारी प्रक्रिया को मानकीकृत किया गया और प्रोबायोटिक के रस में प्रशीतित तापमान पर दो महीने का निधानी आयु होती है। औषधीय पौधे सेंटेला एशियाटिक से एक पेय को मानकीकृत किया गया है; भंडारण के दौरान गुणवत्ता मूल्यांकन में कुल पॉलीफेनोल सामग्री 90.87 और 146.25 मि.ग्रा. जीएई प्रति 100 ग्रा. के बीच और डीपीपीएच गतिविधि 0.142 और 0.279 मि.ग्रा. एईएसी प्रति ग्रा. के बीच पता चला। मटर की किस्म अर्का अपूर्वा ने उच्चतम कुल पॉलीफेनोल सामग्री (17.67 मि.ग्रा. जीएई प्रति 100 ग्रा.) और अर्का कार्तिक ने उच्चतम कुल क्लोरोफिल सामग्री (0.11 मि.ग्रा. प्रति 100 ग्रा.) को बरकरार रखा। सीताफल बीज और बीज के तेल के कीटनाशक गुणों को जैव सक्रिय यौगिकों, एसिटोजेनिन में से एक के लिए जिम्मेदार ठहराया गया है।

ताजा कटे हुए अनानास के निधानी आयु का विस्तार करने के लिए उपयुक्त निष्क्रिय और सक्रिय संशोधित वातावरण पैकेजिंग (एमएपी) को अनुकूलित किया गया था। अमरूद के फलों को गैर–छिद्रित पीपी–फिल्म का उपयोग करके पैक 1– एमसीपी के 500 पीपीबी और एमए में 12 डिग्री सेल्सियस पर 3 सप्ताह के लिए रखा जा सकता है। 1–एमसीपी एक्सपोज़र के साथ खरबूज के गुणवत्ता को प्रभावित किए बिना, भंडारण जीवन को 10 डिग्री सेल्सियस पर 2 सप्ताह की तुलना में 3 सप्ताह तक बढ़ाया जा सकता है । क्रॉसेंड्रा किस्म अर्का श्रेया, फूलों की कटाई आधे खुले चरण में की जाती है, जिन्हें कटाई के बाद 5 दिनों तक संग्रहीत किया जा सकता है, और तीन चौथाई तथा पूरी तरह से खुले फूलों को चरणों में 4–5 डिग्री सेल्सियस पर, 4 दिनों तक संग्रहीत किया जा सकता है। प्राकृतिक एडिटिव्स के साथ धान के पुआल से विकसित बायोडिग्रेडेबल, खाद्य ग्रेड कोटिंग से लेपित प्लेट्स की मोटाई, 1.93 मिमी और घनत्व 0.14 ग्राम / से मी3 था। एक ट्रैक्टर संचालित क्यारी बनाना सह प्याज बल्ब बोने की मशीन और एक इंजन संचालित मिर्च हारवेस्टर को संस्थान में डिजाइन और विकसित किया गया।

सामाजिक विज्ञान

किसानों से नमूना डेटा संग्रह के आधार पर अमरुद की खेती के लिए कुल लागत पर रु. 1,18,986.40 प्रति एकड़ पाया गया । कटाई के बाद के नुकसान (पीएचएल) ने विपणन दक्षता पर प्रतिकूल प्रभाव डाला। अमरूद में उच्च घनत्व रोपण (HDP) की स्थापना लागत 3 मी. x 3 मी. और 4 मी. x 4 मी. के लिए क्रमशः रु.1,79,640 रुपये प्रति एकड़ और रु. 1,21,400 प्रति एकड़ अनुमानित की

गई। अमरूद के उच्च घनत्व रोपण प्रणाली, 3 मी. x 3 मी में वार्षिक रखरखाव की लागत. रु. 3,84,474 प्रति एकड़, जबकि 4 मी. x 4 मी. में रु 2,34,947 प्रति एकड़ थी, जो कि उच्च घनत्व रोपण प्रणाली में कम रिक्ति के लिए 74% अधिक लागत का संकेत देती है । उच्च घनत्व रोपण प्रणाली में लाभ: लागत (ऑ:इ) अनुपात 3 मी. x 3 मी. और 4 मी. x 4 मी. में क्रमशः 2.40 और 2.23 था। दूर के बाजारों में अमरूद की बिक्री सबसे लाभदायक रणनीति के रूप में सामने आई।

केले के बहु–स्थान परीक्षणों में स्थिरता विश्लेषण के लिए बहु–आयामी स्केलिंग दृष्टिकोण पर काम किया गया। चार अलग–अलग सब्जियों की फसलों से विभिन्न स्थानों से संबंधित डेटा को विभिन्न स्थानों में भा.बा.अनु.सं. प्रविष्टियों की उपयुक्तता की पहचान करने के लिए बहु–स्थान परीक्षणों के लिए फसल स्थिरता मॉडल विकसित किया गया । करौंदा परिग्रहण में किए गए प्रमुख घटक विश्लेषण इस फसल पर भविष्य में काम करने वाले प्रजनकों के लिए एक उपयोगी उपकरण होगा, जो लक्षण वर्णन, जीनोटाइप पहचान और माता–पिता के चयन के लिए काम करेंगे। आम में 0.83 (त्वचा का वजन) से 0.998 (पत्थर के वजन) की सीमा में आनुवांशिकता के उच्च अनुमान ने संकेत दिया कि प्रत्येक किस्म के लिए प्रजनन योग्य सूचना के आधार पर प्रजनन मूल्यों का अनुमान लगाने और तुलना करने के लिए सर्वश्रेष्ठ रैखिक निष्पक्षता (BLUP) दृष्टिकोण उपयोगी है। 32 लक्षण (रूपात्मक, रासायनिक, फूल, फल और बीज लक्षण) के आधार पर 21 जामुन एक्सेशन के लिए किए गए विविधता विश्लेषण से पता चला कि बीज की लंबाई अकेले 90.9% परिवर्तनशीलता के लिए योगदान करती है। एलडी 50 मूल्यों का अनुमान लगाने के लिए तीन रूटस्टॉक्स अर्थात, बप्पाकाई, नेकराई और कुरुकान के अंकुरण प्रतिशत के लिए प्रोबेट मॉडल का निर्माण किया गया। विचरण के घटक (जीसीवी, पीसीवी, एच2, जेनेटिक एडवांस,% के रूप में जेनेटिक गेन) 49 टमाटर विविध स्टॉक के लिए काम किया गया। नॉनलीनियर प्रतिगमन मॉडल रोग प्रगति वक्र (AUDPC) के तहत क्षेत्र की गणना करने के लिए विकसित किए गए थे और उच्चतम AUDPC मूल्य को ऊटऋ लृलृऋृढ–1 आइसोलेट के साथ पिंक फ्रेंडशिप में दर्ज किया गया ।

तरबूज और फ्रेंच बीन की खेती के लिए मोबाइल ऐप विकसित किए गए और स्मार्ट फोन के लिए फलों और सब्जियों के मोबाइल ऐप के साथ एकीकृत किया गया, जिसे गूगल प्ले स्टोर से स्थापित किया जा सकता है। वेब आधारित निर्णय समर्थन प्रणाली सभी प्रमुख फूलों की फसलों जैसे कार्नेशन, चाइना एस्टर, गुलदाउदी, क्रॉसेंड्रा, जरबेरा, ग्लेडियोलस, चमेली, गेंदा, गुलाब, रजनीगंधा आदि के लिए डिज़ाइन की गई। तरबूज कली परिगलन (डब्लूबीएनबी) रोग के लिए सिमुलेशन मॉडल और ग्राफिकल यूजर इंटरफेस (जीयूआई) विकसित किए गए।

अमरूद के कुल फसल क्षेत्र में संकर अर्का किरण ने आंध्र प्रदेश, महाराष्ट्र और तमिलनाडु में क्रमशः 0.98%, 0.17% और 0.68% पर कब्जा किया। अर्का सहन का फैलाव कुल सीताफल क्षेत्र में कर्नाटक में 9.78% और तमिलनाडु में 12.5% था। भा.कृ.अनु.प.–भा.बा.अनु.सं. द्वारा जारी बैंगन और मिर्च संकर किस्म के किसानों के खेतों में किए प्रभाव अध्ययन से पता चला कि निजी संकर की तुलना में, बैंगन में अर्का आनंद में उपज (11%) में सुधार देखा गया और मिर्च में अर्का मेघना और अर्का हरिता में 5–10% उपज वृद्धि देखी गई। निजी संकर किस्म (2.90 – 3.17) की तुलना में उच्चतम लाभ: लागत अनुपात भा.कृ.अनु.प.–भा. बा.अनु.सं. की मिर्च संकरों (3.2–3.55) में देखा गया। किसानों के बीच भा.कृ.अनु.प.–भा.बा.अनु.सं. क्रॉसेंड्रा किस्मों के प्रसार और स्वीकृति पर किए गए अध्ययन ने संकेत दिया कि 75% से अधिक किसानों ने अर्का चेन्ना और उसके बाद अर्का श्रेया (25%) और अर्का अंबरा (25%) को स्वीकार किया।

कर्नाटक के दो जिलों में एकीकृत कृषि प्रणालियों में बागवानी हस्तक्षेप के माध्यम से छोटे और सीमांत किसानों की लाभप्रदता को बढ़ाने के लिए कदम उठाए गए। कोविड लॉकडाउन अवधि के दौरान बागवानी उत्पादों के विपणन में शामिल औपचारिक और अनौपचारिक संस्थानों और किसानों की भूमिका का आंकलन करने के लिए और इसके समान स्थितियों के दौरान बागवानी उत्पादन के सफल संचालन के लिए रणनीतियों का सुझाव देने के लिए एक परियोजना शुरू की गई। विभिन्न सफल मॉडलों के विश्लेषण के आधार पर, एक आम रणनीतिक मॉडल की पहचान की गई, जिसे कोविड– 19 लॉकडाउन अवधि के समान स्थितियों के दौरान बागवानी उत्पादन के विपणन के लिए किसानों को औपचारिक और अनौपचारिक संस्थानों द्वारा प्रभावी भूमिका निभाने के लिए सुझाव दिया जा सकता है।

उपरोक्त भा.कृ.अनु.प.–भा.बा.अनु.सं. द्वारा वर्ष 2020 की उपलब्धियों की एक झलक है। इसके बारे में अधिक विस्तृत जानकारी देने के लिए, हम निम्नलिखित अध्याय में आपका स्वागत करते हैं।

2. Executive Summary

The brief summary of salient achievements of ICAR-IIHR during the year 2020 is described below.

The Institute is an important nodal centre for management of plant genetic resources of horticultural crops in the country as it is identified as National Active Germplasm Site (NAGS) for several horticultural crops. As part of long-term program on germplasm exploration and collection, the germplasm at ICAR-IIHR, Bengaluru, was enriched with 27 primary and 13 secondary germplasm of fruit crops. The avocado germplasm at CHES, Chettalli, was enriched by 53 collections. In case of vegetable crops, the germplasm collection in 2020 included 77 germplasm lines in drumstick, 60 in cucumber, 33 in summer squash, 27 in okra, 24 in chilli, 17 in curry leaf and 16 each in bell pepper and dolichos bean. Additional 59 germplasm were added to total germplasm strength of flower crops in crops like tuberose (1), gladiolus (12), gerbera (16) and dahlia (30).

Avocado accessions (*n*=53) collected from Karnataka, Kerala and Tamil Nadu are conserved at CHES (ICAR-IIHR), Chettalli. In Chilli, ten wild accessions of *Capsicum chinense* and *C. frutescens* collected from Andaman & Nicobar Islands and NE India were domesticated and conserved. In brinjal, six wild species (*Solanum torvum, S. gilo, S. indicum, S. macrocarpon, S. mammosum* and *S. seaforthianum*) were raised for maintenance. In okra, nine wild species are maintained and utilized in resistance breeding program in the net house. Three wild species of cucumber namely *Cucumis hardiwikii, C. metuliferous* and *C. hystrix* are conserved and utilized for breeding program. Alternatively, the germplasm of vegetables crops *viz*., chilli (140), brinjal (42), legume vegetable (165), amaranthus (285), drumstick (86), edible leafy vegetables (30), pointed gourd (69) are maintained at CHES, Bhubaneshwar.

Among 13 rose species characterized for their potential in breeding program, only *Rosa multiflora* flowered under Bangalore conditions. Different species of marigold *viz.*, *Tagetes erecta, T. patula* and *T. minuta* were collected and maintained in marigold germplasm. A total of 100 chrysanthemum germplasm are conserved and multiplied in field gene bank. A total of 28 germplasm is being conserved in cold room, multiplied and maintained; IC numbers were obtained for 12 germplasm. About 28 accessions of *Centella asiatica* and 31 accessions of *Gymnema sylvestre* are conserved in the field gene bank. The total germplasm number is 155 in *Eclipta alba and* 71 in *Bacopa monnieri*. The IC numbers were obtained for 36 accessions in *Eclipta alba*, 30 in *Aloe vera* and 2 in *Mucuna pruriens*. Two wild mushrooms were tissue cultured, purified, spawn prepared and at present are under fruiting trial for culture validation. The initial viability of cryopreserved pollen of *Vasconcellea cundinamarcensis* was 76% in comparison to fresh pollen (78%).

The characterization of 38 germplasm lines of French bean indicated that the pod yield per plant ranged from 34 to 241 g, while two lines (IIHR-17 and IIHR-33) showed field resistance to rust. The evaluation of 33 germplasm lines of cowpea, three lines *viz*., IIHR-15, IIHR-28 and IIHR-65 showed field resistance to *Cercospora* leaf spot and cowpea mosaic virus and two lines viz., IIHR-37 and IIHR-91 showed field resistance to aphids. Among 50 germplasm of garden pea evaluated, pod yield per plant ranged from 23.5 (IIHR700) to 80 g (VP-8902) and the accession IIHR-13-4 showed resistance to rust. Among 51 accessions of *Bacopa monnieri*, leaf length varied from 1.30-2.85 cm and leaf width ranged from 0.37-1.53 cm showing considerable variation for leaf size. Floral biology studies revealed that *Eclipta alba* is both self and cross compatible.

Evaluation of 21 jamun genotypes revealed that the fruit weight ranged from 0.5 g (KHA-3) to 8.52 g (Selection-20) and the TSS from 13.3ºB in Selection-20 to 19.66ºB in KHA-14. From farmer's field in Tumkur, jamun genotype that fruits twice in a year (June-July and Nov-Dec) was identified. In jackfruit, three accessions of vegetable type registered average fruit weight of 1650-3152 g with 62-80% moisture and total dietary fibre content of 9-11 g per 100 g FW. *In situ* collections of tamarind pods (*n*=388) were evaluated and the average pulp recovery was estimated at 36.5%. The collections from Telangana had highest pulp recovery of 40.49% followed by Karnataka (39.48%) and Odisha (39.44%). The farmer's accession 'Lakshamana' from Tumkur, Karnataka, had superior yield (251.4 kg pods tree^{-1}), 20% total acidity and 29.78% total sugar in pulp. In bael, fruit yield was maximum in accession 10/3 (73.5 kg per tree, South Indian type) followed by 13/19 (67.3 kg per tree, North Indian type). *In situ* evaluation of five elite trees of rose apple in farmer's field in Bangalore Rural indicated variability in fruit weight (18.5-78 g), fruit size (3.5 cm x 3.6 cm to 5.3 cm x 6.5 cm) and TSS (5 to 8.2°B).

Average fruit yield among 68 genotypes of brinjal varied from 0.40 kg per plant in IIHR-635 to 2.75 kg per plant in IIHR-602. Among 122 germplasm of pole dolichos screened for Dolichos Yellow Mosaic Virus (DYMV) resistance under natural field conditions,

three genotypes namely, IC 556703, IC 556723 and IC 632639 were completely resistant. Dolichos bean variety Arka Krishna (pole type) and Arka Vijay (bush type) showed better stability and selected for further thermo-induction studies. Arka Soumya, Arka Vistar and IIHR-B-DB25 genotypes of dolichos bean were identified with higher cellular tolerance to high temperature. Among 18 accessions of French bean germplasm, IC 632961 reordered highest pod yield of 255 g per plant with dark green colour and flat pod traits, and 18.20 cm pod length. In ridge gourd, fruit yield was maimum in IIHR-158 (230.3 q ha^{-1}) followed by IIHR-164 (212.8 q ha^{-1}) and IIHR-RG-131B (196.5 q ha^{-1}).

Among eight germplasm lines of bitter gourd collected from AVRDC, Taiwan, IIHR-195 recorded maximum fruit yield 32.69 t ha-1 and highest charantin content (1.859 µg g^{-1} DW). Among bitter gourd germplasm selections evaluated for antidiabetic properties, IIHR-191-9 recorded highest charantin content (1.134 µg g^{-1} DW) and IIHR-180-4 recorded highest momordicin content (8.539 µg g^{-1} DW). The genotype BG-155 in bottle gourd registered high marketable fruit yield of 48.53 t ha^{-1} followed by BG-148 (38.45 t ha^{-1}). The ash gourd accession AG-21 recorded maximum yield of 20.15 kg per plant. The genotypes LSR/18/75, LSR/18/8, LSR/18/9 and LSR/18/06-a of curry leaf registered higher fresh leaf yields of 22.4, 21.4, 21.2 and 19.6 kg per plant, respectively. About 20 curry leaf germplasm lines from Tamil Nadu, Karnataka and Odisha, the oil yield varied from 0.11 ml per100 g (LSR/18/162) to 0.63 ml per 100 g (LSR/18/06-b).

In chrysanthemum, the genotypes IIHR4-8, IIHR2-16 and IIHR2-13 were found promising for pot culture and bedding. In China aster, all the Matsumoto series varieties showed dwarf plant stature. The accessions IIHR-CA-17 and IIHR-CA-18 of *Centella asiatica* registered highest biomass yield of 7368.7 and 6784.0 kg ha^{-1} respectively, while IIHR-CA-23 accession had maximum asiaticoside (3.96%). In *Bacopa monnieri***,** the accessions IC 284992 and IC 410932 registered higher bacoside A content of 2.54 and 2.48%, respectively. In *Eclipta alba*, wedelolactone was estimated in leaves (2.84%), flowers (0.034%), stem (0.008%) and roots (0.0003%).

Three mango hybrids (R3P12, R3P16 and R4P18) were selected for better fruit quality parameters. The leaf volatile profiles of the seedlings of three polyembryonic varieties were compared with their respective mother plant. The non-coding RNAs (lncRNAs) identified for high and low TSS cultivars of mango were 33191 and 24706, respectively. lncRNAs identified for high and low acidity varieties were 6393 and 16253, respectively. Gallic acid and protocatechuic acids were the major phenolic acids in pollen and stigma of Alphonso and Amrapali varieties. In general, there was greater expression of flowering genes in Totapuri compared to Alphonso. Wild species of guava (*Psidium friedrichsthalianum*) showed resistance to two isolates of *Fusarium* (GW-10 from Kanpur and GW-G from Guntur) and root knot nematode. *Psidium catellianum* (Lemon guava) tolerated high salinity of 6.18 dS m^{-1}. The progenies of papaya cv Arka Prabhath x *V. cauliflora* (93 progenies out of 1016 F_2) and cv. Arka Prabhath x *V. cundinamarcensis* (198 progenies out of 2328) did not express symptoms of PRSV. The pummelo hybrid R11P9 (3-2 x 19-1) has been selected for low bitterness and sweetness. Pomegranate Selection A 4/2 (open pollinated progeny of Bhagwa developed by individual plant selection) was found promising for quality parameters. A total of 17457 SSR primers were designed using the partial genome sequence data in Jamun.

Among tomato F_1 hybrids, H-505 was found suitable for fresh market and five F_1 hybrids H-501, H-506, PH-1021, PH-1025 and PH-6321 were suitable for indeterminate segment. Tomato wild accession LA - 2157 recorded maximum N use efficiency followed by IIHR – 1940. Five Chilli F_1 hybrid (Arka Tejasvi, Arka Yashasvi, Arka Saanvi, Arka Tanvi, Arka Gagan) were found promising for yield, fruit quality and resistance to ChLCV. Seeds treated with KH_2PO_4 @ 10^{-3} M exhibited higher root/shoot ratio and advancement in germination. Okra hybrid OKH-57 registered highest fruit yield of 29.14 t ha^{-1}. Bottle gourd cv. Arka Nutan and Arka Shreyas are gummy stem blight resistant varieties in cylindrical and club shape segment. Arka Ganga, resistant to Gummy stem blight was developed by crossing resistant parents. Arka Neelanchal Gourav, a Teasel gourd variety (7.82 kg/plant) was identified for commercial cultivation.

Three high yielding marigold F_1 hybrids (male sterile background resulting in male sterile hybrids) with compact flowers having good shelf life were identified. Arka Shubha (MOH 1-2) registered maximum productivity with better flower quality. Pre breeding lines were developed in tuberose for novel colour. Two China aster mutants IIHRV1 and IIHRV2 were found promising for unique flower colour, flower type, vase life and suitable for cut flower. Four gerbera lines were identified for protected cultivation and two lines for open-field cultivation. In *Centella asiatica*, polyploid IIHR-CA-28 was superior for fresh biomass yield (5900 kg ha-1). Kalmegh Selection AP Sel 1 recorded highest leaf andrographolide content (5.53%), followed by AP Sel 2 (5.16%).

The production approaches for horticultural crops are

standardized. Three foliar sprays of triacontanol (3-5 ppm) at panicle initiation, pea and marble stages of fruit growth was effective for reducing fruit drop in mango. Drip irrigation equivalent to 60% evaporation replenishment throughout the crop cycle registered higher water use efficiency of 11.48 kg m^{-3} with 23% saving of irrigation water and benefit cost ratio of 2.40 in guava. The per hectare yield in ultra high density system (2 x 1.5 m) was higher by 26.9% -37.5% over high-density system of 3 x 2.5 m spacing. Retention of 30 canes per vine after back pruning and maintaining 13 leaves on each cane with 30 bunches per vine after forward pruning increased the average bunch weight (517 g) in grapes cv Red globe. Rootstock studies in fig showed that the vegetative vigour, branching and fruiting of Excel and Conadria scions during fourth orchard year were more when grafted on Brown Turkey. Three foliar sprays of GA_3 @ 150-200 ppm during flowering period (April to June) at monthly intervals was effective for improving fruit set, yield and fruit quality parameters in Annona cv Arka Neelachal Vikram. The artificial defoliation (chemical or manual) was ineffective for advancing the flowering season in annona under Bhubaneswar conditions.

In papaya, grafted plants produced flower buds within 3 months after planting at 55 cm height from the ground while the seedling plants continued to grow in vegetative phase. In sapota, intercropping of acid lime was productive and proftable with benefit:cost ratio of 1.86. The advanced ripe stage (16 WAA) was marked with highest fruit quality attributes such as TSS, TSS/acid ratio, sugar content, sugar acid ratio and anti oxidative property; hence was considered as an ideal harvest stage for pineapple to ensure maximum attainable palatable quality. Performance of dragon fruit plants was better in open than in protected condition in terms of plant growth and yield. A fruit-based multi-storey system (mango + dragon fruit + pineapple) has been developed at CHES, Bhubaneswar.

Tomato cv. Arka Samrat grafted on BN 10-2 recorded significantly higher yield (122 t ha^{-1}) followed by Arka Samrat on Hawai 7996 (110 t ha^{-1}), whereas control yielded 104 t ha^{-1}. The chilli cv. Arka Harita on IIHR 3226 recorded the highest yield (36.69 t ha^{-1}). Accession IIHR-B-HP 130 was identified as highly resistant (95.65%), and used as resistant rootstock for the capsicum varieties. An increase of fruit yield by 69.23 % and 33.46% was observed in grafted eggplants on CARI-1 rootstock over both the non-grafted scions. In ridge gourd cv. Arka Vikram, application of nutrient dose @ 150:90:150 kg NPK ha^{-1} through water soluble fertilizers resulted in higher yields (45.61 t ha^{-1}). The integrated nutrient management with use of FYM, chemical fertilizers and PP chemicals (INM) resulted in significantly higher yield (27.12 t ha^{-1}) in ridge gourd variety Arka Prasan. In pole bean cv. Arka Sukomal, bi-weekly application of nutrients through water soluble fertilizers resulted in higher yields. In Palak, 100% substitution of recommended N through farm yard manure recorded the highest leaf yield of 21.66 t ha^{-1} that was on par with INM practice. Safe vegetable production methods recorded 11.80 t ha^{-1} that was on par with INM treatment.

In rose, the N and P acquisition efficiency (31%) was greater in *R. multiflora* rootstock, while K acquisition efficiency (33%) was highest in Natal Briar. Agronomic nutrient use efficiency was more in Arka Swadesh budded on Natal Briar rootstock (1.76 flower stalks per g nutrient). The loose flower cultivation was highly profitable with net return of Rs.3.46 per rupee investment compared to cut flower cultivation (Rs.2.58) in open-field. Rapid multiplication of bulbs from bulblets of 1.0 cm diameter in tuberose var. Arka Prajwal and shortening of propagation cycle was achieved by application of 150:75:125 NPK kg ha^{-1} yr^{-1}. In crossandra var. Arka Shreya, drip irrigation at 1.0 evaporation replenishment (ER) during vegetative and 1.2 ER during flowering phases + fertigation of 75% RDF (90:60:180 kg NPK ha^{-1} per year) produced maximum flower yields (8.84 t ha^{-1}). Standardization of pot culture techniques for flower crops revealed that marigold var. Arka Pari, grown in 6" plastic pots with substrate combination of Arka fermented cocopeat (AFC) + vermicompost (1:1 v/v) and weekly application of nutrient solution (128:24:144 ppm NPK) produced the maximum number of flowers. Foliar spray of 20 ppm paclobutrazol one month after transplanting on crossandra var. Arka Chenna, grown in 6" plastic pots resulted in the maximum number of flowers. The substrate medium with Arka Fermented Cocopeat (AFC) and burnt clay balls (LECA) in 3:1 ratio was found ideal medium for vertical garden.

The mushroom production technology of *Macrocybe gigantea* on paddy straw substrate was standardized. The fructification trial of *Hericium erinaceus* was conducted on a supplemented mixture of corn cob powder. Technology for the production of iron fortified Elm oyster mushroom was standardized, to increase the iron content from 118.39 ppm in non-fortified mushroom to 338.15 ppm in iron fortified mushroom. Foliar application of potassium silicate and *O*-silicic acid at 4 mL/L, significantly increased the yield in Capsicum. With respect to soilless cultivation, brinjal plants raised on Arka Fermented Cocopeat registered maximum plant height, number of leaves, total plant dry biomass, number of fruits, fruit length, fruit girth, fruit weight and yield compared to soil under open-field soilless culture.

Rhizobacterial strains were used for production of bio-encapsulated vegetable seeds. In okra it was observed that film coating with an anhydrobiotically dried bacterial consortium and film coating with a wet cell bacterial consortium, were at par with each other in terms of yield and nutrient uptake parameters of the crop under field conditions. The rose root stocks *viz*., *R. multiflora* and *R. indica*, var. Pushkar and Chaitri performed better under salinity and alkalinity conditions. Arka Herbiwash is a herbal powder developed recently from dried plant parts without synthetic chemicals or adjuvants. It is completely safe product to wash fruits and vegetables.

In artificial inoculated studies on powdery mildew in mango, Alphonso was found susceptible to infection of powdery mildew at all stages and the spread of the disease was rapid than in Lazzat Baksh. There was a positive correlation (r=0.68) between relative humidity (average of preceding 7 days) with powdery mildew severity, while with temperature had negative correlation (r=-0.52) on powdery mildew. A spray module including insecticides and botanicals to manage mango fruit borer *Citripestis eutraphera* was standardised. The infestation of stem borer was more in Alphonso grafted on *Vellaikolumban* rootstock (33.5% cumulative damage) than on Olour (21.5%). *Psidium cattleianum* showed immune reaction to *Meloidogyne incognita* without any galls (Gall index 0).

The spray module involving an insecticide (Lambda cyhalothrin @ 1 ml L^{-1}) and IIHR neem soap @ 10 g L^{-1} was considered effective and safe to manage guava shoot borer. Population dynamics of aphids and PRSV spread in papaya showed that aphid population had positive correlation with maximum temperature, minimum temperature and wind speed, while negative correlation was observed with rainfall and relative humidity. Mechanism of ISR/ SAR in papaya showed an increased activity of the enzymes POD, SOD, PAL and peroxidase and levels of salicylic acid when treated with Sagarika, ActinoPlus, *B. amyloliquefaciens* and Kaolin. Transformation of papaya cv. Arka Prabhath for CRISPR/Cas9 mediated genome editing of papaya targeting eIF4E gene is attempted. Insect pollinator diversity in litchi (*Litchi chinensis*) and avocado (*Persea americana*) was determined. Seven systemic fungicides were evaluated *in vitro* against scab and anthracnose diseases of avocado.

The fruit chafer beetle, identified as *Protaetia alboguttata* (Vigors) (Coleoptera: Scarabeidae: Cetoniinae), was recorded on fig (*Ficus carica* L.). Variety/rootstock evaluation for resistance to stem borer in fig showed that Poona was least susceptible (7.40%) and is considered to be resistant to stem borer. *In vitro* screening of *Trichoderma* isolates JL5, GJ16B, LA and *Bacillus subtilis* against *Alternaria solani* (causal agent of early blight of tomato) through the dual culture assay showed the involvement of volatile organic compounds (VOCs) on inhibition of the pathogen. Integrated management of tomato pin worm, *Tuta absoluta* was worked out. One step RT-LAMP assay was used to develop a novel nucleic acid amplification assay termed reverse transcription (RT) loop-mediated isothermal amplification (RT-LAMP) for specific and sensitive detection of ChiVMV.

Vector population and virus incidence in Integrated Disease Management (IDM) of vector borne viruses was studied. Genome editing of recessive resistance eIF4 genes in chilli for potyvirus resistance was attempted. The sgRNA eIF4E 428 RNA infiltrated plants have shown resistance to the potyvirus. In brinjal, combination of seed treatment (10 ml kg^{-1} seed), nursery treatment (50 ml m^{-2}), soil application (5 t ha^{-1} of FYM enriched in 5 L) and soil drenching (5 ml L^{-1}) at 30 day interval with *Bacillus megaterium* -1% A.S. reduced soil and root nematode population considerably.

Integrated virus disease management in cucumber, two rows of border cropping with maize, installation of reflective mulches, blue and yellow sticky traps, application of Neem oil @ 3 ml L^{-1}, Arka Microbial Consortium @ 20 g L^{-1} and rotational sprays with Arka Vegetable Special @ 3 g L^{-1}, Fipronil @ 1.0 ml L^{-1}, Thiomethoxam @ 0.5 g L^{-1} and Dimethoate @ 2 ml L^{-1} on weekly basis protected (up to 95%) the crop from virus incidence (2-5%) compared to 60-90% virus incidence in control. For integrated nematode management in cucumber, planting African Marigold 45 days before planting cucumber + application of bio-agents (2 kg each of *B. subtilis*, *B. pumilus* and *B. amyloliquefaciens*) enriched neem cake (1 t ha^{-1}) + drenching bio-agent enriched neem cake suspension 10% once in 30 days suggested for reducing *M. incognita* population (70.8-76.1% in roots and soil). A protocol has been standardized using two native bee species *viz*., Indian honey bee, *Apis cerana* and stingless bee, *Tetragonula iridipennis* for pollination of muskmelon (cv. Arka Siri) and cucumber grown under polyhouse. The pathogen causing collar and root rot of pointed gourd has been identified as *Phytophthora melonis* based on morphological, cultural and pathogenic characters together with DNA sequence analysis of ribosomal internal transcribed spacer (ITS rDNA) regions. For management of tea mosquito bug in Moringa, yellow colour sticky traps were found to attract a significantly higher number of adult *H. antonii* (7± 2.26; P<0.001) compared to the blue traps (2.37±0.75). A formulation developed from seed extract of *Annona squamosa* was found effective against aphids (*Aphis craccivora*) in bitter gourd, *Myzus persicae* and

Scirtothrips dorsalis, and whiteflies (*Bemisia tabaci*) in chilli and capsicum.

With respect to Identification of *Phytophthora* in ornamental crops, the sequence analysis showed that 19 out of 23 *Phytophthora* isolates belonged to *P. nicotianae* with nucleotide identity of more than 98%. Crossandra var./line M-4 was found resistant to *M. incognita* and Arka Ambara was moderately resistant. Treatment of gladiolus corms (cv. Arka Ayush) with biocontrol bacteria, *Bacillus pumilus* IIHR Bp-2 significantly reduced the root knot nematode population. Soil application of FYM enriched with biocontrol bacteria, *B. amyloliquefaciens* @ 5 t ha^{-1} before planting and further soil drenching of neem cake enriched with bioagents at 2 l m^{-2} at quarterly intervals reduced population of *Meloidogyne incognita* in soil by 69.4% in gerbera (cv. Arka Ashwa) and increased the spike yield by 20.3%. Root exudates of five marigold varieties/ lines suppressed 62.8-91.9% egg hatching and caused 38.9-69.7% mortality of *M. incognita*. Transmission of aster yellows by *Hishimonas phycitis* in China aster was confirmed. Growing velvet bean in polyhouse and incorporation of its residues at 45 DAS significantly reduced the plant parasitic nematode population in soil to the extent of 49.1-61.9%, respectively

Integration of Quarantine Irradiation treatment (400 Gy) with hot water treatment (52-55 °C for 5-10 min) did not have any adverse effect on the internal quality of Alphonso. Protein fortified fruit roll using Whey Protein Concentrate (WPC, 2 and 5%) was made from mango hybrid Arka Udaya without sugar addition. Guava fruits exposed to 500 ppb of 1-MCP and MA packed using non-perforated PP-film could be kept in unripe condition for 3 weeks at 12 °C. The insecticidal properties of annona seeds and seed oil are due to one of the bioactive compounds acetogenins. Pomegranate genotype Selection A4/2 was found suitable for both fresh and dehydrated arils. Dehydrated arils are dark red with good taste and aril recovery of 24%. Process for preparation of probiotic pineapple juice was standardized and the probiotic juice has shelf life of two months at refrigerated temperature. Passive and active modified atmosphere packaging (MAP) suitable for extending the shelf life of fresh-cut pineapple was optimized.

The biodegradable plates developed from paddy straw with the addition of natural additives, coated with food grade coating had a thickness of 1.93 mm, and density of 0.14 g/cm^3. Garden pea *cv*. Arka Apoorva retained the highest total polyphenol content (17.67 mg GAE/100 g) and Arka Karthik retained highest total chlorophyll content (0.11 mg per 100g). The storage life of musk melon could be extended to 3 weeks at 10 °C with 1-MCP exposure without affecting the appearance and internal quality compared to 2 weeks in control.

In crossandra var. Arka Shreya, flowers harvested at half open stage, could be stored for up to 5 days after harvest, and flowers at three-fourth open and fully opened stages could be stored up to 4 days after harvest at 4-5 °C. A beverage has been standardized from the medicinal plant *Centella asiatica*; quality evaluation during storage revealed a total polyphenol content between 90.87 and 146.25 mg GAE/100 g and DPPH activity between 0.142 and 0.279 mg AEAC/g. A tractor operated raised bed former cum onion bulb planter was designed and developed. An engine operated chilli harvester was designed and developed, with the main components of prime mover, rotary harvesting drums, collecting chamber and power transmission mechanism.

The total cost of cultivation for guava was worked at Rs.1,18,986.40 per acre based on the sample data collection from farmers. The post-harvest loss (PHL) affected the marketing efficiency adversely thereby indicating the need for minimizing the PHL. The establishment cost for High Density Planting (HDP) in guava at 3 m x 3 m and 4 m x 4 m spacing was estimated at Rs.1,79,640/acre and Rs.1,21,400/acre, respectively. Annual maintenance cost in guava HDP system at 3 m x 3 m spacing was Rs.3,84,394/acre compared to Rs.2,34,947/acre in HDP system spaced at 4 m x 4 m indicating 74% higher cost at lesser spacing. The BC ratio at 3 m x 3 m and 4 m x 4 m HDP systems was 2.40 and 2.23, respectively. Regarding marketing of guava**,** selling produce at distant market emerged as the most profitable strategy.

Multi-dimensional scaling approach for stability analysis in banana multi-location trials was worked out. Stability models developed in banana multi-location trails individually for six different yield and attributing traits resulted in three groupings. Data pertaining to four different vegetable crops across locations for various traits and lines were considered for developing crop stability models for multi-location trials in order to identify the suitability of IIHR entries across locations. Principle component analysis in karonda accessions was carried out and could be useful for the breeders working on this future crop for characterization, genotype identification, and selection of parents. The high estimate of heritability in the range of 0.83 (skin weight) to 0.998 (stone weight) in mango indicated that Best Linear Unbiased Prediction (BLUP) approach is useful to estimate and compare the breeding values based on progeny information for each trait. Diversity analysis was carried out for 21 jamun accessions based on 32 traits (morphological, chemical, flower, fruit and seed traits) revealed that seed length

alone contributed for 90.9% variability. Probit models were constructed for germination percentage of three rootstocks viz., Bappakai, Nekkarai and Kurukkan to estimate the LD 50 values. Components of variance (GCV, PCV, h2, Genetic Advance, Genetic Gain as % mean) were worked out for 49 tomato diverse stocks. Nonlinear regression models were developed to compute area under disease progression curve (AUDPC) and highest AUDPC value was recorded in Pink Friendship inoculated with FOG IIHR-1 isolate.

Mobile apps for watermelon and French bean cultivation were developed and integrated with fruits and vegetables mobile app for smart phones which could be installed from Google play store. The web-based Decision Support System was designed for all major flower crops viz., carnation, China aster, chrysanthemum, crossandra, gerbera gladiolus, jasmine, marigold, rose, tuberose. Simulation model and graphical user interface (GUI) were developed for watermelon bud necrosis (WBNV) disease

The guava hybrid Arka Kiran occupied 0.98%, 0.17%, and 0.68% of the total guava growing area in Andhra Pradesh, Maharashtra and Tamil Nadu. The area under Arka Sahan was 9.78% in Karnataka and 12.5% in Tamil Nadu of the total annona growing area. Impact study on IIHR released brinjal and chilli hybrids in farmer's field revealed that improvement in yield (11%) was noticed in Arka Anand in brinjal and 5-10% yield enhancement was noticed in Arka Meghana and Arka Haritha in chilli compared to private hybrids. Highest B:C ratio was noticed in IIHR chilli hybrids (3.2-3.55), compared to private hybrids (2.90-3.17). The study on spread and acceptance of IIHR crossandra varieties among farmers indicated that more than 75% of farmers accepted Arka Chenna followed by Arka Shreya (25%) and Arka Ambara (25%).

Enhancing the profitability of small and marginal farmers through integrated farming systems through horticultural interventions was undertaken in two districts of Karnataka. A project was initiated to assess the role of formal and informal institutions and farmers involved in marketing of horticultural products during the COVID lockdown period and to suggest strategies for successful handling of horticultural produces during similar situations. Based on the analysis of the different successful models, a common strategic model was identified that can be suggested for effective role play by formal and informal institutions and farmers towards marketing of horticultural produces during the similar situations of COVID 19 lockdown period.

3.1. CROP GENETIC RESOURCES

3.1.1. GERMPLASM EXPLORATION AND COLLECTION

The Institute is an important nodal centre for management of plant genetic resources of horticultural crops in the country. In the year 2020, explorations were carried out to collect germplasm of fruit, vegetable, flower and medicinal crops. The existing germplasm wealth of different horticultural crops at the Institute is given below.

FRUIT CROPS					
Crop	**Germplasm collected**	**Areas explored**	**Total viable germplasm**	**No. of germplasm characterized**	**Germplasm registered with NBPGR**
IIHR, Bengaluru					
Mango	-	-	767	41	
Guava	3 (Secondary collections)		70		
Papaya	6 (Secondary collections)		41		
Pomegranate			298		1
Sapota			52		
Jamun	1	Tumkuru	108	21	29
Annona			48	9	3
Pummelo			35		
Rose apple	5	Bengaluru Rural			
Annona muricata			3		1
Carissa macrocarpa			3		1
Tamarind	4 (Secondary collections)		58		
Grapes			20		
Jackfruit	21	Dakshina Kannada	197	3	73
Wood apple			16		
Bael			119	24	
Garcinia			32		
Dragon fruit			6		
CHES, Bhubaneshwar					
Pine apple	7	-	17	5	7
Jackfruit	23	-	24	5	23

Dragon fruit			5		
Mango	-	-	04	-	-
Bael	-	-	103	-	-
Castard Apple	-	-	03	-	-
Underutilized fruit crops	-	-	24	-	-
CHES, Chettalli					
Avocado	53	Karnataka, Kerala, Tamil Nadu	116		

VEGETABLE CROPS

Crop	Germplasm collected	Areas explored	Total viable germplasm	Germplasm characterized		Germplasm registered with NBPGR
				Traits	No.	
ICAR-IIHR, Bengaluru						
Tomato			700			
Chilli	24	Nagaland, Sikkim, Meghalaya & Andaman Islands	2000	As per NBPGR minimal descriptor	50	
Brinjal	3	Goa	358	As per NBPGR minimal descriptor	72	
Watermelon	3	Karnataka & Tamil Nadu	342	GSB resistance	340	2
Muskmelon	5	Karnataka & USDA	120			
Okra	27	NBPGR RS, Thrissur Kerala; Local markets of Erode & Dharmapuri in Tamil Nadu and Palakkad in Kerala, Punjab, Hyderabad & Karnataka	1647	As per NBPGR minimal descriptor	10	
Garden Pea			145	As per NBPGR minimal descriptor	50	

French Bean			318	As per NBPGR minimal descriptor	38	
Cow pea			417	As per NBPGR minimal descriptor	33	
Dolichos bean	16	Tamil Nadu	276		200	
Soybean			88			
Onion	03	Karnataka	65			
Carrot			175			
Radish	10	Punjab, Rajasthan & Tamil Nadu	85	Heat tolerance, yield & root quality	65	
Ridge gourd	3	Karnataka & Tamil Nadu	140			
Bitter gourd			167			
Cucumber	60	USDA through NBPGR	502	20	60	
Cluster bean	2	Bikaner, Rajasthan	44	Nutrient profile	5	
Ash gourd			36		08	
Bottle gourd	08	Dharwad, Tamil Nadu	143		09	
Bell pepper	16	Solan, HP, World Vegetable Center, Taiwan	44	Cell membrane stability & Pollen germination	26	
Drumstick	77	Tamil Nadu, Karnataka & Maharashtra	232	Morphological, biochemical and molecular characterization	52	
Curry leaf	17	Tamil Nadu	123	-	20	
Pumpkin			117	As per NBPGR minimal descriptor	21	
Summer squash	33	Tamil Nadu & Karnataka	110	Yield & fruit quality	33	
CHES, Bhubaneswar						
Dolichos bean	1	Bihar	120			
French bean			20		18	
Field Bean	-	-	25	-	-	-
Chilli			142			

Brinjal			42			
Moringa			86			
Amaranthus			285			
Edible leafy vegetables			30			
Pointed gourd			73			

FLOWER AND MEDICINAL CROPS

Crop	Germplasm collected	Areas explored	Total viable germplasm as on	Germplasm characterized during the year		Germplasm registered with NBPGR
				Traits	No.	
Rose	Nil	Nil	317	Morphological characters	13	
Marigold			60	Morphological characters	4	4
Tuberose	01	DFR, Pune	27	35	01	01
Carnation			80			
Chrysanthemum			100	77	90	
China aster			28	21	28	
Gladiolus	12	IARI, New Delhi, PAU, Ludhiana, DFR, Pune	80	66	05	02
Gerbera	16	ICAR Reseach Complex, Barapani	45	8	10	2
Crossandra	Nil	-	20	6	5	
Dahlia	30	Kolkata & Bhubaneshwar (Secondary collection)	45	7	10	
Gymnema sylvestre (Gudmar)	31	Karnataka & Kerala	31	Leaf size, leaf shape and leaf colour	18	
Centella asiatica			28			2

Bacopa monnieri (Brahmi)	71	Karnataka, Kerala, West Bengal	71	10	51	
Eclipta alba (Bhringaraj)	53	Andhra Pradesh Karnataka, Kerala, West Bengal, Gujarat	155	15	82	

MUSHROOM					
Crop	**Germplasm collected**	**Areas explored**	**Total viable Germplasm**	**Germplasm characterized**	**Germplasm registered with NBPGR**
Mushroom	2	ICAR-IIHR Bengaluru & Hirehalli	93	Nil	Nil

3.1.2. GERMPLASM CONSERVATION AND DOMESTICATION

FRUIT CROPS

At ICAR-IIHR, germplasm of all fruit crops is conserved in the field. Forty underutilized fruit crops and twenty wild fruit species of Kodagu are conserved.

At CHES, Bhubaneshwar, the germplasm of mango (103), pineapple (17), jackfruit (24), bael (12), custard apple (3), dragon fruit (04) and underutilized fruit crops (24) such as wax apple, rose apple, tamarind, jamun, longan, rambutan, egg fruit, avocado, karonda, star gooseberry, star apple, Barbados cherry, carambola, kokum are maintained.

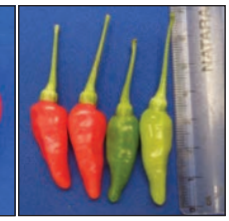
Avocado accessions (*n*=53) were collected from Karnataka, Kerala and Tamil Nadu and planted at CHES (ICAR-IIHR), Chettalli.

VEGETABLE CROPS

Chilli (*Capsicum annuum* L.): Ten domesticated wild accessions of *Capsicum chinense* and *C. frutescens* collected from Andaman & Nicobar Islands and NE India were conserved during the period at ICAR-IIHR for their further use in chilli breeding program.


C. chinense


C. chinense


C. frutescens

Brinjal (*Solanum melongena* L.): Six wild species, *Solanum torvum*, *S. gilo*, *S. indicum*, *S. macrocarpon*, *S. mammosum* and *S. seaforthianum* were raised for maintenance, breeding and seeds were multiplied.


Solanum mammosum


S. gilo


S. macrocarpon

Okra (*Abelmoschus esculentus* L. Moench): Nine wild species namely *Abelmoschus pungense* sub spp. *mezorensis, A. ficulnious, A. tetraphyllus* var. *tetraphyllus, A. tuberculatus, A. moschatus* sub spp. *tuberosus, A. manihot* sub spp. *manihot, A. caillei, A. moschatus* (muskdana) and *A. angulosus* var. *gradiflorus* are maintained and utilized in resistance breeding program in the net house.

Cucumber (*Cucumis sativus* L.): Three wild species namely *Cucumis hardiwikii, C. metuliferous* and *C. hystrix* are conserved and utilized for breeding program.

The germplasm of vegetables crops *viz*., chilli (142), brinjal (42), legume vegetable (165), amaranthus (285), drumstick (86), edible leafy vegetables (30), pointed gourd (73) are maintained at CHES, Bhubaneshwar.

FLOWER AND MEDICINAL CROPS

Rose: Among 13 rose species characterized for their potential in breeding program, only *Rosa multiflora* flowered under Bangalore conditions.

Marigold: Different species of marigold *viz.*, *Tagetes erecta, T. patula* and *T. minuta* were collected and maintained in marigold germplasm. *T. erecta* and *T. patula* are intercrossable, but crossing is difficult in minute flowers of *T. minuta*.

Chrysanthemum: A total of 100 chrysanthemum germplasm are conserved and multiplied in field gene bank.

China aster: A total of 28 germplasm is being conserved in cold room, multiplied and maintained; IC numbers were obtained for 12 germplasm.

MEDICINAL PLANTS: About 28 accessions of *Centella asiatica* and 31 accessions of *Gymnema sylvestre* are conserved in the field gene bank. The total germplasm number is 111 in *Piper betle*, 155 in *Eclipta alba,* 71 in *Bacopa monnieri*, 85 in *Mucuna pruriens*, 45 in *Coleus forskohlii*, 54 in *Andrographis paniculata* and 37 in *Aloe vera*. The IC numbers were obtained for 36 accessions in *Eclipta alba*, 30 in *Aloe vera* and two in *Mucuna pruriens*

Pollen cryopreservation: The cryopreservation protocols for wild relatives and resistant genotypes of horticultural crops are being developed. Cryopreservation of *Vasconcellea cundinamarcensis* was done by collection of fresh pollen, and the initial viability as assessed through *in vitro* germination in liquid nitrogen cryopreserved pollen was 76% germination, while that of fresh pollen was 78%.

Pollen of four wild species of tomato was assessed for viability *in vitro* and cryopreserved in liquid nitrogen. The germination percentage was similar in case of fresh pollen as well as cryopreserved pollen.

***In vitro* germination of wild species of tomato**

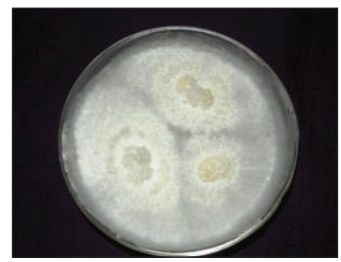
Species	Germination (%)	
	Fresh pollen	Cryopreserved pollen
Solanum pimpinellifolium (1589)	78	78
S. pimpinellifolium (0397)	75	74
S. corneliomulleri (1609)	65	62
S. peruvianum (1940)	85	80

MUSHROOMS

Two wild mushrooms were collected in August 2020. The isolates were tissue cultured, purified, spawn prepared and at present are under fruiting trial for culture validation.

Wild habitat

Sporophores on dead tree trunk



First tissue culture

Wild mushroom collected from Hirehalli

3.1.3. GERMPLASM CHARACTERIZATION

FRUIT CROPS

At CHES, Bhubaneshwar, the characterization of mango, jamun, annona and jackfruit accessions that were collected during 2020 was done using appropriate descriptors.

VEGETABLE CROPS

Chilli (*Capsicum annuum* L.; Family *Solanaceae*): Twenty genotypes were collected. About 50 germplasm lines were characterized as per NBPGR minimal descriptor and 67 lines were maintained during 2020. DNA fingerprinting of nine var./ hybrids/ registered genotypes of chilli was done using SSR markers.

Fruit variability in germplasm of *Capsicum* spp

Brinjal (*Solanum melongena* L.; Family *Solanaceae*): Sixtyeight germplasm lines were characterized as per the NBPGR minimal descriptor.

Variability in fruits of brinjal

French bean (*Phaseolus vulgaris* L.; Family *Leguminosae*): Out of 38 germplasm lines evaluated for yield and yield attributing traits, 21 lines were bush type and remaining 17 lines were pole types. Twenty eight lines had stringed pods and 10 were stringless. Pods were yellow (2) light green (18), green (15), and dark green (3). Ten pod weight ranged from 21-112.5 g (IIHR-262), pod width ranged from 0.8-1.3 cm (IIHR-79), pod length ranged from 9.9-18.3 cm. The lines were highly significant for all traits. Pod yield per plant ranged from 34-241 g (IIHR-61). Two lines (IIHR-17 and IIHR-33) showed field resistance to rust.

IIHR-263 purple pod French bean

Cowpea (*Vigna unguiculata* L. Walp.; Family *Fabaceae*): A total of 33 germplasm lines were evaluated for various yield and yield attributing traits. Ten pod weight ranged from 49-147.5 g (IIHR-98), pod length ranged from 13.5 (IIHR-65) to 39.8 cm (IIHR-31), pod width ranged from 0.3 cm (IIHR-8) to 1.3 cm (IIHR-98) and pod yield per plant ranged from 43.75-218.5 g (IIHR-108), Among 38 germplasm lines, 21 were indeterminate and 12 were determinate; three lines *viz*., IIHR-15, IIHR-28 and IIHR-65 showed field resistance to *Cercospora* leaf spot and cowpea mosaic virus. Two lines viz., IIHR-37 and IIHR-91 showed field resistance to aphids.

Garden pea (*Pisum sativum* L. Family *Fabaceae*): Among 50 germplasm evaluated, ten pod weight ranged from 16.5-97.5 g (IIHR 3), pod length ranged from 3.9 (IIHR-13-17) to 10.8 cm (IIHR-710), number of seeds per pod ranged from 5 (IIHR703) to 9 (IIHR-141) and pod yield per plant ranged from 23.5 (IIHR700) to 80 g (VP-8902), The accession IIHR-13-4 was afila type and showed resistance to rust.

Garden pea IIHR-13-4 Afila type

Dolichos bean (*Lablab purpureus* L. Sweet; Family *Fabaceae*): The germplasm of dolichos pole bean received from ICAR-NBPGR (*n*=119) and dolichos germplasm received through germplasm exchange

from CHES, Bhubaneshwar, (*n*=15) were regenerated, multiplied and conserved at medium term gene bank module of ICAR-IIHR.

Radish (*Raphanus raphanistrum* subsp. *sativus* L. Domin; Family *Brassicaceae*): Overall, 65 accessions were characterized as per NBPGR minimal descriptor and 85 accessions were maintained.

Summer squash (*Cucurbita pepo* L.; Family *Cucurbitaceae*): Thirty-three accessions of summer squash were collected and evaluated for growth and yield traits. Fruit length (19 to 51 cm), girth (32 to 50 cm), average fruit weight (0.45 to 1.22 kg), number of fruits per plant (2.23 to 7.81), yield (41.63 to 59.18 t ha^{-1}) and TSS (4 to 9 ^{o}Brix). Three accessions had recorded yield >55 t ha^{-1}, which was higher than the check (52.1 t ha^{-1}). SQ-2-5-2-6 were extra long, yellow skinned fruits, suitable for harvest at immature stage, before flower drop, and SQ-2-3-1-1 had elliptical shaped, white fruits, which can be selected for further evaluation.

Pumpkin (*Cucurbita moschata* Duch Ex Poir; Family *Cucurbitaceae*): During 2020, 21 butternut types were characterized for 14 quantitative and 11 qualitative traits as per NBPGR descriptor. Average fruit weight ranged from 0.87 to 4.75 kg, yield ranged from 14 to 46 t ha^{-1}. Of these, 4 accessions had high yielding potential of >40 t ha^{-1}; and a wide range of flesh thickness (1.5 to 5.0 cm) and TSS (3-11 ^{0}Brix). Twelve pumpkin germplasm lines were evaluated, and a very early with miniature fruited accession [each fruit weighing around 100 g (U-1)], with yellow skinned and flat round fruit shape was found.

Butternut collections

Curry leaf (*Murraya koenigii* L. Sprengel; Family *Rutaceae*): A total of 123 accessions are maintained in the field gene bank at ICAR-IIHR.

The germplasm of vegetables crops *viz*., chilli (140), brinjal (42), legume vegetable (165), amaranthus (285), drumstick (86), edible leafy vegetables (30), pointed gourd (69) are maintained at CHES, Bhubaneshwar.

Drumstick (*Moringa oleifera* Family: Moringaceae) 52 genotypes were assessed for foliage density and it varied from sparse to dense; 15 accessions *viz*., PKM-1, IIHR-D-98, IIHR-D-107, IIHR-D-4, IIHR-D-8, IIHR-D-5, IIHR-D-120, IIHR-D-11, IIHR-D-13, IIHR-D-28, IIHR-D-34, IIHR-D-35, IIHR-D-69 and IIHR-D-40, IIHR-D-67 possessed dense foliage.

FLOWER AND MEDICINAL CROPS

Chrysanthemum: About 90 genotypes were characterized for 77 traits as per DUS test guidelines.

China aster: A total of 28 genotypes for 21 traits were characterized as per DUS test guidelines.

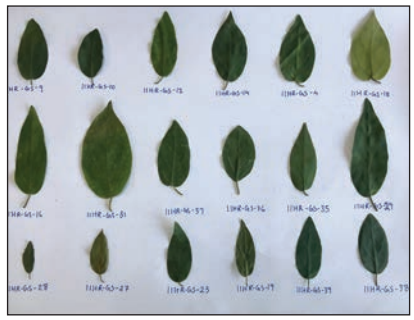
Jasmine: About 41 accessions of jasmine belonging to four commercially cultivated species *viz.*, *Jasminum sambac, J. auriculatum, J. grandiflorum, J. multiflorum* and six other lesser-known spp. (*J. rigidum, J. nitidum, J. flexile, J. malabaricum, J. humile* and *J. primulinum*) are maintained in the field gene bank, and these four species were characterized based on morphological descriptors.

***Bacopa monnieri* (Brahmi)**: Upon characterization of 51 germplasm accessions as per DUS descriptors, variability was recorded for stem pigmentation (dark brown, dark green, light green), leaf colour (light green, dark green) and flower colour (light purple, white). Among the accessions leaf length varied from 1.30-2.85 cm and leaf width ranged from 0.37-1.53 cm showing considerable variation for leaf size.

Variability for leaf traits in Brahmi

***Eclipta alba* (Bhringaraj):** About 82 accessions were characterized for 15 morphological traits *viz.*, plant habit, plant height, plant spread, leaf length, leaf width, internodal length, stem diameter, stem color, number of leaves per plant, number of branches per plant, flower diameter, pedicel length, leaf color, leaf vein colour and leaf pubescence. Wide variations were observed in plant height (18-78.33 cm), leaf length (1.73-7.43 cm), leaf width (0.4-1.87 cm) and internodal length (0.27-6.9 cm). Distinct differences for growth habit, internodal colour, leaf color, leaf shape and stem pubescence were observed among the accessions. Floral biology studies revealed that *E. alba* is both self and cross compatible. The plants showed higher seed set in open pollinated flowers and low set in single bagged flowers. Single bagged flowers recorded 15-25 number of ray florets per head, unbagged flowers had higher ray florets 30-42 per head. Number of disc florets per head in single bagged flower was 20-38 head^{-1}, in open flowers 42-98. Similarly seed produced in open pollinated flowers was higher (42-72 seeds per head) than in single bagged flowers (35-48 seeds per head).

***Gymnema sylvestre* (Gudmar):** The accessions of *Gymnema sylvestre* (*n*=18) were characterized for leaf shape, leaf colour and leaf size traits.



Variation for leaf traits in *Gymnema sylvestre*

3.1.4. EVALUATION OF GERMPLASM FOR YIELD AND QUALITY

FRUIT CROPS

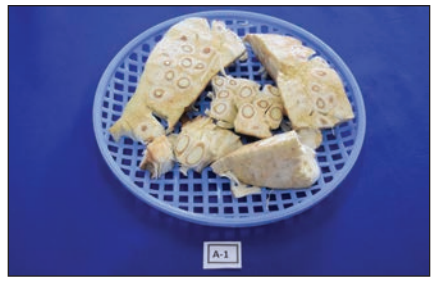
Jamun: Evaluation of 21 jamun genotypes revealed that the fruit weight ranged from 0.5 g (KHA-3) to 8.52 g (Selection-20). The fruit length ranged from 0.87 (KHA-3) to 2.73 cm (Selection-45). The fruit diameter ranged from 0.17 cm (KHA-3) to 1.83 cm (Selection-45). The total soluble solids were lowest in Selection-20 (13.3 ºB) and highest in KHA-14 (19.66 ºB). The Selection-3 registered highest total phenols (194.31 mg GAE 100 g^{-1} FW) and KHA-24 genotype was lowest in total phenols (15.92 mg GAE 100 g^{-1} FW). The antioxidant activity was highest in Selection-3 (271.57 mg AAE 100 g^{-1} FW) and lowest in KHA-25 (27.86 mg AAE 100 g^{-1} FW). Anthocyanin content was highest in KHA-14 (162.0 mg 100 g^{-1} FW) and lowest (32.17 mg 100 g^{-1} FW) in Kaithanal. In jamun seeds, higher alpha-glucosidase inhibitory activity (IC50) was recorded in KHA-14 (46.8±5.2), followed by KHA-25 (47.3±8.3) and KHA-1 (49.2±6.1). The total phenol content was higher in the seeds of KHA-26 (91.8±3.9 mg GAE g^{-1}), Market sample-3 (88.9±15.8 mg GAE g^{-1}), KHA-14 (86.3±6.0 mg GAE g^{-1}), KHA-3 (85.8±5.1 mg GAE g^{-1}) and KHA-1 (85.2±17.2 mg GAE g^{-1}). Antioxidant activity (µM TE g^{-1}), FRAP and DPPH were higher in KHA-24, KHA-14 and KHA-26.

A genotype, collected from farmer's field in Tumkur, fruits twice a year (June-July and Nov-Dec). The average fruit weight of this genotype is 8.6 g and oblong in shape with projected base. The fruits are dark purple colour with pinkish white pulp, acidic sweet to taste, 13.86 ºB TSS. The alpha-glucosidase inhibitory activity (IC50) of seeds was 88.3±9.7 and total phenolic content was 72.2±3.8 mg GAE g^{-1}.

Farmer's genotype in jamun that fruits round the year

Jackfruit: From a survey in Dakshina Kannada, 12 samples were analysed for basic horticultural traits of tender quality as a vegetable and for processing. Two elite clones of table and three vegetable types were analysed for biochemical characters. Accession no. 1/20 (collection from Shri. Ravindra's field in Tumkur, Karnataka) has medium size fruits of 8-10 kg (average 8.7 kg) with dark green peel colour when mature and brownish to black spine tip when ripe, irregular shaped, medium sweet (23 °B TSS), thick, crispy and deep coppery red flakes weighing 17.95 g and of 5.86 mm thickness. It has high amounts of carotenoids (8.16 mg 100 g^{-1}) and lycopene (1.48 mg 100 g^{-1}). Three jackfruit accessions of vegetable type registered average fruit weight of 1650-3152 g with 62-80% moisture. Total dietary fiber content varied between 9-11 g 100 g^{-1} FW. It is harvested during February-March.

Farmer's jackfruit accession 1/20



Vegetable jackfruit accession

Tamarind: *In situ* collections of tamarind pods (*n*=388) from Mizoram, Karnataka, Chattisgarh, Odisha, Maharashtra, Madhya Pradesh, Telangana and Jharkhand were evaluated. The average pod length was 13.48 cm and the pod samples from Karnataka registered maximum pod length of 16.72 cm followed by Odisha (13.71 cm) and Chattisgarh (13.47 cm). The average pulp recovery was 36.5% and the collections from Telangana had highest pulp recovery of 40.49% followed by Karnataka (39.48%) and Odisha (39.44%).

The accession 'Lakshamana' from the field of Shri. Laxmannappa, Nandihalli, Tumkur, Karnataka, had superior yield (251.4 kg pods tree^{-1}) and pod characters than local tamarind (165.0 kg pods tree^{-1}). The total acidity and total sugar in pulp were 20% and 29.78%, respectively.

Pods, seeds and inverted pulp of identified tamarind accession 'Lakshamana'

Under-utilized fruit crops

Bael: The accessions of bael (*n*=24) were evaluated for morphological, biochemical and nutritional traits. Fruit yield was higher in 10/3 (73.5 kg tree^{-1}, South Indian type) followed by 13/19 (67.3 kg tree^{-1}, North Indian type). The fruit weight ranged from 80-1548 g with average pulp recovery of 43.3%, TSS ranged from 27 to 36 °B, acidity ranged from 0.12 to 1.23%. The carotenoids were quantified at 3.25 to 14.96 mg 100 g^{-1} FW, total phenols ranged from 1165.6 to 2438.5 mg GAE 100 g^{-1} and vitamin C content was 23-68.08 mg 100 g^{-1}. The antioxidants (FRAP) were 125.3-150.9 mg AEAC 100 g^{-1}, The nutrient content was 0.66-1.23% K, 0.39-1.62% Ca, 31-52 ppm Fe and 4-13.3 ppm Zn in fruits.

The evaluation of six accessions of *Flacourtia montana* for macro and micronutrients indicated that the concentration of nutrients in fruits was 0.78-0.92% K, 0.49-1.02% Ca, 64-114.8 ppm Fe, 12.7-15.1 ppm Zn.

Rose apple: *In situ* evaluation of five elite trees of seedling origin was done in farmer's field at Hosakote, Bangalore Rural (Chikkakoliga, Vabasandra, T-Agrahara villages). Variability was observed with respect to fruit weight (18.5-78 g), fruit size (3.5 cm x 3.6 cm to 5.3 cm x 6.5 cm), fruit shape and calyx lobe appearance with pulp thickness (0.6-1.1 cm). TSS varied from 5 to 8.2 °B. The concentrations of total phenols, total flavonoids, anti oxidant (FRAP) and antioxidant (DPPH) per 100 g FW were 38-107 mg, 6.32-15.5 mg, 38.3-111.2 mg, 29.1-78.8 mg, respectively.

Rose apple with desirable traits

Variability in rose apple collections

Pineapple: At CHES, Bhubaneshwar, 16 germplasm of pineapple (IIHR-B-PA-1 to IIHR-B-PA-16) were evaluated for their physical and biochemical traits. A wide variation was observed in fruit weight (0.6-1.8 kg), yield (15-35 t ha^{-1}), fruit crown ratio (2.5-8.0), pulp content (40-60%), juice content (36-60%), number of suckers (0.8-3.4 per plant), TSS (13.0-17.0 °Brix), TSS/acid ratio (12-29), sugar/acid ratio (7-16) and total carotenoid content (2.0-2.8 µg g^{-1}). The accessions IIHR-B-PA-1, IIHR-B-PA-2 and IIHR-B-PA-3 are identified as the most promising and early maturing, whereas IIHR-B-PA-8, IIHR-B-PA-9 and IIHR-B-PA-12 (MD-2) are promising mid-season germplasm for the eastern tropical region. Among late maturing germplasm, IIHR-B-PA-13 is promising.

VEGETABLE CROPS

Brinjal (*Solanum melongena* L.; Family *Solanaceae*): Average fruit yield of 68 genotypes varied from 0.40 kg $plant^{-1}$ in IIHR-635 to 2.75 kg $plant^{-1}$ in IIHR-602. Variability with respect to fruit shape, size and color was recorded.

Bell Pepper (*Capsicum annuum* L. var. *grossum*; Family *Solanaceae*): Thirteen bell pepper lines were evaluated for cell membrane stability index at high temperature, and AVPP 0019, AVPP 1363 and CHT3-2 showed maximum cell membrane stability indicating their high temperature tolerance. Study of pollen germination at 37 ºC revealed that CHT3-2, AVPP 1363, AVPP 9814 and AVPP 0019 showed maximum pollen germination at high temperature.

French bean: Eighteen accessions of French bean germplasm were characterized for DUS traits as per NBPGR descriptors. IC 632961 recorded highest pod yield of 255 g $plant^{-1}$ with dark green colour and flat pod traits, and 18.20 cm pod length. The next best accession was IIHR-B-PV 24 with pod yield 185 g $plant^{-1}$, light greenish cream pods and pod length of 14.44 cm. These two accessions are vegetable type, while IC 632961 is more suitable for niche market. It has high antioxidant capacity and protein content.

Dolichos Bean (*Lablab purpureus* L.; Family *Fabaceae*): All available soybean germplasm were evaluated for fresh seed size, fresh seed aroma and fresh pod yield; and their suitability for fresh vegetable purpose. Among them 10 genotypes namely, AGS 339, AGS 350, AGS 380, AGS 406, AGS 447, AGS 460, AGS 461, AGS 610, AGS 457 and AGS 459 were found suitable for vegetable purpose.

A total of 122 germplasm of pole dolichos were screened for Dolichos Yellow Mosaic Virus (DYMV) resistance under natural field conditions during summer of 2020, where only three genotypes namely, IC 556703, IC 556723 and IC 632639 were completely resistant to DYMV, 26 were highly susceptible and the remaining were moderately resistant. The results confirmed the previous year's summer field evaluation at ICAR-IIHR, Bengaluru.

Thermo-tolerance in released varieties of Dolichos bean: A total of eight pole dolichos and seven bush dolichos varieties were evaluated during *Kharif*, winter and summer seasons for pod yield and its attributes in RBD with replications. Among them, Arka Krishna in pole type and Arka Vijay in bush type showed better stability with high performance over three seasons and selected for further thermo-induction studies.

Evaluation of pole type dolichos germplasm for DYMV resistance in field condition

Genotypes	Severity Scale	PDI	Relative Value	CI	Disease Reaction
IC 556703	0	0.0	0.0	0.0	Immune
IC 556723	0	0.0	0.0	0.0	Immune
IC 632639	0	0.0	0.0	0.0	Immune
IC 556739	1	9.0	0.2	1.8	HR
IC 556817	1	8.5	0.2	1.7	HR
IC 556708	3	15.0	0.4	6.0	R
IC 556868	3	16.5	0.4	6.6	R

Nutritional profiling of Dolichos bean: Fifty five country bean indigenous accessions were analysed for protein and mineral content. The accession IIHR-B-DB56 contained highest protein (5.6 mg 100 g^{-1}), while IC 0625259 was the richest source of iron (34.6 ppm) and zinc (58 ppm). Two accessions registered more than 10 ppm copper (IIHR-B-DB 47 and 51) and calcium (IIHR-B-DB 20 and 49). Accession IC 632965 was the richest source of anthocyanin and vitamin C. These accessions could be used as donor parents for trait specific breeding program of country bean improvement. Characteristic spectra developed for pod biochemistry by ATR-FTIR analysis and vibrations at 1516-1518 cm^{-1} and 1634-1637 cm^{-1} were found to be specific for amide stretch.

Screening Dolichos bean var./ germplasm for tolerance to high temperature: Eleven var./ potential accessions (Arka Soumya, Arka Amogh, Arka Vistar, Arka Swagat, Arka Sambhram, IIHR-B-DB25, IC 632964, IC 624258, IC 632965, IC 632967 and IC 624268) were screened for thermo-tolerance through Temperature Induction Response (TIR) technique at vegetative stage. Arka Soumya, Arka Vistar and IIHR-B-DB25 were identified with higher cellular tolerance based on survival percentage (up to 90%), lower growth reduction of root and shoot (8-10%), less reduction in seedling biomass (18-20%) and metabolic changes associated with standardized optimum induction temperature response.

Cluster bean (*Cyamopsis tetragonaloba* L. Taub; Family *Fabaceae*): Elite cluster bean lines were identified and evaluated for their minerals, protein, phenolic, antioxidant content and amino acid profiles along with check Pusa Navbahar. All identified lines viz., IIHRCB 22-1-1, IIHRCB 23-1-1, IIHRCB 26-2-1, IIHRCB 27-1-1 and IIHRCB 32-1-1 had higher amino acid and phenol contents compared to check; IIHRCB 23-1-1 and IIHRCB 27-1-1 had higher protein and iron content; IIHRCB 22-1-1, IIHRCB 26-2-1 and IIHRCB 32-1-1 had higher antioxidant activity; IIHRCB 22-1-1 had greater mineral content (N, K and Ca) compared to check.

Ridge gourd (*Luffa acutangula* (L.) Roxb. Family *Cucurbitaceae*): Eighteen germplasm lines of ridge gourd were evaluated in RBD with two replications during Rabi season for yield and yield components. Superior ridge gourd accession IIHR-156 (35.6 cm) had recorded maximum fruit length, and IIHR-139 (7.8 cm) the lowest; IIHR-139 (10.75) had highest number of fruits plant^{-1}, and IIHR-141 (1) the lowest, fruit weight was maximum in IIHR-131B (183 g) and had IIHR-141 (20 g) the least. Fruit yield was high in IIHR-158 (230.28 q ha^{-1}), IIHR-164 (212.83 q ha^{-1}) and IIHR-RG-131B (196.49 q ha^{-1}), while IIHR-141 (4 q ha^{-1}) recorded lowest.

Evaluation of Ridge gourd germplasm

Germplasm	NF	DF	NM	DM	FL (cm)	FG (cm)	PL (cm)	DH	FP	FW (g)	YP (kg)	YH (Q)
IIHR-131A	6.98	42.17	1.57	38.32	35.55	14.60	7.40	55.00	4.96	121.43	0.60	120.07
IIHR -131B	4.07	43.79	2.96	42.59	31.65	14.60	7.40	55.00	5.37	183.01	0.99	196.49
IIHR -132	6.23	45.73	2.87	40.81	25.10	14.42	6.85	55.00	5.67	160.99	0.91	182.07
IIHR -133	3.84	42.00	1.96	38.56	27.25	13.60	7.30	55.00	5.45	158.69	0.87	173.25
IIHR-145	4.58	44.82	3.50	43.56	23.25	14.05	6.10	55.00	5.20	150.97	0.79	156.75
IIHR -158	5.48	42.72	4.00	44.00	30.35	13.45	8.10	55.00	7.10	162.52	1.15	230.38
IIHR -163	5.59	44.45	2.00	39.05	18.35	13.28	5.90	59.00	6.80	110.09	0.75	149.32
IIHR -144	5.56	46.75	2.96	42.60	24.50	14.75	6.75	55.00	5.90	160.76	0.95	189.08
IIHR -160	5.00	48.50	2.38	45.28	17.75	15.50	6.10	55.00	5.01	133.46	0.67	133.13
IIHR -156	6.29	48.54	2.32	45.57	35.60	14.60	7.80	55.00	6.55	143.50	0.94	187.50
IIHR -165 A	5.29	43.46	2.44	43.88	31.75	15.00	5.70	55.00	5.40	155.94	0.84	167.84
IIHR -165 B	4.49	45.37	2.19	44.32	27.75	14.90	6.50	55.00	3.60	170.82	0.62	122.87
IIHR -166	5.82	43.77	2.06	40.67	30.65	14.20	6.65	55.00	4.80	176.18	0.85	169.50
IIHR -164	4.89	42.02	2.00	41.10	21.30	15.75	6.95	55.00	6.00	178.28	1.07	212.83
IIHR -135	6.54	47.84	2.34	46.56	28.20	14.10	7.55	55.00	5.20	167.11	0.87	174.00

IIHR -139	3.00	44.17	1.88	40.50	7.80	7.65	5.80	55.00	10.75	33.54	0.36	71.40
IIHR -141	3.00	45.50	2.00	37.00	9.35	9.55	4.30	55.00	1.00	20.00	0.02	4.00
IIHR -140	6.50	39.50	3.00	38.80	18.85	13.35	8.05	55.00	5.14	104.04	0.53	106.77
MEAN	5.22	44.54	2.48	41.73	25.06	13.78	6.76	55.21	5.58	138.17	0.77	153.14
Significance	NS	*	NS	*	*	NS	NS	NS	NS	*	NS	*
C.D at P=0.05	1.91	6.81	0.95	5.18	5.24	1.39	1.83	0.03	1.51	18.89	0.17	37.21
CV %	17.42	7.27	18.15	5.92	9.98	4.79	12.87	0.02	12.91	6.51	11.75	11.56

NF-Node number for first female flower appearance; FL-Fruit length (cm); NM-Node number for first male flower appearance; DM-Days taken for first male flower appearance; FP-Number of fruits plant^{-1}; DF-Days taken for first female flower appearance; FG-Fruit girth (cm); FW- Fruit weight (g); PL-Peduncle length (cm); YP-Fruit yield plant^{-1} (kg); DH-Days to first fruit harvest; YH-Fruit yield t ha^{-1}

Fruits of IIHR-158 (*left*) and fruit variability present in germplasm (*right*)

Bitter gourd (*Momordica charantia* L.; Family *Cucurbitaceae*):

Evaluation of bitter gourd germplasm for earliness and fruit characteristics: Seven germplasm lines collected from AVRDC, Taiwan, were characterized for fruit characters. Of these, six lines were uniform and they were characterized for flower and fruit traits. All lines had green coloured fruits. One line had continuous ridges (IIHR-198) and the remaining five lines had discontinuous fruit ridges.

Genetic variability for fruit traits in bitter gourd

Evaluation of bitter gourd germplasm for yield, antidiabetic traits and mineral content: Twenty three germplasm lines were evaluated for yield, antidiabetic traits and mineral content. The promising lines for yield are IIHR-191-8 (38.38 t ha^{-1}) followed by IIHR-148-6 (38.26 t ha^{-1}) and IIHR-191-9 (34.44 t ha^{-1}). Among the germplasm lines evaluated for antidiabetic properties, IIHR-195 recorded highest charantin content (1.86 µg g^{-1} DW) and IIHR-180-4 recorded highest momodicin content (8.54 µg g^{-1} DW). Maximum calcium content was recorded in IIHR-170-1 (1.62% DW) and maximum iron content was recorded by IIHR-189-4 (278.7 ppm 100 g^{-1} DW).

Fruits of IIHR-191-8

Fruits of IHR-195

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.; Family *Cucurbitaceae*): Nine bottle gourd genotypes were evaluated and the genotype BG-157 was the earliest in fruiting (33.67 days) followed by BG-159 (35.00 days). Appearance of first female flower varied from node 9.1 (BG-168) to 28.2 (BG-158); length of fruit varied from 8.17 cm in BG-155 to 44.44 cm in BG-150, and the circumference of fruit from 16.33 cm (BG-159) to 60.33 cm (BG-155). The genotype BG-155 registered high marketable fruit yield of 48.53 t ha^{-1} followed by BG-148 (38.45 t ha^{-1}).

Ash gourd (*Benincasa hispida* (Thunb) Congn.; Family *Cucurbitaceae*): Eight genotypes of ash gourd were evaluated for yield and yield attributing traits. Fruit length ranged from 16.6 cm (AG-25) to 35.1 cm (AG-27); circumference of fruit from 50.2 cm (AG-21) to 103.2 cm (AG-19); fruit weight varied from 2.45 kg (AG-12) to 14.76 kg (AG-27). The accession AG-21 recorded maximum yield of 20.15 kg plant^{-1}.

Variability in ashgourd genotypes

Drumstick (*Moringa oleifera* Lam.; Family *Moringaceae*): Leaf nutrient analysis was carried out in 53 drumstick germplasm lines and the mineral content ranged 0.13-0.83% P, 0.88-3.12% K, 0.06-0.73% Ca, 0.06-0.07% Mg, 0.056-0.307% S, 122.7-395.8 ppm Fe, 20.7-661.6 ppm Mn and 21.7-69.3 ppm Zn on dry weight basis.

Curry Leaf (*Murraya koenigii* (L.) Sprengel; Family *Rutaceae*): Forty-five curry leaf germplasm were evaluated for fresh leaf yield per plant, leaf size, leaf color, leaf texture and leaf fragrance in one year old plants. The genotypes LSR/18/75, LSR/18/8, LSR/18/9 and LSR/18/06-a registered significant higher fresh leaf yield per plant (22.4, 21.4, 21.2 and 19.6 kg, respectively), than variety Suwasini (15.6 kg plant^{-1} yr^{-1}). The essential oil yield varied from 0.63 ml 100 g^{-1} (LSR/18/06-b) to 0.11 ml 100 g^{-1} (LSR/18/162), while the check variety Suwasini yielded 0.27 ml 100 g^{-1}.

Variability in leaf size

Essential oil composition of curry leaf germplasm: The chemical composition of essential oils of 20 fresh curry leaf germplasm was analysed using a GC-MS and 99 volatile compounds were identified. The number of chemical compounds varied from 28 in BRR/18/10 to 45 in RRP/18/4. The *trans*-caryophyllene content varied from 16.7% (BRR/18/8) to 69.4% (LSR/18/162). The other major essential oil compounds found were valencene (11.5%), gamma-terpenene (9.43%), alpha-humulele (7.08%) and alpha-pinene (6.0%).

Nutritional characterization of curry leaf germplasm: Forty five curry leaf genotypes were characterized for nutrients content and found in the range of 0.13-0.29% P, 0.55-3.22% K, 1.79-7.90% Ca, 0.368-1.462% Mg, 0.063-0.266% S, 134.65-643.8 mg kg^{-1} Fe, 3.55-15.8 mg kg^{-1} Cu, 9.6-53.15 mg kg^{-1} Mn, 31.05-131.75 mg kg^{-1} Zn and 10.76-34.93 mg kg^{-1} B. The calcium content was high in genotypes BRR18/15 (7.90%) and LSR18/9 (7.89%), compared to the reported reference value of 0.8% indicating that these genotypes are superior source for calcium.

FLOWER AND MEDICINAL CROPS

Chrysanthemum: The evaluation of 20 germplasm for yield and flower quality indicated that the genotype Arka Yellow Gold recorded higher loose flower yield. The genotypes IIHR4-8, IIHR2-16 and IIHR2-13 were promising for pot culture and bedding.

China aster: A total of 28 germplasm lines were evaluated for yield and quality traits. In white flower colour group, cultivars Phule Ganesh White and Arka Archana recorded high loose flower yield, in pink colour group, Arka Kamini was promising for cut flower. All the Matsumoto series varieties showed dwarf plant stature.

***Centella asiatica* (Mandukaparni)**: Evaluation of 12 germplasm accessions of *Centella asiatica* showed that IIHR-CA-17 and IIHR-CA-18 gave the highest biomass yield of 7368.7 and 6784.0 kg ha^{-1} respectively. Analysis for the bioactive secondary metabolites showed that IIHR-CA-23 had the highest amount of asiaticoside (3.96%) and total triterpenoid content (10.81%) among the accessions.

***Bacopa monnieri* (Brahmi):** HPLC method for estimation of total bacoside A (bacisode-A3, bacopaside-II, jujubogenin and bacopa saponin content) has been standardized. The evaluation of 65 accessions indicated that bacoside A content ranged from 0.89-2.54%. The accessions IC 284992 and IC 410932 registered higher bacoside A content of 2.54 and 2.48%, respectively. The bacoside A content was less than 2% in eleven accessions.

***Eclipta alba* (Bhringaraj)**: The HPLC method for estimation of wedelolactone in *E. alba* has been developed and validated. Wedelolactone was estimated in different plant parts, maximum content was found in the leaves (2.84%), followed by flowers (0.034%), stem (0.008%) and roots (0.0003%). The variability in wedelolactone content among 68 accessions was 0.002 to 0.213% in the whole plant samples.

3.2. CROP IMPROVEMENT

3.2.1. FRUIT CROPS

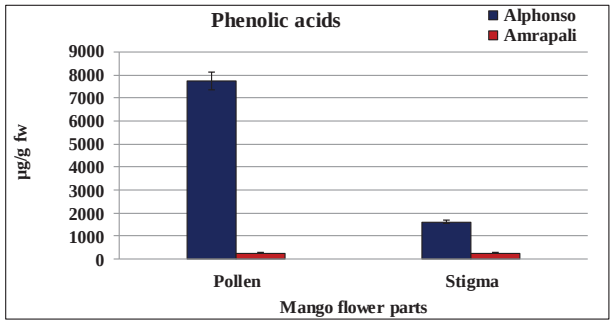
Mango

Evaluation of hybrids: Hybridization was carried out in five different combinations and nine F_1 progenies were raised for evaluation. Out of 34 hybrids (progenies of Amrapalli x Vanraj) evaluated for fruit quality parameters, three (R3P12, R3P16 and R4P18) were selected for further evaluation. Forty eight OPs of Vellaikolumban (29), Vanraj (13), Goa Mankhurad (2) and Mulgoa (4) were not superior in taste and pulp colour.

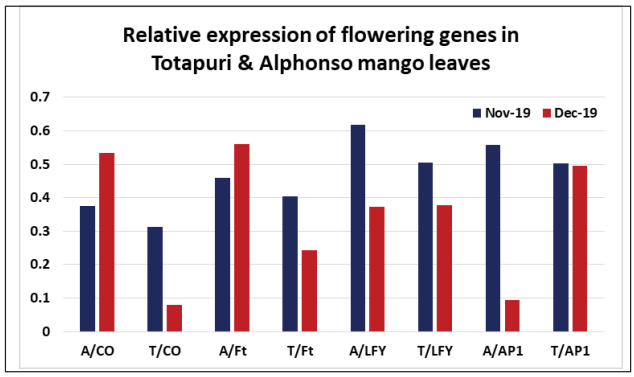
Studies on polyembryony: The fragment analysis and allele inheritance pattern from gene scan data of 14 out of 16 SSR primers in progenies of cross combinations involving polyembryonic var. Vellaikolumban as female with six monoembryonic varieties as male parents revealed that most of the progenies did not have 50:50 ratio of alleles flow from both the parents to confirm that they are hybrids from the zygotic embryo, but most had maximum allele flow from the maternal parent, with 6.25 to 37.5 % allele flow unassigned to either of them, while the other two primers (MiIIHR17 and MiIIHR31) indicated all the progenies of one cross combination (Vellaikolumban x Alphonso) to be hybrids. When leaf volatile profiles of the seedlings of three polyembryonic varieties were compared with their respective mother plant, it was found that where only one or two seedling emerged per seed, they were similar to the respective mother plant while the last emerging seedling was different from mother plant where more than three seedlings emerged per stone.

Transcriptome analysis: A total of 12940 differentially expressed genes were identified in mango cultivars with contrasting TSS namely Hur, K-0-7 and Dattatreya local for high TSS and Adderijeerige, Huleappekai and Halasage, for low TSS of which 5956 were up regulated genes and 6984 were down regulated genes. Similarly with high acidity cultivars namely Adderijeerige and Nandagar and low acidity cultivars, Bridabani Hur and Dilpasand, 11317 genes were identified among which 5665 were up regulated and 5652 were down regulated. The noncoding RNAs (lncRNAs) identified for high and low TSS cultivars were 33191 and 24706 respectively. Where as in high and low acidity varieties, lncRNAs identified were 6393 and 16253 respectively.

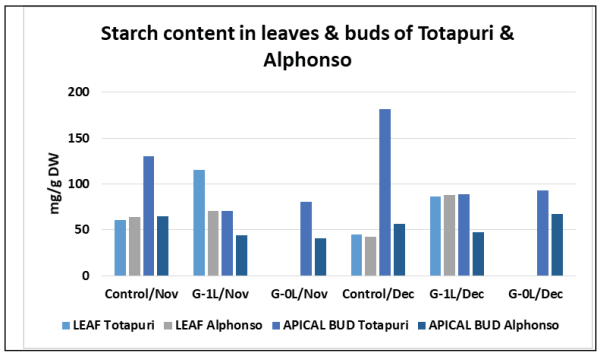
Mango flower metabolites: To understand the variations on the fruit set pattern, metabolites were assessed in the pollen and stigma of cvs. Alphonso and Amrapali. Among these, auxins and gibberellins were more and abscisic acid, amino acids and phenolic acids were less in pollen and stigma of cv. Amrapali compared to Alphonso. Phenolic acids were significantly less in Amrapali flowers. Lower content of phenolic acids and abscisic acids may help in better fruit set and retention in cv. Amrapali. Pollens were found to have very high phenolic acids compared to stigma. Gallic acid and protocatechuic acids were the major phenolic acids in pollen and stigma of both the varieties.



Biochemical and molecular basis of variation in flowering in mango: Samples of leaf, bark and apical bud were studied in Totapuri (regular bearer), and Alphonso (irregular bearer), in November (before vegetative/ floral differentiation) and December (after differentiation), and analyzed for expression of flowering genes, hormones, sugars, amino acids and C:N ratio. The year 2019-2020 was on-year for Alphonso (96% flowering), while in Totapuri only 66% flowering was recorded in girdled/ 1 leaf branches. Defoliated branches displayed 100% vegetative differentiation in both vars., indicating that leaves are the primary source of floral signal. The relative expression of flowering inducer genes *CONSTANS* (*CO*), *FLOWERING LOCUS T* (*Ft*), *APETALA* (*AP1*) and *LEAFY* (*LFY*) were studied between the two varieties, and among the treatments, in leaf, bark and apical bud. In general, expression of all the flowering genes studied in leaves were higher in Alphonso; the relative expression decreased by December in most genes, with the exception of *CO* and *Ft in* Alphonso, and *AP1* was on par in both sampling periods in Totapuri.



Expression of flowering genes in leaves of Totapuri and Alphonso: Sugar content increased on girdling in both vars., in November and December samplings, but on flowering it was used as energy source and depleted in both control and girdled/ 1 leaf branches. Starch content was almost twice higher in buds of Totapuri; and depleted in both var. on girdling and defoliation, and upon flowering initiation. Glucose, fructose, sucrose and mannose were the major sugars detected, higher in the leaves than apical bud.



Starch content in leaves and buds of Totapuri and Alphonso

Of the hormones salicylic acid, abscisic acid, jasmonic acid and methyl jasmonate were higher in apical bud compared to leaf, in girdled/ 1 leaf branches and more so in Totapuri than Alphonso. Of the amino acids Trp increased significantly with flowering, further high contents of Leu, Phe in leaves, Arg and Tyr in apical bud were recorded in girdled/ 1 leaf treatment. Buds contained higher C:N ratio than leaves, which decreased with flowering in the December samples.

Guava

Breeding for wilt resistance: Hybridization involving the wild species *Psidium cattleianum* as male parent and Arka Poorna, Arka Rashmi, Arka Mridula and Arka Kiran as female parents resulted in the recovery of 1620 seeds of which 1030 seeds germinated. The resultant seedlings are being screened for nematode and wilt resistance. Another wild species, *Psidium friedrichsthalianum* showed resistance to two isolates of *Fusarium* (GW-10 from Kanpur and GW-G from Guntur) and root knot nematode (*Meloidogyne incognita*) with gall index 1.0 after 6 months of challenge inoculation in pot culture studies.

Susceptible *Psidium guajava* (Left); Resistant *Psidium friedrichsthalianum* (Right)

Mutation studies: Seeds of purple guava were subjected to LD_{50} @ 250 G to induce mutation for developing wilt resistant root stock. Out of 4000 seeds inoculated, 67 seedlings survived after screening in threshold toxin concentration (40% = 6.69 mM fusaric acid equivalent). The toxin survived seedlings were multiplied and rooted in MS media supplemented with suitable hormones. The acclimatized plants are subjected to root challenge bioassay with the GW-10, *Fusarium* isolate.

Double Haploid (DH) production: Androgenesis and Gynogenesis has been initiated in guava cv Arka Poorna. MS media supplemented with different hormone concentration were tested by inoculating the anthers and ovaries of guava var. Arka Poorna flower buds (0.5 cm to 0.75 cm diameter**).** Callus formation in anthers started from 7-8th day after inoculation and was sub cultured between 25 to 30 days. Callus initiation in ovules was observed after 45 days of inoculation.

Optimizing productivity under salinity and drought stress: Guava species responded differentially to NaCl induced salinity with tolerance limit ranging from 3.81 to 6.18 dS m^{-1}. *Psidium catellianum* (Lemon guava) tolerated high salinity of 6.18 dS m^{-1} and *P. chinensis* exhibited low salinity tolerance of 3.81 dS m^{-1}. Salinity treatment (200 mM) did not alter total cytokinin content in the roots but increased total polyamines content in leaves of guava species. Among the component cytokinins, isopentenyl adenosine (Ipa), and zeatin riboside increased and zeatin and dihydrozeatin riboside content decreased, and component polyamines, spermidine, spermine and putrescine increased differentially in all the guava species. The increase in Ipa (2.4 fold) and spermine (2.9 fold) was high in salinity tolerant, *Psidium catellianum* (Lemon guava). This indicated possible involvement of Ipa and spermine in salinity tolerance of guava species.

Papaya

Breeding for PRSV resistance: The F_1 intergeneric progenies of both hermaphrodites (S4-17, S4-18, S4-1) and females (S4-15, S4-13) of Arka Prabhath x *Vasconcellea cauliflora* and F_1 progenies of hermaphrodite (S1-19, S1-17, S6-20) and female (S5-12, S2-14 and S2-18) of Arka Prabhath x *V. cundinamarcensis* were advanced further to F_2 and BC_1 generation based on desirable fruit quality coupled with PRSV tolerance. A total of 93 progenies out of 1016 F_2 progenies of Arka Prabhath x *V. cauliflora* and, 198 progenies out of 2328 progenies of Arka Prabhath x *V. cundinamarcensis* did not express symptoms at the end of inoculation period and were field planted for further evaluation.

IGHS-1-17 GHS 1-19 IGH 6-20

Field view of the selected intergeneric progenies

IGHS-1-17 IGHS-1-19 GHS-6-20

Fruit shape and Pulp colour of the selected intergeneric progenies

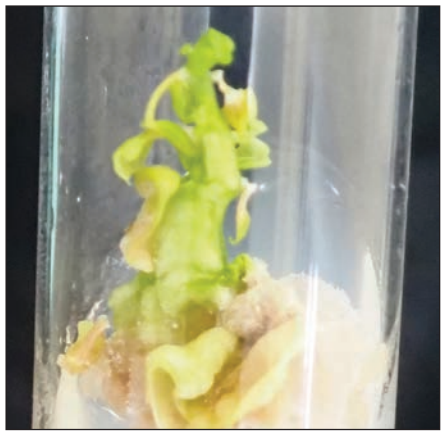
Evaluation of back cross progenies: Two progenies *viz.*, S 20-10 and S 21-4 (of the cross Arka Prabhath x *V. parviflora* x Arka Prabhath) having desirable fruit traits (676-784 g fruit weight, TSS of 13.64-14.20 ^{O}B, pulp thickness of 2.78-3.0 cm), coupled with PRSV tolerance were selfed, and this resulted in the generation of 210 BC_1 F_1 progenies showing varying degrees of PRSV tolerance. From the earlier intergeneric cross, field planting of 117 F_1 intergeneric progenies namely Arka Prabhath x *V. cauliflora* (101 progenies) and Arka Prabhath x *V. cundinamarcensis* (16 progenies) was done, and these progenies are in fruit development phase with varied level of PRSV tolerance. In the new intergeneric crosses of Arka Prabhath x *V. cundinamarcensis*, fruit set was 66.6% in 60 flowers out of 90 flowers crosses.

Targeted molecular mutagenesis: With the application of TILLING technology in papaya cv. Arka Prabhath, several genes of ethylene biosynthesis, perception and downstream action, including ACC synthase, ACC oxidase, ETR1, PG and a unique eIF4e host protein involved in PRSV interaction, have been targeted for SNPs using Real Time quantitative PCR and High Resolution Melting (HRM) analysis methodologies. Flowering and fruit initiation have already started, in both M1 and M3 progenies of selected M2 lines. Various observations regarding plant height, height to first flowering, days to first flowering, inter-nodal traits, stem girth, pigmentation, canopy volume, leaf traits and sex typing have been recorded. Several promising lines have been identified. One mutant, $R_{25}P_{10}$, showed field tolerance to PRSV.

Fruit pulp colour variations in mutant lines

$R_{25}P_{10}$ M_1 plant showing field tolerance to PRSV

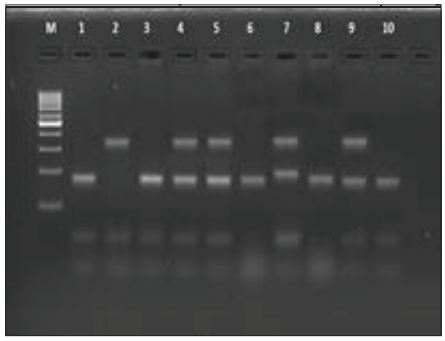
Accelerated apomixis breeding by doubled haploid technology: Immature and unfertilized egg cell-containing embryos of papaya cv. Arka Prabhath were used as explants. Various hormone, media and stress treatments were combinatorially used for callus and organogenic induction. The cultures showed various levels of morphogenesis. A large number of immature ovules from unfertilized fruits of papaya (Arka Prabhath) have been cultured *in vitro* on MS media with modifications. Pollen from male/hermaphrodite plants were subjected to gamma irradiation at different doses and were used to pollinate hermaphrodite (anthers removed previously)/ female flowers. Fruits were harvested from the plants and seeds extracted aseptically for culturing on MS media with modifications. Culture responses are being recorded regularly.



Shoot induction in immature, unfertilized embryogenic egg cell tissue in papaya

Hybrid embryo rescue: Two SSR primers namely m*Cp*CIR3 and m*Cp*CIR25 were used for hybridity testing in the female parent A P (Arka Prabhath) and male parents (*V. cundinamarcensis* and *V. cauliflora*) and the F_1 progenies obtained by crosses between A P x *V. cauliflora* and A P x *V. cundinamarcensis.* The amplification of species-specific PCR product confirmed that the progeny were true hybrids.

Crosses	Primers	Amplicon size
A. P x *V. cundinamarcensis*is	m*Cp*CIR3	318 bp
A. *P* x *V. cauliflora*	m*Cp*CIR3	NA
A. *P x V. cundinamarcensis*	m*Cp*CIR25	261
A. *P* x *V. cauliflora*	m*Cp*CIR25	265



SSR gel profiling for parents and hybrids with primer m*Cp*CIR3

Lane M-100 bp Marker; Lane 1-Arka Prabhath, Lane 2-*V. cundinamarcensis,* Lane 3-10- Hybrids of A P x *V. cundinamarcensis*

Pummelo

Evaluation of hybrids: 245 hybrids from four different cross combinations and 240 half-sibs are being evaluated for less bitterness, thin skin and precocity in bearing. Flowering was observed in 9 hybrids and 12 half sibs of which 7 hybrids and 8 half sibs were characterized for fruit quality traits. The hybrid R11P9 (3-2 x 19-1) has been selected for low bitterness and sweetness.

Pomegranate

Evaluation for quality: Selection A 4/2 (open pollinated progeny of Bhagwa developed by individual plant selection) was found promising with dark red (RHS RG53A) and bold arils (8.42 x 5.74 mm). It is sweet (>13 ^{0}B) and soft seeded with high anthocyanin content (61.82 mg 100 g^{-1} arils). It is semi vigorous with medium size fruits (200-300 g) and yields 15.53 kg in 4 year old plant), which is at par with Bhagwa. The rind colour is red with orange shade (RHS colour code RG44A with ORG32A).

Sapota

Evaluation of progenies for yield: Ten selected progenies were evaluated which showed no significant differences in growth. The yield and fruit quality parameters of 223 progenies of Cricket Ball x PKM-1 revealed that the per plant yield varied from single fruit (4-6) to 365 (4-19) fruits. The weight of fruit ranged from 26.5 g (4-6) to 120 g (11-3). Higher fruit weight (>100 g) was recorded in 10-13, 11-13, 10-1, 8-7, 6-14, 4-7 and 2-3. In these progenies, fruit diameter varied from 4.7-6.5 cm, TSS (15.5-29.3 ^{o}B) was higher in progenies 3-4,3-9 and 7-8. The number of seeds per fruit ranged from 1.3 to 6.3, it was low (<2) in 2-4, 2-8, 3-1 and 3-4. Among the progenies of PKM-1 x Cricket Ball, the number of fruits per plant ranged from 1-50, and fruit weight ranged from 21.76-72.0 g, TSS ranged from 12.0-29.0 ^{o}Brix, number of seeds per fruits were 3.34-4.34. The fruit pulp colour were dark brown, yellow and pinkish.

Jamun

Evaluation of mutants: Mutant populations of jamun (387) were evaluated for growth characters: plant height ranged from 270-670 cm, stem girth 8.5-22.0 cm, leaf length 8.0-15.0 cm, leaf width 1.7-6.2 cm. Six mutants flowered and fruited during 2020.

SSR mining and diversity analysis: A total of 17457 SSR primers were designed using the partial genome sequence data. Among them 60 SSRs were randomly selected to assess the genetic diversity of different genotypes of jamun and related species. Total genomic DNA was isolated from 104 jamun genotypes and 6 related species collected from ICAR-IIHR, Bangalore, and from 28 genotypes received from NE region, Tripura. PCR conditions for 60 SSR primers were standardized and diversity and genetic relatedness among them analysed. Fruit biochemical parameters of 27 jamun

genotypes located at ICAR-IIHR, Bangalore, was done for TSS, acidity, antioxidants, anthocyanin, phenol and vitamin C.

Jackfruit

Genotyping and diversity analysis: Jackfruit samples from IIHR germplasm collection and Andhra Pradesh and West Bengal states received from AICRP Fruit centres was done using SSR markers.

Annona

Breeding for quality: Backcrossing of Arka Sahan with *A. squamosa* cv. Balanagar (BC_1F_1) was carried out to develop self fruitful population and about 1600 progenies were evaluated. The progeny 10/3 was found promising with 360-400 g fruit weight and 30°B TSS. About 500 progenies of crosses between atemoya and custard apple were found to be unstable for yield and self-fruitfulness.

Annona progeny 10/3

Grapes

Breeding for mildew resistance: In grape rootstock breeding, hybridization between Dogridge and 110R yielded 85 hybrid progenies of which 57 plants survived. 173 M_1 mutant progenies of Dogridge were added during the current year to the already established 150 M_1 progenies in the field taking the total to 323. Further, 1000 hardwood cuttings of Dogridge were gamma irradiated and planted. The survival of cuttings was 60%.

In grape scion breeding program, hybridization of Red Globe as female parent and Bianca as male parent was taken up. 120 hybrid progenies were screened at nursery stage of which 14 were tolerant to downy mildew.

Banana

QTLseq analysis: The pooled bulks of *Fusarium* wilt tolerant and susceptible F_1s, with their contrasting parents Calcutta 4 (tolerant) and Kadali (susceptible) resulted in three QTLs on the chromosomes 2, 9 and 10. The genes corresponding to these QTLs have been selected for further expression studies. QTL seq-analysis was performed using the same mapping population for seeded and non-seeded characters in banana. A genomic region has been identified on the chromosome 2. In an attempt to identify circular RNA in banana genome involved in biotic and abiotic stress. A total of 1961 circular RNAs were identified, 1464 from abiotic and 497 from biotic stresses. For construction of linkage map of *Musa balbisiana*, from GBS data of F_1's a total of 98,822 SNPs have been identified and construction of linkage map is under progress. Stomatal density of banana genotypes belonging to different groups was recorded. From 181 genotypes, stomatal density of 22.74±6.01 in adaxial surface 110.1±16.5 in abaxial surface of leaf was observed.

3.2.2. VEGETABLE CROPS

Tomato

Hybrid development: Twenty-three hybrids along with five checks (Lakshmi, Shivam, Abhinav, Arka Rakshak and Arka Samrat) were evaluated for yield related parameters. Among 23 hybrids, four semi-determinate F_1 hybrids H-505 were suitable for fresh market and five F_1 hybrids (H-501, H-506, PH-1021, PH-1025 and PH-6321) were suitable for indeterminate segment. Higher TSS content was observed in the hybrids, H-385 (5.05 ^{0}Brix), H-371 (5.03 ^{0}Brix) and H-391 (4.77 ^{0}Brix). The fruit firmness was highest in hybrid H-504 (7.19 kg cm^{-2}) followed by hybrids H-387 (6.67 kg cm^{-2}) and H-397 (6.57 kg cm^{-2}).

Breeding for processing and dual-purpose hybrids: 220 germplasm lines selected based on market preferred traits were evaluated in an unreplicated trial. Ten plants of each genotype were grown in a single row. A set of 20 determinate and semi-determinate lines were identified for processing traits. The selected tomato lines were characterized with regard to seed content, TSS, acidity, pH and colour. The replicated trial of the selected lines is underway. These lines were used to develop more than 50 hybrids. The evaluation trial of the developed hybrids is under progress.

Phenotyping for nitrogen use efficiency in tomato: 10 promising genotypes under high and 10 promising genotypes under low N were selected for further evaluation. Under both high N source and low N source media high magnitude of phenotypic variation was recorded for various traits. Under high N, tomato wild accession LA - 2157 recorded maximum N use efficiency followed by IIHR–1940, and LA - 1274 recorded least N use efficiency (100.74) followed by PKM-1. Under low N, LA - 2157 recorded maximum N use efficiency followed by LA - 1963 and LA - 1274 recorded least N use efficiency.

Performance of tomato genotypes for nitrogen use efficiency and related parameters under complete Hoagland nitrogen media

Genotypes	N concentration (%)	Total N accumulation (mg N)	N utilization efficiency (g^2 TDW mg^{-1})	N uptake efficiency (mg N g^{-1} RDW)	Nitrogen use efficiency
PKM – 1	4.08	64.56	3.87	33.48	129.75
Arka Abhed	5.08	95.28	3.69	43.91	161.93
Arka Vishesh	5.06	70.29	2.75	54.65	150.20
Arka Meghali	4.58	76.97	3.66	49.73	182.17
LA - 2157	5.53	66.85	2.18	176.92	386.51
LA - 0483	5.02	64.05	2.54	66.27	168.21
LA -1274	4.86	47.78	2.02	49.78	100.74
LA - 1963	5.13	68.98	2.62	66.12	172.94
LA - 0397	5.33	94.18	3.31	66.76	221.57
IIHR - 1940	5.11	90.59	3.47	64.75	224.64
C.D	**0.12**	**4.08**	**0.16**	**10.54**	**30.70**
C.V	**5.41**	**3.24**	**3.21**	**9.20**	**9.50**

Note**:** TDW: Total dry weight; RDW: Root dry weight

Biochemical and Transcriptome analysis: TV55 (resistant) and 15SBSB (susceptible) plants were inoculated with ToLCBV using whitefly mediated inoculation method. A significant difference in viral DNA accumulation between resistant and susceptible plants from five days to 21 days post inoculation was noticed. The resistant plant RNA samples from respective intervals has been pooled with respect to control and inoculated and used for transcriptome analysis. Phytohormones responsive to biotic stresses like SA, JA, MeJA, *cis*-JA, ABA have been analysed using LC-MS; JA content was more in the initial period of inoculation suggesting its response to herbivore (whitefly) infestation and in later stages the SA content was increased in response to virus inoculation suggesting its role in resistance mechanism against ToLCBVD. When contrasting genotypes for early blight tolerance were screened for phenolic acids and flavonoids, 18 phenolic acids and 15 flavonoids were identified. Estimation of phytohormones showed significant difference in salicylic acid and ABA levels during disease progression.

Chilli

Breeding for ChLCV resistance: To overcome chilli leaf curl disease, genotypes resistant to ChLCV were identified (IHR4615, IHR4597 & IHR4517). Using the identified resistant sources, 52 F_1 hybrid combinations were developed and evaluated along with popular commercial F_1 hybrids and five F_1 hybrid combinations were found promising for yield, fruit quality and resistance to ChLCV. The F_1 hybrids identified by VTIC for release during the period are;

Arka Tejasvi: F_1 hybrid **s**uitable for dry small (Teja) segment, plants medium tall & spreading, fruits pendent, 7-8 x 1-1.1 cm, firm, highly pungent (90-95000 SHU), green and turns deep red (90-100 ASTA) on maturity, medium wrinkled and resistant to powdery mildew and ChLCV, yield potential 30-35q dry chilli yield $acre^{-1}$.

Arka Yashasvi: F_1 hybrid **s**uitable for dry medium segment, plants tall & spreading, fruits pendent, 9-10 x 1.2-1.4 cm, firm, medium pungent (40-50000 SHU), green and turn deep red on maturity (90-100 ASTA), medium wrinkled and tolerant to powdery mildew, RKN (root knot nematodes) and resistant to ChLCV, yield potential 30-35q dry chilli yield $acre^{-1}$.

Arka Saanvi: F_1 hybrid suitable for dual small (green & dry) segment, plants medium tall & spreading, fruits pendent, 7-8 x 1-1.2 cm, firm, medium pungent (50-60,000 SHU), green and turns red (80-90 ASTA) on maturity, medium wrinkled and resistant to ChLCV, yield potential 30-35 q dry chilli yield acre^{-1} (or) 100 q green chilli yield acre^{-1}.

Arka Tanvi: F_1 hybrid suitable for dual medium segment, plants tall & spreading, fruits pendent, 9-10 x 1-1.1 cm, firm, medium pungent (60-65,000 SHU), green and turns deep red (90-100 ASTA) on maturity, dry fruits wrinkled and tolerant to powdery mildew, RKN (root knot nematodes) and resistant to ChLCV, yield potential 30-35 q dry chilli yield acre^{-1} (or) 100 q green chilli yield acre^{-1}.

Arka Gagan: F_1 hybrid suitable for green, upright segment, plants medium tall & spreading, fruits 7.5 - 8.5 x 1-1.1cm, firm, highly pungent (1-1.2 lakh SHU), green, medium wrinkled and tolerant to *Phytophthora* root rot, bacterial wilt, RKN (root knot nematodes) and resistant to ChLCV, yield potential 100 q green chilli yield acre^{-1}.

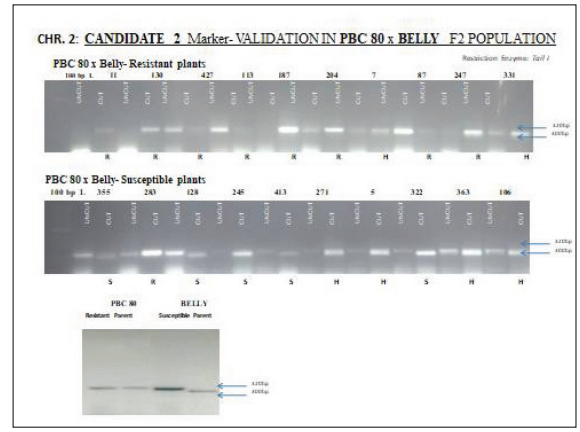
Breeding for pungency in chilli: 680 SSRs were used to screen pungent (IHR 4501, IHR 4550 and IHR 4569) and non-pungent (IHR 4604) chilli genotypes; and 125 polymorphic SSRs and 15 polymorphic markers that differentiate various pungent genotypes were identified. Designed 21 gene specific primers from the genes involves in capsaicinoid pathway. These primers were used to

differentiate four different categories of pungent genotypes *viz.*, mild, medium, hot and extremely hot types. The PCR products were analyzed and sequenced to identify the changes at gene level. The sequence data of *BCAT* (Breached-Chain Amino Acid Aminotransferase) gene revealed the SNP level of sequence variation in selected group as well as species. Among the F_1 hybrids developed for high pungency, IHR-B.JH1 was found promising yielding up to 5 kg red ripe fruits per plant under polyhouse conditions with capsaicinoid content of 7,28,333 SHU.

IHR-BJH1 (F_1)

Breeding for drought tolerance in chilli: Selected *Capsicum* sp. accessions *viz*., IHR3014, IHR4608, IHR4600, IHR4593, IHR4598, IHR3915, IHR4615, IHR4597, IHR4517, IHR4634, IHR3448, IHR4491, IHR4550, IHR3529, Arka Suphal, Devanur Delux & Attigere Dabbi were crossed in diallel fashion and thus developed 91 F_1s along with parents were evaluated during the period. The promising F_1 combinations are being advanced for further evaluation.

Breeding for anthracnose fruit rot resistance: 62 *Capsicum* genotypes were screened for anthracnose fruit rot resistance and contrast parents for anthracnose fruit rot resistance among *C. baccatum* accessions identified. A total of 357 F_2 segregating populations along with contrast parents were genotyped by using genotyping by sequencing (GBS). Through genome-wide association studies (GWAS), total of 19 SNPs (QTNs; Quantitative Trait Nucleotides) significantly associated with fruit rot resistance (at –log10 (p) value >2.82 for % lesion area), of which five SNPs located on *chr2* (physically positioned at 12666827 bp to 141379584 bp) and seven SNPs located on *chr6* (physically positioned at 247161384 bp to 252255814 bp) were found highly significantly associated. These SNPs were converted to PCR based CAPs and dCAPs markers. Resistance related genes within the candidate genomic regions on *chr2* (major locus) were searched on pepper pangenome and Cluster of Nucleotide binding site-leucine rich repeat (NBS-LRR) domain involved in disease resistance in plants was found. The identified SNPs associated with candidate resistance loci are being validated in the segregating populations and will be further used in anthracnose fruit rot resistance (AFRR) breeding program.



Amplification of candidate genes linked to chilli AFRR located on *Chr 2* in phenotyped F_2 populations

Seed pre-treatments for water stress tolerance: Among various pre seed treatments tested, seed treatment with KH_2PO_4 @ 10^{-3} M, glycine, betaine 50 mM and *Bacillus* spp. strain p72 improved performance of chilli genotypes (tolerant (IIHR 4517) and susceptible (IIHR 3453) at different water stress levels (-0.5 MPa, -1.0 MPa and 1.5 MPa). At low water stress (-0.5 MPa), both tolerant and susceptible genotypes exhibited high germination parameters compared to untreated. However, at high water stress (-1.5 MPa) only bio-primed (*Bacillus* spp. strain p72) seeds performed better with 20% germination in tolerant genotype. Seeds treated with KH_2PO_4 @ 10^{-3} M exhibited higher root/shoot ratio and advancement in germination, whereas seeds treated with glycine betaine 50 mM exhibited lower membrane injury index and higher antioxidant enzyme activity. Seeds treated with *Bacillus* spp. strain p72 exhibited higher mobilization efficiency, in both the genotypes.

Brinjal

Grafting studies: Elite brinjal genotypes viz., POBL-2, IIHR-438-2, IIHR-586, Muktakeshi, Sel-4, Arka Harshitha and Black star were grafted on *Solanum torvum, S. seaforthianum, S. gilo* and *S. mammomosum.* There was about 78% graft success, and all the grafts were transplanted to the main field for further evaluation for yield and disease reaction.

CARI-1 grafted on *Solanum torvum*

Mutation studies: A bacterial wilt resistant line Cari-1 was irradiated with 160 GY gamma rays and colchicin with the aim to develop seedlessness in that background and another line Dongar bhati was treated with 160 GY gamma irradiation and colchicin and further M0 seeds were obtained.

Biochemical profiling of advance breeding lines: A total of 15 germplasm lines of brinjal were analysed for biochemical parameters. Highest TSS was recorded in BRSRVAR-7 (4.8 °Brix) and least in IIHR-574 (3.2 °Brix), maximum acidity was recorded in IIHR574 (0.29%) and lowest in MAHY-39, MAHY-10 and IIHR-575 (0.16%), highest vitamin C content was found in IIHR-438-2 (12 mg 100 g^{-1} FW). The maximum phenol and flavonoids content was found in IIHR-576 (181.30 and 246.89 mg 100 g^{-1} FW respectively), and higher anthocyanin was recorded in Dhruva (10.67 mg100 g^{-1} FW).

Evaluation of advance breeding for mineral composition: Among 15 germplasm lines of brinjal evaluated, maximum content of nitrogen and phosphorus was recorded in IIHR-576 (2.46 and 0.83% respectively), potassium in Mahy-39 (3.16%), copper and manganese in IIHR-500A (13.20 and 30.60 mg kg^{-1} respectively), zinc in Lalith (15.10 mg kg^{-1}) and iron in BRSRVAR-7 (82.20 mg kg^{-1}).

Evaluation of F_1 hybrids: Of the 20 F_1 hybrids evaluated for yield and yield contributing traits, five hybrids, Cari-1 x 2019/BRRVAR-7 (2.50 kg $plant^{-1}$), VMG-6 x 2017/SRVAR-6 (2.00 kg $plant^{-1}$). Cari-1 x Arka Neelanchal Shyma (1.75 kg $plant^{-1}$), 2018/BRLVAR-1 x VMG-6 (1.00 kg $plant^{-1}$) and Arka Harshitha x Satputia (0.5 kg $plant^{-1}$) were promising for yield and resistance to bacterial wilt.

Evaluation of F_8 population of purple oblong fruit type for bacterial wilt resistance: Of 11 individual plant selections of cross between IIHR104 x Arka Keshav screened for yield and resistance to bacterial wilt, one IPS namely, IIHR104 x A. Keshav-2-5 was promising with potential yield of 3.25 kg $plant^{-1}$ with no wilt incidence, whereas check variety Kusuma completely succumbed to bacterial wilt. The mean fruit weight was 280 g.

Individual plant selection: Among 12 individual plant selections of cross between IIHR 104 x Arka Neelakant-4-3 evaluated for yield and resistance to bacterial wilt, one IPS namely IIHR-104 x Arka Neelakant-4-3 was promising with yield potential of 2.85 kg $plant^{-1}$ with high level of resistance to bacterial wilt, whereas check variety Kusuma completely succumbed to wilt. The mean fruit weight was 250 g. A total of 10 individual plant selections of cross between IIHR586 x Arka Nidhi were evaluated for yield and resistance to bacterial wilt of which one IPS namely IIHR-586 x Arka Nidhi-1-5 was promising for yield (2.65 kg $plant^{-1}$) with no bacteria wilt incidence, whereas check Black Star completely succumbed to bacterial wilt.

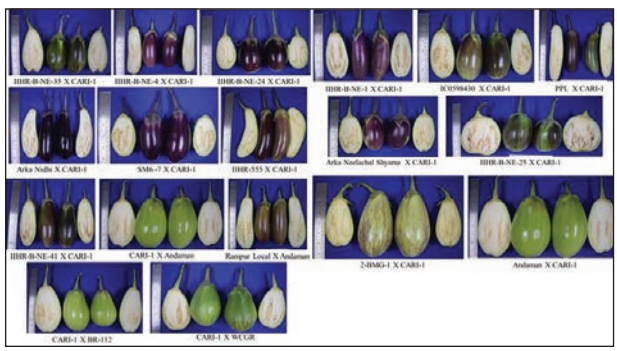
Performance of Manjarigota advanced breeding lines for yield: Out of 11 advanced breeding lines evaluated for yield and fruit quality, one advanced breeding line IIHR-438-2 x IIHR-571-1-2 had a potential yield of 2.55 kg $plant^{-1}$. Flowers were purple with green fleshy calyx and fruits borne in clusters which are attractive dark purple color with white stripes, glossy, and oval in shape, with excellent cooking and keeping quality.

Performance of advanced breeding lines for resistance to bacterial wilt: A total of 10 advanced breeding lines derived from a cross between IIHR438-2 x 2BMG -1 were evaluated for yield and resistance to bacterial wilt, of which one IPS namely IIHR438-2 x 2BMG-1-4

was promising with potential yield of 2.40 kg plant^{-1}, resistance to bacterial wilt, tall plant and spreading growth habit, having dark green stem and foliage, purple flowers and fleshy green calyx, fruits borne in clusters, light purple in colour with white stripes and glossy oval in shape. The check MEBH-10 completely succumbed to bacterial wilt.

Introgression of fruit and shoot borer resistance genes: Among seven interspecific F_8 lines (*S. macrocarpon* x *S. melongena)*, higher yield was observed in S1 (56.25 t ha^{-1}), followed by S4 (8-17) (28.8 t ha^{-1}) and S2 (8-6) (24.15 t ha^{-1}), compared to susceptible check, Arka Kusumakar (8.09 t ha^{-1}). Among 13 F_8 interspecific lines evaluated for BFSB under natural epiphytotic conditions, three advanced breeding lines viz., 8-14 (S7), 8-12 (S6) and 8-17 (S4) recorded less fruit borer incidence (<10%) at marketable fruit stage, whereas in Arka Kusumakar 39.09% incidence was recorded. Through artificial challenging of interspecific F_8 populations with *Leucinodes* adults in net house, 8-17 (S4), 8-16 (S3), 8-6 (S5), 8-12 (S6) and 8-8 IPS showed no incidence of BFSB and were further forwarded. Biochemical analysis of fruits showed higher phenolic content, polyphenol oxidase, peroxidase and solasodine content in selected lines. Molecular analyses confirmed the presence of *S. macrocarpon* alleles in the advanced interspecific lines.

Screening of germplasm for bacterial wilt resistance: At CHES, Bhubaneswar, a total of 31 genotypes of brinjal consisting of varieties, advanced breeding lines and wild species were evaluated for bacterial wilt resistance caused by *Ralstonia solanacearaum*. Among the genotypes, *Solanum melongena* cv. CARI-1 (2.84% wilt) exhibited the highest bacterial wilt resistance. *S. torvum* (3.39%), Utkal Anushree (3.50%), B-NE-3 (4.29%), IIHR-B-NE-1 (4.43%), Arka Nidhi (5.38%), Arka Anand (5.50%), Arka Harshitha (5.79%), Surya (6.71%) and IIHR-IC0598430 (8.29%) were also found to be highly resistant to bacterial wilt. CARI-1 based 18 F_1 hybrids along with 12 hybrids were evaluated for bacterial wilt resistance, yield and yield attributing traits. CARI-1 based F_1 hybrids showed superiority in yields, however showed a varied level of resistance to bacterial wilt.



Okra

Evaluation of advanced lines for yield, pod quality and resistance to YVMV: Among 22 okra breeding lines evaluated, IIHR-10-11-875 was promising with highest fruit yield (22.30 t ha^{-1}), dark green fruits of 12-13 cm fruit length, deeply lobed leaves and no incidence of YVMV under natural epiphytotic conditions, followed by IIHR-386-1-1-26 (19.56 t ha^{-1}) with short fruit length (8-10 cm) and no incidence of YVMV. The improved varieties viz., Arka Anamika, Pusa Sawani and Parbhani Kranti showed 30-35% YVMV incidence and the susceptible check, AC1685 showed 100% susceptibility.

Evaluation of hybrids for yield and pod quality: Of 16 F_1 hybrids along with three commercial check varieties evaluated, OKH-57 gave the highest fruit yield of 29.14 t ha^{-1} followed by OKH-31 (26 t ha^{-1}), with no incidence of YVMV. The yield in check varieties Arka Nikita (24.50 t ha^{-1}), Janni (21.5 t ha^{-1}) and Radhika (19.20 t ha^{-1}) were recorded. All the three hybrids are green and tolerant to YVMV. The fruits are green, smooth, 3-4 branches plant^{-1}, 12.5 cm fruit length, 1.97 cm fruit diameter.

OKH-57 OKH-31

Screening of RIL populations for yield, pod quality and resistance to YVMV: Of 22 F_5 RIL's (recombinant inbred lines) evaluated for yield, pod quality and resistance to YVMV during summer of 2020, four F_5 RIL populations viz., OKH-13-8-5-F_5, OKH-14-4-1-F_5, OKH-15-3-2-F_5 and OKH-18-1-6-F_5 were selected based on yield, earliness, dark green fruits, 5 ribs, smooth, branching habit, shorter intermodal length, good stem girth and resistance to YVMV; and further advanced; F_6 RIL, IIHR-285-1 x 1685 was also found superior with high yield, pod quality and resistance to YVMV.

Evaluation of advanced breeding lines for yield and pod quality: Among the lines evaluated, five breeding lines were found promising for yield, pod quality and resistance to YVMV and were advanced further.

IC-205648

RIL -IIHR-285 X AC1685 F_6

Nucleus seed production: Nucleus seeds of GMS-4 (Female parent) (5.26 kg) and IIHR-299-14-11 (Male parent) (2.99 kg) of Arka Nikita were produced during Kharif 2020.

SSR markers: A total of 51 SSR markers were synthesized using transcriptome data and used for validating 36 okra varieties Comprehensive okra transcriptome data revealed 50,761 small long non-coding RNAs (LncRNA) (>200-950), 6,860 medium LncRNA (950-3000) and 54 long LncRNA (>3000).

French bean

Evaluation of F_3 for MYMV resistance in pole type: F_3 population of crosses between Arka Sukomal x Jade; Arka Sukomal x Arka Arjun; Allama x Jade; Allama x Arka Arjun and reciprocals were evaluated and 60 improved pod selections were made for MYMV resistance along with characters like, light green straight pods, non-stringiness and high yield. Seeds were collected from the plants for further evaluation in the F_4 generation.

Hybridization to improve pod quality of stem fly and heat tolerant breeding lines: F_1 seeds collected from the crossing between breeding lines of IC 525224 x IC 525239; IC 525235 x Arka Anoop and IIHR-231, IIHR-239 (quality podded lines) were sown and plants of F_2 generations were evaluated for stem fly and heat tolerance with dark green stringless pods and the seeds of such F_2 plants were collected for further evaluation in F_3 generation.

Hybridization: To incorporate disease resistance in flat podded (Kentucky Wonder) group of French bean, IC 632961 was crossed with Arka Sukomal and Arka Arjun in reciprocal way. The developed F2 progenies will be evaluated for disease response and horticultural traits at Bhubaneswar.

Cowpea

Breeding for resistance to rust with good pod quality: F_3 generation of the cross between IIHR-8 x Kashi Kanchan; IIHR-11 x Kashi Kanchan, IIHR-16 x Kashi Kanchan and their reciprocals were sown and the plants were evaluated for rust resistance with high yield and good pod quality. Improved IPS has been made for further evaluation in fifth generation. Crosses are being done between cowpea aphid borne mosaic virus resistant germplasm with high yielding lines.

Garden Pea

Combined resistance to powdery mildew and rust: F_1 seeds collected from the crossing between IIHR 13-11, IIHR 13-18 (rust resistant) and Arka Priya, Arka Pramodh, IIHR 141, Arka Ajith (powdery mildew resistant, with good pod quality) were evaluated for rust and powdery mildew resistance and seeds are collected from rust and powdery mildew free plants for further evaluation F_3 generation.

Dolichos Bean

Evaluation for yield and quality: Of the 100 advance breeding lines of pole x bush type Dolichos bean evaluated for plant type, growth habit, green pod yield and quality, three crosses namely, Arka Amogh x 10/DOLPVAR-1-1-IPS-1 (3.4 kg $plant^{-1}$), NM-05-43 x 10/DOLPVAR-1-IPS-10 (3.1 kg $plant^{-1}$) and NM-05-43 x 10/DOLPVAR-1-IPS-10-1 (2.9 kg $plant^{-1}$) were promising, and surpassed the best check Arka Swagath (1.5 kg $plant^{-1}$).

Evaluation of F2 populations: At CHES, Bhubaneswar, selection for anthocyanin content in different pod type and selecting individual plants was carried out. Red podded genotype (IC 632965, pod 7-7.5 cm long, flat) rich in anthocyanin (1.51 mg g^{-1} FW) crossed with creamy greenish, non-pigmented genotype (IC 632970, pod 10.5-11 cm long, round) where anthocyanin pigment found to be dominant over non- pigment in F_1 progenies. In F_2 population (184 plants) segregation occurs in 3:1 ratio for pigmented vs. non-pigmented pod. Three individual plant selections made from this population, namely IC 632970 x IC 632965-96 (11 cm, flat, anthocyanin 1.8 mg g^{-1} FW), IC 632970 x IC 632965-11 (pod 11.5-12 cm, flat, anthocyanin 1.85 mg g^{-1} FW) and IC 632970 x IC 632965-69 (pod 10 cm, round, anthocyanin 1.9 mg g^{-1} FW); yield varied between 1.5 to 2.0 kg $plant^{-1}$.

Hybridization for photo-insensitiveness and pod traits: At CHES, Bhubaneswar, F_1 progenies developed for Arka Swagat (PIS) x IC 632967 (early, purple pigmented) and Arka Swagat (PIS) x IC 632968 (flat, long podded), Arka Swagat (PIS, green) x Swarna Rituvar (PIS, creamy white), IC 632967 (early, purple pigmented) x IC 632965 (red podded, rich in anthocyanin) with the objective of incorporating photo-insensitiveness, anthocyanin content and desired pod traits in different background. F2 progenies will be evaluated for photo-insensitivity and horticultural traits.

Vegetable Soybean

Evaluation of genotypes: Ten genotypes - AGS 339, AGS 350, AGS 380, AGS 406, AGS 447, AGS 460, AGS 461, AGS 610, AGS 457 and AGS 459 were suitable for vegetable purpose. Among them, ASG 339 and AGS 350 had superior vegetable quality for fresh green seed and pod traits.

Radish

Evaluation for yield: Among 65 accessions evaluated for root characters, maximum root weight was observed in Acc 42, 43, 44 compared to check variety, Pusa Chetki, root length in Acc 2 (35 cm), Acc 5 (36 cm) compared to Pusa Chetki (11.5 cm), greater root circumference in Acc. Nos. 42, 43, 44 (18 cm) compared to Pusa Chetki (11.5 cm). Among 65 accessions characterized in polyhouse conditions**,** 19 entries - Acc 49 and 15 are tall and vigorous (best), Acc 6, 8, 17, 21, 22, 26, 34, 35, 38, 48, 51, 52, 54, 55, 56, 57, 63 & 65 were heat tolerant at high temperature (40 °C), with good rooting capacity. Among 20 accessions evaluated for biochemical quality, IIHR 46, 49, 50, 51, 62, 73, 63, 64 and 65 have lesser pungency with less than 1 mg 100 g^{-1} FW isothiocyanates and high TSS of 11.97 °Brix (IIHR 4, followed by IIHR 62 (7.3 °Brix) and IIHR 52 (8.15 °Brix). Nutritional profiling of 22 accessions of radish pods for protein content revealed four promising accessions (IIHR 53, IIHR 18, IIHR 37 and IIHR 46).

Carrot

Carrot germplasm evaluation: Among seven diverse colored carrot germplasm lines evaluated for yield and quality, three germplasm lines Pusa Rudhira (red colour, 27.44 t ha^{-1}), IPC-3 (purple colour, 26.65 t ha^{-1}) and VR-186 (red, 26.42 t ha^{-1}) were promising.

Evaluation for plant growth and yield parameters: Out of 7 lines evaluated during Rabi season, two lines namely CARTVAR-7 (257.20 q ha^{-1}) and CARTVAR- 3 (204 q ha^{-1}) gave significantly higher yield than other lines. Plant height varied from 58.99 cm (CARTVAR-6) to 66.60 cm (CARTVAR-3), number of leaves was more in CARTVAR-3 (average 12.38 $plant^{-1}$), root length was significantly higher in CARTVAR-7 (16.13 cm) and CARTVAR-3 (15.59 cm), average root weight was significantly higher in CARTVAR-7 (96.45), root diameter was highest in CARTVAR-7 (3.86 cm) closely followed by CARTVAR-3 (3.88 cm), core diameter was lowest in CARTVAR-5 (1.75 cm) and highest in CARTVAR-7 (2.29 cm), TSS was at par in all the cultivars with highest in CARTVAR-1 (10.20 °Brix), average fresh leaf weight was highest in CARTVAR-3 (148.75 g), harvest index was highest in CARTVAR-7 closely followed by CARTVAR-4 - 0.95 and 0.89 respectively

Evaluation for plant growth and yield parameters in hybrids: Of seven hybrids evaluated during Rabi season, one line namely CARHYB-4 (293.57 q h^{-1}) gave significantly higher yield, followed by CARHYB-7 (220.91 q h^{-1}). Plant height varied from 58.87 cm in CARHYB-1 to 41.02 cm in CARHYB-5, number of leaves was highest in CARHYB-7 (average of 8.68 $plant^{-1}$), root length was significantly higher in CARHYB-7 (17.10 cm) and CARHYB- 4 (16.62 cm), average root weight was also significantly higher in CARHYB-4 (110.09 g), root diameter was high in CARHYB-4 (4.50 cm), followed by CARHYB-7 (4.34 cm), core diameter was lowest in CARHYB-6 (1.79 cm) and highest in CARHYB-4 (2.39 cm), TSS was at par in all the hybrids with highest in CARHYB-2 (11.16 °Brix), average fresh leaf weight was highest in CARHYB-1 (72.1 g), harvest index was highest in CARHYB-4 closely followed by CARHYB-7 - 1.97 and 1.76-, respectively.

Back crossing between male sterile lines (A lines) and maintainer lines (B lines) for root yield and quality traits: BC9 F_1 resulted in identification of two best lines namely, MS 84-250 X MF 79-301 and MS 82-10 x MF 81-10. MS 84-250 X MF 79-301 recorded higher root length 15 cm, root weight 76 g, root diameter 3.5 cm and TSS 8.6 °B, deep orange root with self colour core, smooth surface and carotene content 16.8 mg 100 g^{-1}.

Evaluation and improvement of selected advanced breeding lines (C lines) for root yield, high carotene content and quality traits: To develop pollen parent (C line), high carotene advanced breeding male lines were evaluated. Of 28 lines, three carrot lines namely HC 72 (carotene content 19.74 mg %, deep orange, long, cylindrical, self core and late bolting), HC 75 (carotene content 18.50 mg %, deep orange and big thick root) & HC 73 (carotene content 17.46 mg %, deep orange, big thick, cylindrical and long roots) had high carotene content with good quality characters.

Evaluation of advanced breeding lines for powdery mildew and nematode resistance: The lines HC 105 (PDI 12.6), HC 31 (15.40) and HC 50 (18.00) were identified for Powdery mildew resistance. A total of 95 advanced lines were evaluated for nematode resistance, of which five were found to be resistant to nematodes namely HC 88 (0 galls), KSP 135 (<10 galls), HC 69 + KSP 135 (<20 galls) and HC 72 (<30 galls); susceptible HC 113 (>100 galls). Mapping population is developed with following combination for identifying markers resistant to nematodes in carrot

Evaluation of advanced lines for yield and qualities: Out of 50 lines, the following performed better for various yield and quality traits: high yield: KSP135 (30 t ha^{-1}), KSP134 (28 t ha^{-1}) & HC 261 (24 t ha^{-1}); high TSS: HC 54 A (14.9 °B), HC 88 (14.8 °B) & HC 21B (14.7 °B); root length: HC 54 (23.66 cm) & HC 88 (21.00 cm); high carotene+TSS+NR+ PMR: HC 88; high carotene+high TSS: HC 21B, HC 21C, HC 105 & HC 261; Black carrot: HA 277 & HA 272 (Black self core); HA 271 & HA 272 (yellow core); Red carrot: RC 7(27.44 t ha^{-1}) and RC 4 (26.90 t ha^{-1}); Purple carrot: PC 6 (26.67 t ha^{-1})

Double haploid production using gynogenesis: The onion flowers were harvested before anthesis stage and different hormonal concentrations were used to standardize the protocol for development of haploid plant. The anthers were removed from sterilized unopened buds and the ovary was inoculated into MS media with different hormonal combinations for development of haploid callus.

Effect of biopriming on seed germination and seedling growth: Seeds were treated with different bacterial strains for 24 h and subsequently incubated at 25 °C under different polyethylene glycol (PEG) induced osmotic stresses (0, -0.2, -0.4, -0.6, -0.8, -1.0 MPa). Seed treatment with bacterial strains influenced the germination and seedling vigour index as compared to the untreated and hydro-primed seeds. *Bacillus* strain (B4) was found to be best among all the tested strains.

Ridge gourd

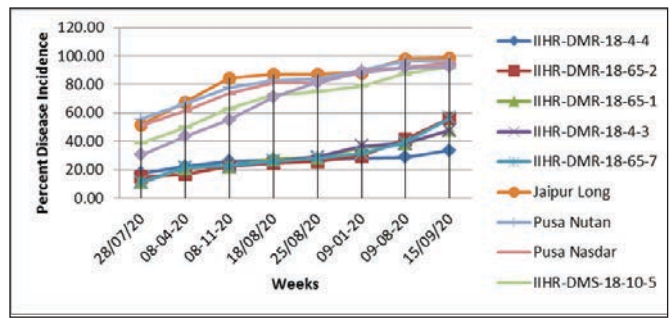
Breeding for ToLCNDV resistance: Sixteen advanced breeding lines including four susceptible lines were evaluated in two replications for ToLCNDV resistance during summer. Data has been recorded on virus incidence at weekly intervals and Vulnerability index against ToLCNDV and area under disease progression curve (AUDPC) was calculated. Of the 17 lines, five lines were resistant with zero incidence, namely IIHR-137, IIHR-138, IIHR-RV-28-2, IIHR-RV-58-3 and IIHR-RV-60-1, against the susceptible lines which recorded high VI and AUDPC viz., IIHR-RV-23-4 (VI=50.44 and AUDPC=346.50) and IIHR-SV-44-2 (VI=46.92 and AUDPC=321.22).

Identification/ validation of molecular marker linked to ToLCNDV resistance: For identification of molecular markers linked to ToLCNDV resistance gene, the parents, Arka Prasan and IIHR-Sel-1 were selected for molecular tagging of ToLCNDV resistant loci. Out of 50 DNA markers, only one marker i.e. LaRGAP 63 had shown polymorphism with an amplified product size (460 bp) in susceptible plants while smaller product size (455 bp) was observed in the resistant plants. PCR amplification of 252 DNA samples with LaRGAP 63 showed the segregation pattern of 3:1 (susceptible: resistant) with ($\chi 2$ = 0.09; p = 0.77) indicating co-segregation of marker with resistant gene. LaRGAP 63 marker showed that 455 bp band size was present in 61 F2 plants (designated as R) and 460 bp band size was present in 191 plants (designated as S). The marker LaRGAP 63 was analyzed for its co-segregation with disease resistance and the results revealed that LaRGAP 63 showed 80.95% co-segregation with ToLCNDV resistance.

Genotypic segregation pattern of LaRGAP 63 marker locus using 252 F2 plants derived from the cross of Arka Prasan × IIHR-Sel-1

Marker	Observed plants		Expected ratio	χ^2	*P* (5%)	Co-segregation with trait (%)
LaRGAP 63	R	S	R:S			
	61	191	1:3	0.09	0.77	80.95

Breeding for Downy mildew resistance: Twenty-three advanced breeding lines (F_8 and BC_1F_8 generations) including 13 susceptible lines were evaluated for yield and downy mildew resistance during Kharif under natural epiphytotic conditions without spraying any fungicides. Disease incidence started after 6 weeks of sowing and data was recorded on 10 yield related traits, disease incidence of downy mildew at weekly intervals. Wide variability was recorded among the lines: fruit number per plant ranged from 1-7.5 and yield per hectare ranged from 8.44-102.70 q. Five superior lines with high yield and slow mildewing types with PDI <30.0 were identified: IIHR-DMR-18-4-4 (8.24 t ha^{-1}, PDI=26.15, AUDPC=1286.32), IIHR-DMR-18-65-2 (4.74 t ha^{-1}, PDI=28.84, AUDPC=1366.94), IIHR-DMR-18-65-1 (5.56 t ha^{-1}, PDI=28.89, AUDPC=1411.67), IIHR-DMR-18-4-3 (10.27 t ha^{-1}, PDI=29.01, AUDPC=1419.44) and IIHR-DMR-18-65-7 (4.91 t ha^{-1}, PDI=29.59, AUDPC=1417.01).



Downy mildew disease progression in ridge gourd advanced breeding lines

Advancing the male sterile back cross populations: Ten back cross populations (BC_3, BC_4, BC_5 generation) were raised for maintenance of male sterility in different genetic back grounds (green/ long/ medium/ short fruits). All of the back cross progenies were 100% male sterile indicating the maintenance of sterility. In all the 10 back cross populations, IP's having the fruits similar to their male parent were selected and were back crossed with respective male parents to advance the generation. Fruit length ranged from 12.14-46.33 cm in the advanced back cross populations.

Breeding for andromonoecy: In order to transfer andromonoecy into long fruited background, crosses have been made in different genetic backgrounds for polyhouse cultivation. BC_2F_1, BC_3F_1 populations were raised and all these were monoecious. Self-pollination was done in these populations to get the BC_2F_2, BC_3F_2 seeds. Further evaluation revealed that they segregated into 1:3 (Andromonoecious:Monoecious) ratio. The BC_2F_2, BC_3F_2 andromonoecious plants were back crossed with respective male parent that were used for the initial production of F_1 hybrids.

Estimates of chi square values and their probability for classical Mendalian ratio for androemonoecious sex expression in the $BC_{2/3}F_2$ population

Population	Observed Plant number		Best fit Ratio	χ^2	*P* (5%)
	AM	M	AM:M		
IIHR-49AM x IIHR-51 (BC_3F_2)	7	21	1:3	0	1
IIHR-49AM x Pusa Nutan (BC_2F_2)	19	66	1:3	0.318	0.573
IIHR-49AM x Phule Sucheta (BC_3F_2)	22	78	1:3	0.480	0.488
IIHR-49AM x IIHR-6 (BC_3F_2)	21	80	1:3	0.954	0.329

AM-Andromonoecious, M-Monoecious

Breeding for yield and quality: Twenty-four advanced breeding lines (F_8 generation) were evaluated during summer. Data recorded on 10 quantitative parameters revealed significant differences for seven, for yield IIHR-Sel-18-13 recorded highest (34.02 t ha^{-1}), followed by IIHR-Sel-18-50 (32.24 t ha^{-1}) and IIHR-Sel-18-55 (30.3 t ha^{-1}). IIHR-Sel-18-13 was superior with respect to fruit weight, yield and fruit quality.

Fruits of IIHR-Sel-18-13

Bitter gourd

Evaluation of advanced breeding lines: One hundred fifty-five IPs (F_6 generation Individual Plant Selections) were evaluated in single progeny rows (10 plants in each) for yield and yield traits. Of these 105 were uniform and IIHR IP-19-28-5 (38.32 t ha^{-1}) followed by IIHR IP-19-145-6 (37.66 t ha^{-1}) and IIHR IP-19-18-4 (36.73 t ha^{-1}) recorded highest yield. IIHR-IP-PGY-8 recorded highest yield (28.86 t ha^{-1}) among the short-fruited types and among creamy white fruit types, IIHR-IP-17-3 recorded highest yield (13.74 t ha^{-1}). Segregation was observed with respect to fruit colour, type of fruit ridge and fruit length.

Fruit diversity in advanced breeding lines

Fruits of IIHR IP-19-28-5

Evaluation of advanced population of gynoecious lines: In order to transfer the gynoecy, 12 F_2, four F_3, eight BC_1F_3 and 13 F_1's in different genetic back grounds depending on various fruit traits have been raised. Progeny of all these F_1 crosses were monoecious indicating the recessive gene nature of gynoecy. Selfing

of these lines was done to advance the generations for further evaluation. F_2, F_3, BC_1F_3 population have segregated into both monoecious and gynoecious plants. Gynoecious plants of these populations were back crossed with the respective male parents to increase the fruit length.

Screening for combined resistance to ToLCNDV and CABYMV: Thirty-four resistant advanced breeding lines were screened against both Leaf curl virus and CABYMV during summer. Out of the resistant lines, 13 lines showed high resistance, among them LCVR-19-26-11 (VI=0.00 and AUDPC=0.00) found with highest resistance against leaf curl virus till end of the crop with VI ranging from 0-10 against the susceptible lines whose VI was 25-41. These lines were also screened for CABYMV; six lines were moderately susceptible to CABYMV virus. Among them LCVR-19-20-4 (VI=31.67 and AUDPC=1120.00) was superior with least incidence of CABYMV compared to other lines. LCVR-19-26-11 was the best line against leaf curl virus and CABYMV.

Evaluation of germplasm lines against ToLCNDV and CABYMV: Twenty nine germplasm lines were screened against both ToLCNDV and CABYMV during summer. There was severe incidence of both the diseases and scoring was done at 15 days interval and vulnerability index and AUDPC were calculated. Of the germplasm lines screened, Pusa Do-Mausami (CR,G) showed high resistance, HIRKANI (CR) showed resistance and 11 lines showed moderate resistance against ToLCNDV till end of the crop season, but all the lines were susceptible to CABYMV. Seeds of these promising lines were multiplied for further evaluation.

Screening populations derived from SxR crosses against powdery mildew: Seventy eight IPS of F_3 population and 23 IPs of BC_2 F_2 populations of S x R crosses in different genetic back grounds were raised for evaluation for powdery mildew resistance during Rabi-summer season of 2019-20. Of 513 IPs (Individual Plants), 327 plants were resistant (mean score<2) to powdery mildew. Already identified PMR marker, McSSR 57 was used for screening and validation. Of the 508 plant DNAs used, successful validation was achieved in 416 plants which were resistant phenotypically, but in 58 samples the marker failed to express and the remaining 34 did not give any result.

Sixty eight resistant IPs of F_4 population and 19 IPs of BC_2F_3 population of S x R crosses in different genetic back grounds were screened for powdery mildew resistance. Of the 1141 IPs (Individual Plants), 840 plants were resistant (mean score 0) in different genetic backgrounds.

Cucumber

Screening of advance lines for yield, quality and downy mildew resistance: Eleven advance lines including two popular checks were evaluated during Kharif 2020. Among them IIHR-588-1-5-26 (IC-324310) was superior for yield (30.30 t ha^{-1}) with 11.89 fruits $plant^{-1}$, light green, smooth cylindrical, free from bitter taste and moderately resistance to downy mildew (36.48 PDI) and free from streak virus; followed by IIHR-621-2-5 (IC332376) (28.2 kg $plant^{-1}$) with 49.6 PDI. However, the check Swarna Ageti recorded 21.59 t ha^{-1} with downy mildew of 65.2 PDI.

IIHR-588-1-5-26

Evaluation of advance lines for yield, quality and resistance to downy mildew: Seven advance lines with commercial check Swarna Agethi were evaluated during Rabi 2020 in an RBD for yield, quality and resistance to downy mildew disease. Among them IIHR-588-1-5-26 recorded the highest fruit yield of 28.17 t ha^{-1} with 45 PDI followed by IIHR-621-1-2- (24.37 t ha^{-1} with PDI of 35). IIHR-588-1-5-26 fruits are light green, with white spine and free from bitter taste. However, the check Swarna Agethi recorded 17 t ha^{-1} with 69 PDI downy mildew disease.

Evaluation of hybrid for yield, quality and resistance to downy mildew: Nine F_1 hybrids along the commercial check Chitra and Malini were evaluated during summer 2020 in an RBD with three replications. Among them hybrid CHYB-62 recorded the highest fruit yield of 45.35 t ha^{-1} with 32% PDI followed by CHYB-10 (35.69 t ha^{-1}) with 30 PDI. Fruits are light green, cylindrical, smooth and free from bitter taste. However commercial check Malini recoreded a fruit yield of 38 t ha^{-1} with 39 PDI followed by Chitra (36.24 t ha^{-1} with 39 PDI)

Development of gynoecious slicing F_1 hybrid for yield, quality resistance to downy mildew: Three predominantly gynoecious hybrids were developed using Indian slicing with European English type lines. These hybrids were raised in an observational row trial with two commercial checks namely, Multi Star (Riwkjwan), Chitra (Hyveg) and Malini (Seminis). Among them EC-977487 x IIIR-588-1-5-26 yielded 4.5 kg $plant^{-1}$, and had

green, smooth fruits, free from bitter taste under open field condition. However, commercial check gave 6.5 kg plant^{-1}. It has to be tested under poly house for further performance.

Double haploid production using androgenesis: The anthers from unopened buds (in the uninucleate) stage were harvested from the cucumber hybrid lines developed and grown in the polyhouse of ICAR-IIHR. The anthers were inoculated into MS media with different concentrations of hormones for formation of callus. Two different pre-treatments were given, one being 1 day at 4 °C and 1 h at 30 °C, the other being 2 days at 4 °C and 1 h at 30 °C incubation before inoculation.

Double haploid production using gynogenesis: Ovaries were collected before anthesis and treated with 0.2% Bavistin before incubation at 4 °C for 4 days, and different hormonal concentrations are being used to standardize the protocol for development of haploid plant. Two different pre-treatments were followed, one being 2 days at 4 °C, the other is 4 days at 4 °C incubation before inoculation.

Bottle gourd

Release of gummy stem blight resistant varieties: Arka Nutan and Arka Shreyas are gummy stem blight resistant varieties in cylindrical and club shape segment, taking 45 and 48 days for the first female flower appearance on 9th and 12th node and 56 and 60 days for first picking of fruit. Arka Shreyas has good shelf life with less weight loss, firmness and colour retention up to 10 days of storage under RT and yields 48 t ha^{-1}, Arka Nutan yields about 46 t ha^{-1}.

Arka Nuthan

Arka Shreyas

Release of bottle gourd F_1 Hybrid: Arka Ganga, resistant to Gummy stem blight was developed by crossing resistant parents, and takes 47 days for the first female flower appearance at 12th node and 56 days for first picking of fruits, fruits are green, oblong/ oval, has good shelf life with less weight loss, firmness and colour retention up to 10 days of storage under RT and yields 60 t ha^{-1}.

Arka Ganga

Artificial screening of promising lines and hybrids for gummy stem blight: Promising gummy stem blight resistant lines and hybrids from field evaluation were subjected to *in vivo* screening with artificial challenge under glass house condition. Lines BG-77-6-1, BG-114-3, BG-95 and hybrid IIHRBGH-10 showed resistant reaction. Whereas, BGAIC-6, Hybrid-11 and Hybrid-7 showed moderately resistant reaction.

Evaluation of F_1 hybrids for yield, quality and resistance to gummy stem blight: F_1 hybrids were developed utilizing resistance sources for gummy stem blight and to assess the genetics of resistance for important fruit traits and for resistance. F_2 and backcross generations were developed for identifying molecular markers and studying inheritance.

Ash gourd

Individual plant selection: Of the 13 promising IPSs advanced from 31 IPS's based on fruit shape, size, number of fruits and resistance to gummy stem blight.

Bell pepper

Heterosis breeding: Through heterosis and combining ability studies, we identified two superior hybrid combinations for yield and attributing traits viz. i) Arka Mohini x CW308 with 37.47% yield heterosis and ii) Yolo Wonder x California Wonder with 37.37% yield heterosis over commercial check Indra.

Plant growth and physiological response to deficit moisture stress: Reduction in plant height was observed in 15 genotypes of *Capsicum* spp. evaluated, ranging between 6.44-22.98%; least in genotypes IHR 3915, IHR 4491 and Arka Lohit, accompanied by 36.48% reduction in overall photosynthesis rate, under 50% FC compared to 100% FC. However, the genotypic differences ranged from 22.55-53.37%. The genotypes IHR 3529, IHR 4600

and IHR 4550 showed lower reduction in photosynthesis rate, <50% FC stress conditions when compared to the remaining genotypes evaluated. The genotypes showed overall 57.18% reduction in transpiration rate, ranging between 31.68-68.83% among the genotypes. The lowest reduction in transpiration rate was observed in genotypes IHR 3529, IHR 3014 and IHR 4600. Under 50% FC significant reduction in stomatal conductance was observed among the genotypes compared to 100% FC. The water stress at 50% FC caused 67.74% reduction in stomatal conductance. Among the genotypes, reduction ranged from 42.14-79.09%, lower reductions were in genotypes IHR 4600, IHR 3014 and IHR 3529. The genotypes also showed overall 22.78% reduction in PS II, the lowest reduction was observed in IHR 3529, IHR 4491 and IHR 3241.

Summer squash

Eleven elite lines of summer squash was evaluated with commercial check Patty pan in RBD for yield and quality, of these SQ-2, SQ-1, SQ-5, SQ-12 and SQ-14 recorded higher number of fruits per plant (>5.0), higher yield per plant was observed in SQ-2, SQ-14 and SQ-5 (>3.5 kg plant^{-1}). The yield per ha was highest in SQ-2 and SQ-14 (>55.0 t ha^{-1}). Except SQ-5, all the superior lines had whitish yellow flesh colour. Majority of elite lines had TSS value around 5.0 ^{o}Brix.

SQ-2-5

Evaluation of summer squash hybrids for yield and quality: Among 9 segregation population evaluated for growth, flowering, fruiting and yield traits, no significant difference was observed in plant length, node to female flowers appeared, fruit girth and peduncle length. Among the hybrids, SARY-4 x SQ-14 and SQ-14 x SQGL-2 had higher number of fruits per plant (>5), was cylindrical in shape, yellow skinned at maturity. Three segregant population (SQGYL-1 x SQ-1, SQ-14 x SQGL-2, SQ-15 x SQYL-1) recorded high yield potential (>55 t ha^{-1})

SQGYL x SQ-14

Evaluation of butternut elite lines for yield and quality: Ten elite lines of butternut were significant for all the fifteen quantitative traits evaluated. The fruit weight ranged from 0.71 (BN-6) to 2.32 kg (BN-2-3-1); Number of fruits per plant ranged from 3.20 to 7.47 (BN-6). The fruit length ranged from 15.33 to 39.33 cm (BN-2-3-1). The yield potential ranged from 24.73 t ha^{-1} (BN-10) to 56.33 t ha^{-1} (BN-2-3-1). BN-2-3-1 also recorded earlier fruiting compared to check.

BN-25 x BN29

Evaluation of butternut hybrids for yield and quality: Nine hybrids of butternut types were evaluated for 15 quantitative traits. The fruit weight ranged from 0.79 to 1.93 kg, where BN-4 x BN-14 and BN-8 x BN-20 were small fruiting types (<1.0 kg). Among them, BN-23 x BN-20 followed by BN-25 x BN-29 recorded higher yield. These hybrids did not registered fruit fly or virus infestation in field conditions. Hence, the selected segregating population will be advanced.

BN-25 x BN29

Evaluation of advance populations for carotene content in varied market segments of pumpkin: Carotenoid content ranged from 0.22 to 6.64 mg100 g^{-1} in advance populations of Kashi Harit x A. Chandan, Ambili x A. Chandan and Swarna x A. Chandan with deep orange flesh colour.

Curry leaf

Evaluation of advance breeding lines: Forty-five advance breeding lines of curry leaf were evaluated for fresh leaf yield, leaf color leaf texture and leaf fragrance. Of them, four lines namely, LSR/18/75 (22.4 kg $plant^{-1}$ $year^{-1}$), LSR/18/8 (21.4 kg $plant^{-1}$ $year^{-1}$), LSR/18/9 (21.2 kg $plant^{-1}$ $year^{-1}$) and LSR/18/06-a (19.6 kg $plant^{-1}$ $year^{-1}$) were superior over the best check Suwasini (15.6 kg $plant^{-1}$ $year^{-1}$) and forwarded for second year evaluation.

LSR/18/75

Moringa

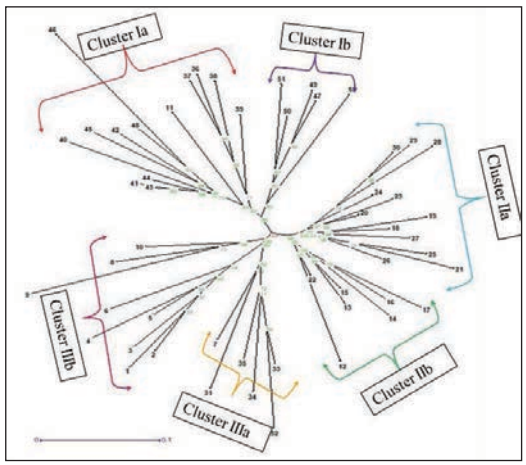
Identification of genotypes for high leaf yield and quality in *M. oleifera*: Among 52 genotypes tested for leaf yield traits, the edible leaf weight/ shoot ranged from 93.8 g (IIHR-D-149) to 375.4 g (IIHR-D-28) followed by IIHR-D-4 (351.0 g) and IIHR-D-52 (306.7 g). Edible leaf yield per plant was maximum in genotype IIHR-D-28 (8.69 kg) followed by IIHR-D-4 (10.74 t ha^{-1}) and IIHR-D-131 (10.04 t ha^{-1}).

Using Ward's minimum variance method, dendrogram was generated to estimate the genetic diversity for different morphological, minerals, phytochemical traits and leaf yield among drumstick genotypes. This showed four major clusters and six sub clusters. Cluster I found to be the largest cluster with 18 genotypes, followed by cluster II (14). The sub cluster III showed highly distinct properties by having highest mean values for shoot length (190.58 cm), shoot thickness (8.94 cm), node to first flower initiation (23.97), number of leaves per shoot (26.50), whole leaf weight per shoot (691.43 g), edible leaf weight per shoot (363.21 g), whole leaf yield per plant (14.81 kg) and edible, leaf yield per plant (7.70 kg), nitrogen (3.51%), iron (134.1 ppm), copper (15.8 ppm), protein (21.94 g $100g^{-1}$ DW), total phenols (2569.18 mg 100 g^{-1} DW), FRAP antioxidant activity (2920.73 mg 100 g^{-1} DW), DPPH antioxidant activity (3503.40 mg 100 g^{-1} DW) and total oxalates (1117.83 mg 100 g^{-1} DW). IIHR-D-4 and IIHR-D-109 were grouped in sub cluster III.

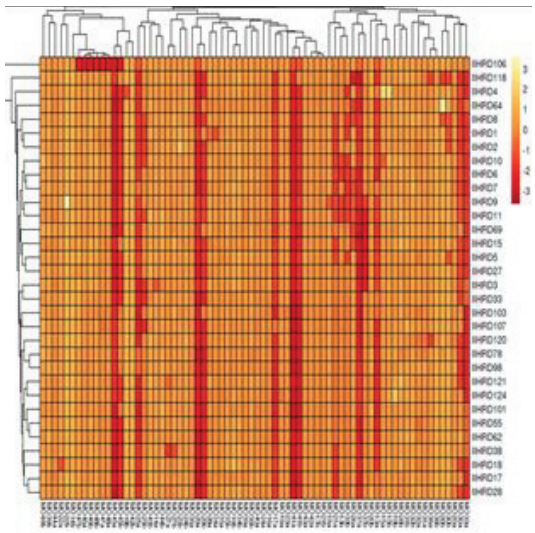
IIHR-D-28

Drumstick leaf yield stability estimation among the genotypes: The leaves harvested in three seasons after pruning two and half month's growth stage of shoots was used to assess yield and nutritional stability. Among the 52 genotypes evaluated, IIHR-D-28, IIHR-D-109, IIHR-D-4 had higher mean performance values (X_i= 8.69 kg, 7.36 kg and 6.72 kg) with b_i value higher than unity (b_i = 2.17, bi=2.79 and bi=1.44, respectively) and non-significant S^2d_i value.

Molecular diversity using SCoT markers in drumstick: In addition to morphological and biochemical diversity, genetic diversity using genetic markers was attempted with total of 36 SCoT DNA markers. Of them, 20 markers were informative and reproducible with clear and distinct banding patterns for 52 drumstick accessions. A total of 3798 bands with an average of 189.9 bands per primer ranging from 97 (SCoT 9 and SCoT 35) to 344 (SCoT 17) bands. There were 62 polymorphic bands, out of 101 amplified bands and the average number of polymorphic bands per primer was 3.1.



Development of EST-SSRs in Moringa: About 300 sequences contained SSR motifs with 59 in root, 52 in stem, 43 in leaf, 69 in flower and 77 in pod transcriptome sequences. 48 primer pairs were synthesised and characterised for different marker attributes in 32 accessions of *M. oleifera*, which showed traits like extra-long fruit, purple petiole, short fruits, high fruit yield etc. The number of alleles varied from 4-30, average of 13 alleles/SSR. The PIC values of polymorphic SSRs varied from lowest 0.51 (MO42) to highest 0.94 (MO32), with a mean value of 0.78. Based on PCA analysis IIHRD4 of short fruit trait, from the second cluster can be crossed to the genotype IIHRD 98, long fruit type, and the population thus developed can be used for mapping the fruit trait in *Moringa*. The genotype IIHRD 15 with high yield can be crossed to IIHRD 78 with high Ca levels to combine the traits into one hybrid. Overall, seven clades were identified, which could differentiate among 32 genotypes of *Moringa* as assessed by the relative genetic variability from 3 to -3. The genetic diversity and the genetic differentiation of *M.* oleifera ICAR-IIHR genotypes have been assessed in depth for their utilization combining traits through different breeding programs.



Elucidean heatmap showing the variation among *M. oliefera* genotypes in accordance with the EST-SSR clustering

Teasel gourd

Evaluation and identification for commercial cultivation: At CHES, Chettalli, 47 lines of teasel gourd were evaluated and a high yielding accession (JB/11-178A) which produced significantly higher yield (9.63 kg plant^{-1}) than the standard check var. Arka Neelanchal Gourav (7.82 kg plant^{-1}) was identified for commercial cultivation and around 45,000 plants were supplied to more than 250 farmers of Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Telangana, Gujarath, Odisha and Maharashtra

JB/11-178A

Screening of inter-specific hybrid progeny for yield and quality: Among the eight F_2 clones of *M. subangulata* subsp. *renigera* × *M. sahyadrica* evaluated at CHES, Chettalli, F_2-1 gave highest yield of 7.20 kg plant^{-1} followed by F_2-4 (6.70 kg plant^{-1}) under natural pollination. Though F_2-4 is the second higher yielder (6.70 kg plant^{-1}) it has been selected for having uniform, top shaped and dark green coloured fruits. The F_2 plant had a mixture of traits from both the parents. It had bulls eye nectar guide like its male parent, leaf was highly lobed like its female parent, flower size was large like its male parent and flower colour was yellow like its female parent. F_2-4 showed higher values for total phenols, total flavonoids, antioxidant activity (FRAP) and dietary fiber (475 mg 100 g^{-1} FW, 38.64 mg 100 g^{-1} FW, 359.54 mg 100 g^{-1} AEAC units FW and 2.32% respectively) compared to its parents. However, vitamin C content was high (92.3 mg 100 g^{-1} FW) in the male parent (*M. sahyadrica*).

Long term seed storage in vegetable crops: Irrespective of moisture levels, the seed quality was maintained under both controlled (15 ^{o}C) and ambient temperatures up to 60 months in tomato, onion, watermelon, pumpkin, peas, chilli. Seeds with recommended moisture levels were as good as low moisture seeds in French bean, cowpea, dolichos, coriander, bottle gourd and brinjal after 60 months of storage under ambient temperature, whereas ultra-low moisture had affected seed quality

in these crops. Seeds with recommended moisture as well as ultra-low moisture levels showed significant reduction in seed quality after 60 months of storage under ambient temperature in bitter gourd. However, at controlled temperature of 15°C these seeds maintained high seed quality. In okra, drying below recommended moisture level resulted in hard seeds. The varietal variation for extreme seed desiccation was found to be very negligible

3.2.3. FLOWER CROPS

Rose

Breeding for protected cultivation: Consistency in performance of IIHRR 13-3-1 and IIHRR 7-7 was observed for production of cut flowers under protected cultivation. Compact flowers of IIHRR13-3-1 were slow opening and light yellow in colour (Yellow Green Group-154-C). IIHRR 7-7 is a high yielder (300 flower stalks m^{-2}) with an average length of 75 cm and light pink colour (Red purple group 65-C). IIHRR 7-1 has red flowers, with large tight buds of average 6 cm length, red colour (Red Group-53-A).

IIHRR 7-1

Breeding for open field cultivation: IIHRR 3-18-2 of light pink colour (Red Purple Group-65-D) and of long stalk flowers, with less number of prickles and attractive flower opening type and having a vase life of five days can be cultivated in open field, for production of cut flowers.

IIHRR 3-18-2

Garden Roses: Among 13 garden roses evaluated, IIHRR 9-13, IIHRR 4-15-12 and IIHRR 4-4-2 were found to be well suited for landscape. IIHRR 9-13 is a climber with bright red (Red Purple Group-67-B) flowers and well suited for pergolas. IIHRR 4-4-2 is of floribunda group with bush type, spreading habit and low infestation of pest and disease, making it environmental friendly as well as easy to maintain for Rose gardens. IIHRR 4-15-12 has bright red purple flower (Red Purple Group-68-A) with slow opening of flowers. Good carbon sequestration ability of these rose genotypes (7.2 -8.4 kg $plant^{-1}$ $year^{-1}$) indicates their potential contribution for sustainable environment in combination with aesthetic values.

Fragrant Roses: Fragrant genotypes (53) were evaluated for yield and quality; RF 2-1 recorded highest yield (1.06 kg $plant^{-1}$ $year^{-1}$), number of petals ranged between 15-70 and flower diameter 4-10 cm, 0.04% of Rose oil content in Arka Parimala petals.

Rootstock breeding: Among the 20 genotypes evaluated for their self rooting ability, six genotypes were selected (RR1-1, RR1-3, RR1-5, RR1-6, RR1-7, RR3-9) with more than 90% success in rooting. Based on bud uptake ability three genotypes (RR 1-7, RR 3-6, RR 6-5) were found superior with more than 80% bud uptake.

Resistance breeding for biotic stress: IIHRR 13-4 has been evaluated and found to be resistant to powdery mildew both *in vitro* and *in vivo* condition. Studies were undertaken to understand the genetic and molecular mechanism behind resistance to powdery mildew resistance in IIHRR13-4 through different motifs present in the NBS domain of NBS-LRR group of R genes. Eleven Resistant Gene Analogues (IHRR13-4R1, IIHRR13-4R2, IIHRR13-4R3, IIHRR13-4R4, IIHRR13-4R5, IIHRR134R6, IIHRR13-4R7, IIHRR13-4R8 IIHRR13-4R9, IIHRR13-4R10, IHRR13-4RS10) were isolated from powdery mildew resistant line IIHRR 13-4 based on the sequence and similarity to RGAs from rosaceae family and other crops.

Marigold

Development of male sterile lines: Genetic male sterile lines have been stabilized in both apetaloid and petaloid sterile types of flowers both in yellow and orange category. Inheritance studies indicated apetaloid sterility being governed by single recessive gene '*ap*' while petaloid sterility is governed by single dominant gene '*P*'.

Breeding of African marigold: Three African marigold hybrids, Arka Bangara, Arka Bangara-2 and Arka Agni, have been approved by Central Variety Release Committee based on trials conducted under All India

Coordinated Research Project. Three F_1 hybrids on male sterile background resulting in male sterile hybrids that are high yielding and with compact flowers having good shelf life were identified by VTIC of the institute.

Arka Vibha: F_1 hybrid of African marigold was identified for its attractive flower shape, highly compact, attractive orange colour (RHS colour Orange group N25 C), with a shelf life of 8-9 days, and yield potential of 10-12 tons $acre^{-1}$

Arka Vibha

Arka Abhi: F_1 hybrid of African marigold was identified for its attractive radiant lemon yellow colour (RHS Yellow group 5 A), large flowers (7-8 cm), with good shelf life (6-8 days) and high yield of 10-11 tons $acre^{-1}$.

Arka Abhi

Arka Bhanu: F_1 hybrid of marigold was identified for its attractive, compact flower shape and golden yellow colour (RHS Yellow group 12 B), with a shelf life of 7-8 days. Yield potential is 10-11 tons $acre^{-1}$

Arka Bhanu

Breeding of French marigold: Two French marigold varieties Arka Madhu and Arka Pari have been approved by CVRC based on trials conducted under AICRP. Six lines with round the year production ability have been selected and advanced for further evaluation.

Arka Madhu Arka Pari

Breeding for biochemical component: Nine new F_1 hybrids along with on three different male sterile background were evaluated for their potential as source of carotenoid. Carotenoid content among different hybrids ranged between 2.64-3.85 g 100 g^{-1} DW. Based on productivity per unit area and flower quality, MOH 1-2 was identified as Arka Shubha.

Arka Shubha: F_1 hybrid of African marigold was identified for its high carotenoid content (3.25%). Plants are spreading type with a yield potential of 12-14 tons $acre^{-1}$. Flowers are orange in colour (RHS colour Orange group N25 C), with shelf life of 5-6 days.

Arka Shubha

Tuberose

Breeding for garland purpose: Tuberose genotype 17-23 SP-08 was found promising for garland purpose, with green tinge on flower buds, produced on long spikes (80.05 cm), better rachis length (30.32 cm), more number of florets per spike (50.33), average bud weight of 1.15 g, bud length (6.13 cm), small florets with flower diameter (4.09 cm) and greater number of spikes per plant (6.40) with good multiplication rate of 9.0 bulbs per clump per year.

Breeding for novel colour tuberose: Pre-breeding lines were developed for novel colour. Out of 761 colour progenies evaluated for their flowering and yield parameters, 80 lines exhibited different colour intensities on flower bud and open floret along with better flowering and yield traits.

Novel coloured tuberose line

Breeding for disease resistance: Twenty three self-pollinated progenies and 11 hybrid progenies were screened for leaf blight, disease index and host reaction against leaf burn disease caused by *Alternaria* under field conditions, and percent disease index was low in eight genotypes - 1 SP-7 (4.76), 11 SP-16 (5.11), 23-SP-25 (5.25), 13 x 12-2 (6.14), 23-SP-9 (6.22), 23-SP-7 (6.22), 23-SP-9 (7.20) and 23-SP-8 (7.24).

Gladiolus

Breeding for cut flower: Twenty gladiolus hybrids belongs to three different cross combinations *viz*., Arka Amar x Arka Pratham, Arka Pratham x Arka Amar and Arka Amar x Pink Friendship were evaluated, and the seven hybrids belonging to red purple, purple and red colour group with novel flower characteristics such as frilled petal, double row of flower arrangement and high flower yield with high corm and cormel multiplication efficiency were selected for further evaluation. The hybrids such as 15-1-99 (Red purple 73 A, red 53 A blotch having white yellow 5 D on lower lip), 15-1-215 (Red purple N 74 A, red purple 60 A blotch having white yellow 3C on lower lip), 15-1-339 (Purple 76 B middle purple violet 80 B margin, yellow 4 D near lower lip), 15-1-48 (Red 53 B middle, having red 53 A margin), 15-5-238 (Red purple 63 A middle, red purple 67 A margin, yellow 3 D lower lip), 15-1-154 (Red purple 63 B middle, red purple 61 B margin, having yellow 9D lines) and 15-5-384 (Red purple 67 B, having red purple 67 A border with yellow 3 D blotch) were advanced for further multiplication and performance evaluation.

15-1-99 15-1-215 15-1-339 15-1-48 15-5-238 15-5-384

Breeding for pest and disease resistance: Twenty lines of gladiolus were scored for gall index caused due to root knot nematodes under natural field conditions. There were no galls observed in the lines 215, 105 and 12. In other lines, gall index ranged from 0.4 to 1.4. Twenty gladiolus lines were evaluated under field condition against *Fusarium* wilt disease and 15-5-238, 15-1-154, 15-1-120 and 15-5-200 recorded nil disease incidence during first year of evaluation.

Chrysanthemum

Four chrysanthemum varieties *viz*., Arka Pink Star, Arka Kirti, and Arka Chandrika, Arka Usha Kiran (state varieties) have been approved by Central Variety Release Committee based on trials conducted under AICRP on Floriculture.

Breeding for pot culture and bedding: Six half-sib lines were evaluated with Arka Pink Star as check for pot culture and bedding. Half-sib lines IIHR4-8, IIHR2-16 and IIHR2-13 were promising and novel for flower colour, dwarf plant habit and early flowering, suitable for pot culture and bedding are at pre-release stage. Of six hybrids evaluated, hybrids CH1, CH4 and CH5 were promising for flower colour and floriferousness.

IIHR4-8 IIHR2-16 IIHR2-13

Promising and novel chrysanthemum half-sib lines for pot culture and bedding

Breeding for photo insensitivity:

Of the 20 genotypes evaluated for photo-insensitivity, Arka Pink Star, Marigold, Pusa Anmol and Ajay, and Kargil, Arka Kirti and Rekha showed photo-insensitive reaction.

Breeding for disease resistance:

Of 120 genotypes/lines evaluated for white rust (*Puccinia horiana*), 15 genotypes/ lines recorded no disease symptoms.

China aster

China aster variety Arka Archana has been approved by Central Variety Release Committee based on trials conducted under AICRP on Floriculture.

Breeding for cut flower and bedding: Of the 24 lines evaluated for cut flower traits, lines P18, KS-1, 3-4 in brick red colour group; lines J3-2, CC39, C5 in pink colour group; lines G13, I69, I69-2, MIS-2 in purple/ violet group, were promising for attractive unique flower colour, long flower stalk and extended vase life.

Of the 24 F_5 spreading type lines evaluated for landscape purpose, lines 15-15-4, 15-27-1 and 15-19-2 were promising for early flowering, attractive flower colour and floriferousness. One of the plant selection from Matsumoto Blue i.e. L-29, was promising for its dwarf stature, violet colour, bedding and pot culture.

IIHRJ3-2 for cut flower L-29 for bedding and pot culture

The pure line IIHRJ3-2 was derived from the cross Arka Kamini x Local White, evaluated with checks for cut flower quality traits for three consecutive years from 2018-19 to 2020-21. It was novel for its very light pink flowers (RHS colour chart Red Purple group, 65D, Fan 2), semi-double with long flower stalk (47.67 cm) and vase life (10.11 days). It is suitable for cut flower arrangement.

Evaluation of China aster pure lines with checks

Line/ Genotype	Plant height (cm)	Days to flower	Branches plant^{-1} (No.)	Flower diameter (cm)	Flowers plant^{-1} (Nos.)	Stalk length (cm)	Vase life (days)
J3-2	67.89	73.33	10.33	5.04	56.44	47.67	10.11
C-5	49.11	62.44	12.78	5.01	37.78	33.33	9.44
CC39	66.33	62.00	11.89	7.24	29.44	35.00	8.11
L-5	47.78	71.67	17.11	5.20	56.78	38.67	7.89
Local Pink (C)	47.56	74.56	12.00	5.22	37.11	35.00	7.06
SAT-1 (C)	42.44	70.78	11.11	4.58	31.33	29.89	7.22
Arka Kamini (C)	52.33	80.44	14.22	5.41	47.11	37.44	8.28
SEm±	0.79	0.44	0.42	0.06	1.14	0.74	0.21
CD (P=0.05)	2.47	1.37	1.31	0.18	3.55	2.32	0.67

Breeding for loose flower yield: Of the 36 lines evaluated for loose flower yield, lines KS-5, KS-1, I69-2, Local White and L-5 recorded high loose flower yield (>100 g plant^{-1}).

Mutation breeding: Two mutants IIHRV1 and IIHRV2 were found promising for unique flower colour, flower type, vase life and suitable for cut flower, bouquet making and flower arrangement. Two induced mutants from Arka Kamini, one each from Arka Archana and Arka Shashank were stabilised, found promising for pot and bedding purpose as they have unique flower colour, flower form with floriferous growth.

Evaluation of genotypes for vase life: Of the 32 genotypes/ lines evaluated for vase life, IIHR3-4, MIS-2, Namdhari White, Arka Shashank, CC31A and C5 recorded more than 9 days of vase life.

Gerbera

Identification of lines for protected and open cultivation: Four lines were identified for protected cultivation. The salient features of identified lines was: AV 13, a red purplish group 67A with stalk length of 57 cm, flower diameter (11 cm), semi double type with 35.2 plant^{-1} year^{-1} number of flowers; AV10, a red purple group 65B with a stalk length of 62.5 cm and flower diameter of 10 cm, single type with 39.5 plant^{-1} year^{-1} number of flower; AV26, a red purple group 42 with a stalk length of 54.5 cm, semi double type with a flower diameter of 9.8 cm. and 39.5 plant^{-1} year^{-1} number of flowers; AV22, a Yellow group 3B 66 with a stalk length of 66.8 cm, semi double type with flower diameter of 10.9 cm and 35.0 plant^{-1} year^{-1} number of flowers.

Two lines have been identified for open cultivation. The salient features of identified lines are given below: White with a stalk length of 52.3 cm and flower diameter (8.6 cm), 42.9 plant^{-1} year^{-1} number of flowers; pink, with

a stalk length 61.2 cm, flower diameter of 9.2 cm and 44.9 plant^{-1} year^{-1} number of flowers.

White

Pink

Crossandra

Mutation studies: Fifteen mutants of crossandra were evaluated for qualitative and quantitative economical characters, three mutants have been identified and planted in replicated trial based on flower yield, shelf life, and flower size. Mutant of Arka Shreeya flowers are slightly bigger than the local (20%), but smaller than Arka Shreeya (10%), yields on par with Arka Shreeya (1.3 kg plant^{-1} year^{-1}), shelf life slightly higher than Arka Shreeya (2.7 days). Mutant of Arka Chenna is slightly bigger than the local (20%), but smaller than Arka Chenna (7%), yielding on par with Arka Chenna (1.1 kg plant^{-1} year^{-1}), with shelf life slightly higher than Arka Chenna (2.9 days). Mutant of Local Orange is slightly bigger than the local (20%), yielding on par with Arka Chenna (1.05 kgs plant^{-1} year^{-1}), having the shelf life on par with Arka Chenna (2.7 days).

Dahlia

Germplasm evaluation: Sixty germplasm evaluated consists of huge flowers which are suitable for garden purpose. Pompon type for loose flowers and ball type flower suitable for loose flowers as well as cut flowers for bouquets.

Type of flower	Plant height (cm)	Flower diameter (cm)	No. of flowers	Flowers shelf life (days)
Exhibition	45-95.6	15-21	50-60	2-4.0
Pompon type	120-151.5	6-8.2	50-60	2-3.1

Exhibition Type

Pompon type are suitable for loose flowers

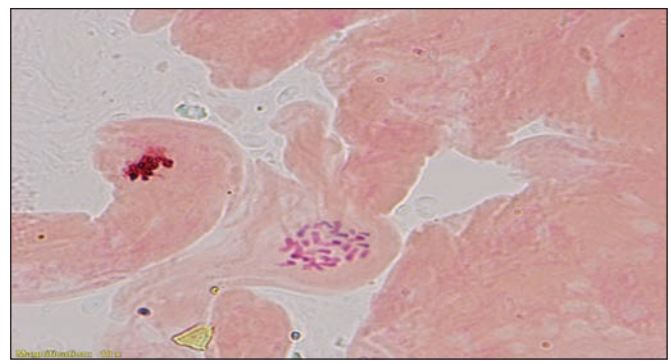
Type of flower	Plant height (cm)	Flower diameter (cm)	No. of flowers	Flowers shelf life (days)
Pompon type	120-151.5	6-8.2	50-60	2-3.1
Ball type	50-70.5	3-4.5	120-151.5	3-6

Segregating population selected for further selection: Three thousand plants of segregating population from OP population were evaluated for various traits based on form of flower (single, semi-double, double), colour, vigour, stature of the plants (tall and dwarf, spread, erect) and suitability of flower (cut flower, potted purpose and garden). About 95% of the plants were of single type and rouged out. The range of morphological parameter were observed for plant height (20-70.5 cm), flower diameter (3-4.5 cm), number of flowers (55-151), flowers remaining in the plant (8-16 days). The plants with some economic value were retained and allowed to cross among themselves

3.2.4. MEDICINAL CROPS

Mandukaparni

Evaluation of polyploid for yield and quality: Evaluation of polyploids with the check variety Arka Prabhavi showed that the polyploid IIHR-CA-28 was significantly superior for fresh biomass yield (5900 kg ha^{-1}) than the check Arka Prabhavi (4300 kg ha^{-1}). IIHR-CA-28 reported asiaticoside content of 4.07% and total triterpenoid content of 10.39%, which was on par with the check variety Arka Prabhavi



Cells showing chromosome doubling in the polyploid of *Centella asiatica*

Kalmegh

Evaluation of promising selections: Five promising selections along with two checks (Anand Kalmegh and CIM Megha) were evaluated for morphological traits, yield and yield attributes. Higher dry biomass yield was recorded in AP Sel3 (3.54 t ha^{-1}), followed by AP Sel 2 and AP Sel 1 with 3.34 and 3.21 t ha^{-1} respectively. AP Sel 1 recorded highest leaf andrographolide content (5.53%), followed by AP Sel 2 (5.16%), compared to the checks (3.56 and 3.2%). The lines were also evaluated for their ratooning ability. In general, all lines exhibited good ratooning ability except the check CIM Megha. Highest biomass yield of of 2.8 t ha^{-1} was recorded in ratoon crop of AP Sel 2.

Evaluation of segregating population: Hundred F3 families were raised and evaluated for yield attributing traits from the selected IPs from F_2 populations of eight crosses. High variability was observed among and within families for plant height, number of branches, days to flowering and leaf yield per plant. Individual plant selections were made based on their growth, yield attributes for further evaluation.

Bhringaraj

Evaluation of promising selections: Eight promising selections IIHR EA4-4, IIHR EA6-6, IIHR EA50-3, IIHR EA58-1, IIHR EA59-2, IIHR EA64-5, IIHR EA72-7 and IIHR EA 75-8 with distinct morphological traits were evaluated for morphological traits, biomass and wedelolactone content. Plant height varied significantly among the selections, at 90 days after transplanting (DAT), accession IIHR EA 72-7 recorded maximum plant height (80.73 cm). The maximum dry herbage yield per plant was recorded in the selection IIHR EA 58-1 (52.73 g), followed by IIHR EA59-2 (42.6 g), while the selection IIHR EA 6-6 recorded minimum dry herbage yield per plant (28.53 g). Maximum wedelolactone content was recorded in the selection IIHR EA 58-1 (0.375%), followed by IIHR EA 59-2 (0.112%), and minimum wedelolactone content was recorded in the selection IIHR EA 4 (0.010).

3.3. CROP PRODUCTION

3.3.1 FRUIT CROPS

Mango

Effect of plant growth regulator: Three foliar sprays of triacontanol (3-5 ppm) at panicle initiation, pea and marble stages of fruit growth were found effective for reducing fruit drop and enhancing quantum and quality of produce in mango var. 'Banganpalli', than NAA (10-30 ppm) and GA_3 (25-75 ppm) under Bhubaneswar condition.

Guava

Irrigation at phenological stages: In Arka Mridula, fruit yield (42.3 kg $plant^{-1}$ and 26.4 t ha^{-1}) and fruit weight (167.4 g) were higher due to drip irrigation equivalent to 60% evaporation replenishment during both vegetative and reproductive phases. Drip irrigation equivalent to 60% evaporation replenishment throughout the crop cycle registered higher water use efficiency of 11.48 kg m^{-3} with 23% saving of irrigation water and benefit cost ratio of 2.40.

Standardization of fertigation: The highest fruit yield (56.9 kg $plant^{-1}$ and 35.6 t ha^{-1}), net returns (Rs.7,09,880 ha^{-1}) and B:C ratio (4.95) was recorded with soil application of recommended dose of P fertilizers + fertigation of RDF-NK through WSF. Average fruit weight was significantly higher (154.5 g) with fertigation of 75% RDF through water soluble fertilizers due to lesser number of fruits (364 $plant^{-1}$).

Grapes

Source-sink relationship: Three coloured grape varieties were evaluated to study the source sink relationship to optimize yield and quality.

Red Globe: Retaining 30 canes per vine after back pruning and maintaining 13 leaves on each cane with 30 bunches per vine after forward pruning increased average bunch weight (517 g). The increase in cane number (40) and bunch number (40) reduced the average bunch weight (419 g) even after retaining higher number of leaves (15) on each cane. As Red Globe is a less vigorous variety with less leaf area, higher bunch weight could not be achieved with highest bunch load (40 numbers) even with maximum number of leaves.

Crimson Seedless: Yield per vine varied from 6.94 kg in vines having 20 canes and 30 bunches with 11 leaves retained on each cane to 14.27 kg in vines with 40 canes and 30 bunches. The yield increase was not noticed by maintaining higher number of bunches (40) with highest number of leaves. Retaining 30 canes and 13 leaves on each cane with 40 bunches recorded maximum bunch weight (478 g); least bunch weight (384 g) was in vines with 40 canes and 40 bunches with 11 leaves retained on each cane.

Fantasy Seedless: Average bunch weight was highest

(365 g) in vines with 30 canes and 30 bunches with 15 leaves on each cane. There was reduction in average bunch weight (233 g) due to maintenance of highest number of bunches. Anthocyanin content ranged from 39.53 mg to 54.87 mg 100 g^{-1} and the highest being in less number of canes (20) + more leaves (15) + less number of bunches (30).

Fig

Rootstock studies: The vegetative vigour, branching and fruiting of Excel and Conadria scions during fourth orchard year were more when grafted on Brown Turkey (Yercaud collection) and Poona rootstocks than those respectively on their own roots. The stem borer infestation was less for Deanna scion on Poona rootstock than on Brown Turkey and on own roots. The fruit yield and fruit quality were not satisfactory so far for any of the stock-scion combinations and there was no clear-cut influence of the rootstocks on the leaf nutrient concentrations of the scion varieties; hence rootstock intervention might not be promising for improving adaptability of exotic fig varieties.

Annona

Rootstock studies: Growth of Arka Sahan grafted on seven different rootstocks was more or less uniform, with very little fruit yield during the fourth year after field planting though tree spread tended to be less on *Annona reticulata*.

PGR for fruit set: Three foliar sprays of GA_3 @ 150-200 ppm during flowering period (April to June) at monthly intervals was effective for improving fruit set, yield and fruit quality parameters in Arka Neelachal Vikram.

Off-season flowering through application of defoliants: The peak season of flowering in custard apple coincides with the period of stress characterized by high air temperature and low moisture content in the soil profile in hot and humid climate of Odisha. This causes poor fruit set, high flower and fruit drop and low yield. Problem of low fruit set could be managed by defoliating the plants in the month of October. This will induce off-season flowering in relatively cooler months, i.e., November-January. Though application of KI (1-3%), urea (5-15%), and ethephon (1200 ppm) were effective in inducing defoliation, but the new shoots that emerged after defoliation could not maintain their growth and abscised with the onset of natural period of leaf shedding during December–January like manually defoliated plants. The study concluded that artificial defoliation (chemical or manual) is ineffective for advancing the flowering season in annona under Bhubaneswar conditions.

Papaya

Vegetative propagation: It was reconfirmed that spraying of BA 100 ppm + GA_3 200 ppm to de-topped papaya plants of five-months could induce maximum number of side shoots for use as scions for grafting or as cuttings for inducing rooting. Wedge grafted papaya plants were field planted after one month of grafting and were compared with seedling plants of same age for vegetative and reproductive parameters. After three months of planting, grafted plants recorded less plant height (65 cm), less internodal length (2.1 cm), maximum stem girth (9.5 cm) compared to plant height (90 cm), internodal length (3.5 cm) and stem girth (6.6 cm) of seedling plants. Grafted plants produced flower buds within 3 months after planting at 55 cm height from the ground, while the seedling plants continued to grow in vegetative phase.

Grafted papaya plants in reproductive phase after 3 months of planting

Seedling papaya plants in vegetative phase after 3 months of planting

Sapota

Cropping system: The evaluation of sapota based intercropping systems for five years indicated that acid lime was an ideal intercrop for sapota yield (1428.6 kg ha^{-1}), intercrop yield (2.0 t ha^{-1}), benefit:cost ratio (1.86) and internal rate of returns (116%). The net returns in sapota + acid lime intercropping was Rs.41,950 ha^{-1} followed by control sapota (Rs.19808 ha^{-1}). The intercropping did not affect the soil nutrient status.

Pineapple

Shade intensity: Influence of three shade intensities were examined on growth, biomass allocation pattern,

leaf chlorophyll content, nutrient uptake, fruit yield and quality of pineapple in mango-based intercropping system at CHES (ICAR-IIHR), Bhubaneswar. The mean shade intensity under low, medium and high were 23.8, 48.6 and 73.3% and the mean PAR availability was 76.2, 51.4 and 26.7% respectively compared to monoculture pineapple system. Significantly higher absolute growth rate (AGR), crop growth rate (CGR) and relative growth rate (RGR) and dry matter accumulation was recorded under medium shade intensity. The biomass accumulation was significantly high in leaf followed by fruit, stem and roots. Contents of Chl a, Chl b and Chl a+b increased with shade intensity. Higher fruit yield, fruit weight and fruit/crown ratio were recorded under medium shade intensity. In eastern tropical region of India pineapple may be cultivated as an intercrop with ~50% shade intensity.

Pineapple cultivation under medium shade intensity at CHES, Bhubaneswar

Physico-biochemical changes: Physico-biochemical changes in pineapple cv. Queen were studied at maturation and ripening stages at CHES, Bhubaneswar. The fruits attained breaker stage at 14 WAA (weeks after anthesis), initial ripening stage after a week of breaker stage, then ripening stage and full-ripe stage were attained at 16 WAA and 17 WAA, respectively. Pulp carotenoid content increased more than five times during ripening. Juice content, pulp content, TSS, TSS/acid ratio, sugar content and sugar/acid ratio increased progressively during maturation and their highest value were recorded at the advanced ripening stage (16 WAA). The total flavonoid content (TFC) and FRAP activity exhibited synchronous increase during maturation. The advanced ripe stage (16 WAA) was marked with highest fruit quality attributes such as TSS, TSS/acid ratio, sugar content, sugar acid ratio and anti-oxidative property; hence was considered as an ideal harvest stage for pineapple to ensure maximum attainable palatable quality.

Optimized harvesting stage of pineapple var. Queen

Dragon fruit

Training systems: Performance of dragon fruit plants was better in open than protected condition in terms of plant growth and yield. Growth characters were better in white pulped than pink pulped cultivar. The maximum number of flowers emerged during 3rd week of June in both the cultivars. The minimum days taken for bud emergence to flowering were 18.80 and 17.80 days in white and red pulped cultivars in single post with cement ring system. Average fruit weight was 557 g in pink and 431 g in white pulped cultivars. In two year old dragon fruit plants, the number of fruits per pole (73.6) and TSS (12.87 ^{0}B) was higher in pink pulped than white pulped cultivar (40.5 and 9.25 ^{0}B).

Dragon fruit cultivation in open field

Changes in quality during maturation: Changes in composition in dragon fruit during maturation were studied at CHES, Bhubaneswar. There was a rapid decline in the chlorophyll content and a corresponding increase in betacyanin content (>2 folds). The pattern of betacyanin content in the pulp and peel of dragon fruit was synchronized, a gradual increase in pulp content was concomitant with a proportionate decrease in peel content during the fruit ripening process. The highest pulp content (~67%) was registered at advanced ripening stage. There was a substantial increase in TSS (>2 times), TSS/acid ratio (~7 times), reducing sugar (>2.5 times), total sugar (>2.5 times) and sugar acid ratio (~10 times),

as also total flavonoid content and FRAP antioxidant activity during ripening. The redness (*a**) and chroma *(C*)* coordinates were important colour coordinates to define ripening of dragon fruit. There were no distinctive peaks in the ethylene production or in CO_2 evolution rate during maturation of dragon fruit which validates its non-climacteric nature.

Breaker Stage **Early ripe** **Advanced ripening**

Stages of fruit maturation in red-fleshed dragon fruit

Fruit-based multi-storey system

A fruit-based multi-storey system (mango + dragon fruit + pineapple) has been developed at CHES, Bhubaneswar, to enhance per unit productivity by growing CAM fruits with mango considering their light preferences. Dragon fruit and pineapple have been selected for intercropping in low density mango orchard. About 50% area of mango plantation was used for intercropping. Dragon fruit occupied 35% area and pineapple 15%. The LER (land equivalent ratio) of the system is estimated at 1.4. The cost benefit ratio of the system was 2.85.

Mango + dragon fruit + pineapple multistory system

3.3.2. VEGETABLE CROPS

Protected cultivation

Parthenocarpic cucumber: For parthenocarpic cucumber, a fertilizer dose of 113-75-113 kg NPK ha^{-1} was optimum, which recorded an yield of 104.2 t ha^{-1}. Based on pooled yield, net returns and B:C ratio (1.81:1), it is concluded that a fertilizer doze of 113-75-113 kg NPK ha^{-1} was ideal for parthenocarpic cucumber in polyhouses.

Parthenocarpic cucumber was grown in polyhouse for 70 days in organic system, which recorded a yield of 67.9 t ha^{-1}, earning a net revenue of 1.18 to 1.45 lakh $acre^{-1}$ and a B:C ratio ranging from 1.46 to 1.67 in different organic farming treatments under polyhouse.

Cherry tomato: Among the five hybrids of cherry tomato tested in polyhouse, Cheramy (Red round) recorded significantly highest yield of 65.0 t ha^{-1}, with an average berry size of 12 g and TSS of 6.5 ^{o}Brix. A spacing of 75 cm x 60 cm with single stem pruning was optimum.

French bean: Among the five fertigation treatments tested for pole type French bean under polyhouse, 75:100:75 kg NPK ha^{-1} was optimum with a yield of 25.0 t ha^{-1}.

Grafting studies

Tomato: Arka Samrat (F_1 Hybrid) was used as scion and grafted on two different rootstocks with different traits viz., BN 10-2 (Bacterial Wilt + Root Knot Nematode), Hawai 7996 (Bacterial wilt resistance). The ungrafted Arka Samrat was used as control treatment. Arka Samrat on Hawai 7996 recorded a graft success of 84% followed by Arka Samrat on BN 10-2 (82%). Arka Samrat on BN 10-2 recorded significantly higher yield (122 t ha^{-1}) followed by Arka Samrat on Hawai 7996 (110 t ha^{-1}), whereas, ungrafted control yielded 104 t ha^{-1}. Quality parameters like TSS ranged from 4.4 ^{o}Brix (Arka Samrat on Hawai 7996) to 4.6 ^{o}Brix (Arka Samrat on BN 10-2), while fruit firmness ranged from 7.08 kg cm^{-2} (Arka Samrat) to 7.18 kg cm^{-2} (Arka Samrat on BN 10-2).

Chilli: Grafting study was carried out using Arka Harita as scion and two different root stocks viz., IIHR 3226 (*Phytophthora* resistant) and IIHR 3291(*Phytopthora* root rot and RKN resistant) along with Arka Harita (control). Arka Harita on IIHR 3226 and IIHR 3291 recorded a graft success of 65 and 55%. Among the graft combinations, Arka Harita on IIHR 3226 recorded the highest yield (36.69 t ha^{-1}) followed by Arka Harita on IIHR 3291 (35.78 t ha^{-1}) and Arka Harita seedlings (33.10 t ha^{-1}). Arka Harita (seedlings) recorded significantly higher ascorbic acid content in the fruits (132 mg 100 g^{-1}) than the other treatments (120-122 mg 100 g^{-1}).

Capsicum: At CHES, Bhubaneswar, capsicum germplasm has been screened for the bacterial wilt disease caused by *Ralstonia solanacearum*, through sick plot evaluation and artificial inoculation. IIHR-B-HP 130 accession was identified as highly resistant (95.65%), and used as resistant root stock for the capsicum varieties (Arka Mohini, Inspiration, Bachata and Pasarella) by grafting and screening under sick soil conditions. Grafted capsicum showed very low wilting

(0 to 8.33%) compared to non-grafted (73.3 to 93.3%). Grafted capsicum cultivation can be explored for commercial cultivation in bacterial wilt prone areas.

Brinjal: Seven highly resistant *Solanum* root stocks were evaluated through grafting with two scions VNR212 (F_1 hybrid, VNR seeds Private Limited.) and Arka Neelachal Shyama (high yielding OP variety). Grafting had significant impact on vigor, flowering and fruiting traits of both the scions. An increase of fruit yield by 69.23% and 33.46% was observed in grafted eggplants on CARI-1 rootstock over both the non-grafted scions The grafts on to the rootstocks *viz*., *Solanum torvum*, CARI-1, Utkal Anushree and IC0598430 exhibited reduced severity of bacterial wilt under both sick soil and field conditions.

Grafted brinjal production under acidic laterite soils of Odisha

Ridge gourd

Water productivity and nutrient management: In ridge gourd cv. Arka Vikram, application of nutrient dose @ 150:90:150 kg NPK ha^{-1} through water soluble fertilizers resulted in higher yields (45.61 t ha^{-1}) followed by application of 125:75:125 kg NPK ha^{-1} (42.39 t ha^{-1}). The lowest yield (34.28 t ha^{-1}) recorded with the nutrient application 50:30:50 kg NPK ha^{-1}.

Organic farming: The integrated nutrient management (INM) (FYM, chemical fertilizers and PP chemicals) treatment produced significantly higher yield (27.12 t ha^{-1}) in ridge gourd variety Arka Prasan. Safe vegetable production methods recorded the yield of 25.54 t ha^{-1}. The organic treatment where 100% N was substituted with farm yard manure (FYM) recorded the yield of 25.12 t ha^{-1} followed by 75% N through FYM (23.24 t ha^{-1}). Yield reduction in 100% recommended N through FYM is around 17% compared to INM. Only chemical treatment without FYM produced the lowest yield of 21.15 t ha^{-1}.

Dolichos (Pole type)

Organic farming: In dolichos cv. Arka Vistar, the INM (FYM, chemical fertilizers and PP chemicals) produced significantly higher yield (26.77 t ha^{-1}) than other treatments except safe vegetable production methods (25.24 t ha^{-1}). Among organic treatments, substitution of 100% of recommended N through FYM yielded 19.70 t ha^{-1} followed by 75% N through FYM (16.74 t ha^{-1}). Yield reduction in 100% recommended N through FYM is around 26% compared to INM. Only chemical treatment without FYM produced the lowest yield of 16.52 t ha^{-1}.

Pole bean

Water productivity and nutrient management: In pole bean cv. Arka Sukomal, bi-weekly application of nutrients through water soluble fertilizers resulted in higher yields (31.4 t ha^{-1}) followed by weekly application of same amount of fertilizers (29.64 t ha^{-1}). The fertilizer dose was 75:100:75 kg NPK ha^{-1}. The soil application of the nutrients recorded lowest yield compared to other treatments (24.05 t ha^{-1}).

Palak

Organic farming: Among organic treatments 100% substitution of recommended N through farm yard manure recorded the highest leaf yield of 21.66 t ha^{-1}, which was on par with INM practices (23.6 t ha^{-1}) and safe vegetable production methods (23.3 t ha^{-1}), indicating the suitability of leafy vegetable crops for organic farming in Palak variety Arka Anupama. Only chemical treatment without FYM produced the lowest leaf yield of 17.2 t ha^{-1}. The recommended dose of fertilizer adopted was 50:25:50 kg N:P_2O_5: K_2O ha^{-1}.

Coriander

Organic farming: INM produced significantly higher leaf yield (12.14 t ha^{-1}) in three cuttings in Kharif grown coriander var. Arka Isha. Safe vegetable production methods recorded (11.80 t ha^{-1}**),** which was on par with INM treatment**.** Substitution of 100% recommended N through farm yard manure treatment recorded a leaf yield of 12.00 t ha^{-1}, on par with INM practices, indicating the suitability of leafy vegetable crops for organic farming. Only chemical treatment without FYM produced the lowest leaf yield of 8 t ha^{-1}.The recommended dose of fertilizer adopted was 60:60:30 kg N:P_2O_5:K_2O ha^{-1}.

3.3.3. FLOWER CROPS

Gerbera

Irrigation and nutrient scheduling: In gerbera var. Arka Red, scheduling the irrigation at 0.8 ER and fertigation with 11.25:7.5:22.5 g NPK m^{-2} month^{-1} (75% RDF) @ 40:25:25% NPK at vegetative phase and 60:75:75% NPK at flowering phase, along with Arka Microbial Consortium (@ 12.5 kg ha^{-1}) recorded the maximum leaf area, number of leaves plant^{-1} and the maximum flower yield (297 flowers m^{-2}) under open conditions. A 40.8% increase in yield, along with 25% reduction in fertilizer use over conventional practice was observed. The vase life for flowers was 5.42 days when held in tap water under ambient condition (temperature 25-28 ^{o}C and RH 55-70%).

Rose

Irrigation, nutrient scheduling, rootstocks and plant densities: The overall performance of cut flower genotype Arka Swadesh budded on three rose rootstocks *viz*., Natal Briar, *Rosa multiflora* and Nishkant was studied during 2017-2019. The flower stalk yields of Arka Swadesh were similar in Natal Briar and *Rosa multiflora* (213-222 m^{-2} yr^{-1}).The average stalk length (cm) was significantly higher in *R. multiflora* (53.2) and Natal Briar (51.7) than in Nishkant (48.3). The N and P acquisition efficiency (31%) was greater in *R. multiflora*, while K acquisition efficiency (33%) was highest in Natal Briar. Agronomic nutrient use efficiency was more in Natal Briar (1.76 flower stalks g^{-1} nutrient). There were differences in root parameters among rootstocks.

The 3-yr study in rose indicated that drip irrigation equivalent to pan evaporation (17.8 t ha^{-1}) and application of 60:20:70 g N:P_2O_5:K_2O per plant per year in 12 splits (18.1 t ha^{-1}) are required for loose flower genotype Arka Parimala. For cut flower cultivation in open field, drip irrigation @ 0.75 E_p and application of 60:20:70 g N:P_2O_5:K_2O per m^2 per year in 12 splits are found optimum both from yield and profitability point of view in Arka Swadesh. The loose flower cultivation was highly profitable with net return of Rs.3.46 per rupee investment compared to cut flower cultivation (Rs.2.58).

In protected condition, both plant densities (40 cm x 20 cm, 12 plants m^{-2}, and 45 cm x 15 cm, 15 plants m^{-2}) resulted in similar flower stalk number (246) in cut flower rose. Among three cut flower genotypes, Arka Swadesh registered significantly higher yields (289 flower stalks m^{-2}) than Arka Pride (230 flower stalks m^{-2}) and Arka Ivory (220 flower stalks m^{-2}). Among nutrition levels, (50:15:60 g NPK m^{-2} + FYM 2 kg) registered maximum flower yield in all three cut flower cultivars (253-255 m^{-2}). Increase in nutrient dose resulted in significant yield increase in Arka Swadesh that registered similar flower stalk number per m^2 per year (223.5-239.3). Economic indicators computed based on annuity value approach indicated that the net return per rupee investment was more than one (1.23-2.00). From economic point of view, planting density of 12 m^{-2}, Arka Swadesh genotype and nutrient dose of 50:15:60 g NPK m^{-2} were better due to higher net return per investment (2.20).


Loose flower and cut flower rose genotypes in open field




Cut flower rose genotypes with long flower stalks (>60 cm) in protected condition

China aster

Irrigation and nutrient scheduling: In China aster var. Arka Archana, scheduling irrigation at 0.8 ER at vegetative phase, bud phase and flowering phase in combination with 180:120:60 kg NPK ha^{-1} $year^{-1}$ (RDF) through fertigation @ 40:20:20% NPK at vegetative phase, 30:40:40% NPK at bud phase and 30:40:40% NPK at flowering phase resulted in the highest flower yield (19.24 t ha^{-1}), compared to conventional practice (13.82 t ha^{-1}) of soil application of nutrients. The increase in flower yield was to the tune of 39.22% over the conventional practice.

Tuberose

Propagation efficiency: Rapid multiplication of bulbs from bulblets of 1.0 cm diameter in tuberose var. Arka Prajwal and shortening of propagation cycle was achieved by application of 150:75:125 NPK kg ha^{-1} $year^{-1}$ (half P, 1/6th of N and K were applied as basal dose along with 25.0 t ha^{-1} of FYM and 12.5 kg ha^{-1} AMC; half P and rest of N and K in five equal splits at monthly intervals). Seasonal effect on the propagation efficiency was also observed, bulbs planted in March, at the second month after planting produced 1 bulb $plant^{-1}$ of 2.67 cm diameter weighing 20 g $bulb^{-1}$ post dormancy storage period. Similarly, from the bulbs planted in June, at the third month after planting, 1 bulb $plant^{-1}$ of 2.59

cm diameter weighing 21 g bulb^{-1} was obtained post dormancy storage period.

Crossandra

Irrigation and nutrient scheduling: In crossandra var. Arka Shreya, scheduling the irrigation at 1.0 evaporation replenishment (ER) during vegetative and 1.2 ER during flowering phase in combination with 90:60:180 kg NPK ha^{-1} year^{-1} (75% RDF) through fertigation @ 25:25:25% NPK at vegetative phase and 75:75:75% NPK at flowering phase produced the maximum flower yield (8.84 t ha^{-1}) and recorded significantly lower (18.14%) physiological loss in weight (PLW) in harvested flowers. The yield increase in this treatment combination was 29% over the conventional practice with 25% reduction in the fertilizer use.

Eco-friendly pot culture of flowering ornamentals

Standardization of suitable pot types, substrate combination and nutrition solution was done in flower crops like chrysanthemum, crossandra, China aster and marigold. In China aster var. Arka Archana, plant growth parameters like plant height (41.67 cm), number of primary branches (12.4), plant spread (536.64 cm^2), and yield parameters like number of flowers per plant (26.47) and flower size (24.41 cm^2) were maximum in the plants grown in plastic pots by using the substrate combination of soil+sand+FYM (1:1:1 v/v) along with the weekly application of nutrient solution of 96:18:108 ppm NPK/ plant. Among the soilless media tried, plants grown in Arka fermented cocopeat (AFC) + vermicompost (1:1 v/v) performed better compared to AFC alone. In a growth regulator experiment, foliar spray of 20 ppm paclobutrazol one month after transplanting on plants of China aster var. Arka Archana grown in 6" plastic pots resulted in production of dwarf plants (24.27 cm), with maximum plant spread (22.73 cm), the maximum number of flowers (25.27 plant^{-1}) and maximum size of flowers (27.5 cm).

In chrysanthemum, var. Arka Pink Star in 6" coir pots grown on substrate combination of Arka fermented cocopeat (AFC) + Vermicompost (1:1 v/v) along with weekly application of nutrient solution (96:18:108 ppm NPK/plant) recorded maximum plant spread area (220 cm^2) and number of flowers per pot (35). Foliar spray of 20ppm paclobutrazol one month after transplanting on chrysanthemum, var. Arka Pink Star pot plants in 6" plastic pots resulted in the maximum number of flowers (37 plant^{-1}) at flowering, recorded plant height of 20 cm and spread area of 218 cm^2.

Marigold var. Arka Pari, grown in 6" plastic pots on a substrate combination of Arka fermented cocopeat (AFC) + vermicompost (1:1 v/v) along with weekly application of nutrient solution (128:24:144 ppm NPK) produced the maximum number of flowers (166.89/plant) and the plant height at flowering was 29.39 cm with plant spread of 39.79 cm. This treatment combination also recorded the highest uptake of nitrogen (2.87 g plant^{-1}), potassium (3.24 g plant^{-1}), magnesium (0.85 g plant^{-1}) and sulphur (0.21 g plant^{-1}). Foliar spray of 20 ppm paclobutrazol one month after transplanting on plants of marigold var. Arka Pari, grown in 6" plastic pots resulted in the maximum number of flowers (175 plant^{-1}) and at flowering, recorded plant height of 26.77 cm and spread of 41.48 cm.

Crossandra var. Arka Chenna grown in 6" plastic pots on a substrate of red soil + FYM + sand (1:1:1 v/v) along with weekly application of nutrient solution (128:24:144 ppm NPK) recorded the maximum flowering duration of 142.10 days, number of flowers plants^{-1} (656.48), length of spike (6.60 cm) and plant spread of 29.11 cm. Foliar spray of 20 ppm paclobutrazol one month after transplanting on plants of crossandra var. Arka Chenna, grown in 6" plastic pots resulted in the maximum number of flowers (861.90 plant^{-1}) at flowering, recorded plant height of 18.91 cm and spread of 28.38 cm at flowering.

Standardization of media for vertical landscapes

Arka Fermented Cocopeat (AFC) and burnt clay balls (LECA) in 3:1 ratio, was found to be the most ideal medium for vertical garden. It resulted in uniform and sustainable growth of the plants with enhanced aesthetic value. This substrate combination provided adequate drainage and supported proper plant growth. Adequate biological load of beneficial microbial consortium in this medium is an added advantage over the existing commercial media.

3.3.4. MUSHROOM

Production of *Macrocybe gigantea*: The production technology of *Macrocybe gigantea* on paddy straw substrate was standardized. Spawn dose of 10% enhanced the biological efficiency to 91.52%.


Fructification of *Hericium erinaceus:* The fructification trial of *Hericium erinaceus* was conducted on a supplemented mixture of corn cob powder, coir waste with a biological efficiency of 18.81% and on corn cob and sawdust mixture showing a biological efficiency of 16.08%.


Production of Elm oyster mushroom: Technology for the production of iron fortified Elm oyster mushroom was standardized, to increase the iron content from 118.39 ppm in non-fortified mushroom to 338.15 ppm in iron fortified mushroom, an increase of 185.62%. A delivery system for human consumption was also standardized in the form of Arka Rasam. Consumption of 10 g of dry iron fortified mushroom powder is recommended for daily use can give 3.38 mg of iron which is 18.77% of DV (18 mg day^{-1}). Since the bio-availability of iron from iron fortified mushroom is very high (21%), 0.71 mg of bio-available iron is available through the consumption of 10 g of the powder. This takes care of 73.95% of bio-available iron requirement for post-menopausal women, 29.83% requirement of menstruating women, 62.28% for pregnant women, 35.14% requirement of girls of 12-16 years age and 39.01% requirement of bio-available iron of 12-16 years boys.


Iron fortified dehydrated Elm oyster mushroom **Iron fortified dehydrated Elm oyster mushroom powder**

3.3.5. SOIL HEALTH MANAGEMENT

Guava

High density planting: The yield per hectare in the ultra-high-density plots (2 x 1.5 m, 3333 plants ha^{-1}) was higher by 26.9% (30.36 t ha^{-1}) and 37.47% (39.73 t ha^{-1}) of the high-density plots (3 x 2.5 m spacing, 1333 plants ha^{-1}) in the 3rd and 4th harvests, respectively. In high-density planting, the yields per plant were 45.3 % (16.65 kg tree^{-1}) and 36.1% (18.64 kg tree^{-1}) higher in the 3rd and 4th harvests, respectively, than in the ultra-high-density plot. The nutrient removal was higher with the higher yield. The nutrients required per hectare to produce 22.19 t ha^{-1} of guava fruit included 103.12 kg N, 14.81 kg P, 99.03 kg K, 40.06 kg Ca, 31.41 kg Mg, 34.99 kg S, 1.72 kg Fe, 0.151 kg Mn, 0.504 kg Zn, 0.19 kg Cu and 0.21 kg B at high density planting in the 3rd harvest. While in ultra-high density plot, the total nutrients required to produce 30.36 t ha^{-1} of guava fruit was 131.54 kg N, 18.63 kg P, 129.88 kg K, 53.98 kg Ca, 41.26 kg, Mg, 45.34 kg S, 2.25 kg Fe, 0.205 kg Mn, 0.731 kg Zn, 0.25 kg Cu and 0.28 kg B. Comparison of soil and leaf nutrient analysis showed that N, P, K, Zn and Mn content in leaf and soil microbial parameters were lower in bronzing affected plants than in healthy plants.

A B C

A) Guava under high density planting (3rd year after planting)
B) Overview of guava under ultra-high-density planting (3 years after planting)
C) Fruiting in guava under high density planting (4th harvest)

Capsicum

Foliar application of micronutrient and silicon: The effects of foliar application of zinc, boron with silicon (in the form of potassium silicate and *O*-silicic acid) @ 4 mL L^{-1} at 12 DAP and muriate of potash (MOP) at 5 g L^{-1} was studied. Eight sprays were given at different stages of crop and after every pinching. Application of potassium silicate and *O*-silicic acid at 4 mL L^{-1}, significantly increased yield i.e., 45.58 and 43.42 t ha^{-1}, which was 22 and 15.6% higher over control. Potassium silicate or *O*-silicic acid sprayed with micronutrients i.e., zinc and boron was found superior compared to recommended package of practice.

Influence of *O*-silicic acid sprayed with micronutrients on capsicum

Tomato

Soilless cultivation: Nutrient scheduling of 194, 32 and 228 ppm of N, P and K recorded highest number of fruits; yield per plant (9.43 kg) and per hectare (132.02 t) in tomato hybrid Arka Rakshak compared to other NPK levels. Among the substrates studied, tomato plants raised on Arka Fermented Cocopeat registered higher values for growth, yield and yield attributing characters, quality parameters compared to soil.

Tomato hybrid Arka Rakshak fruit setting on Arka Fermented Cocopeat

Brinjal

Soilless cultivation: Scheduling of 172 ppm N-NO_3, 33 ppm P and 200 ppm K per plant recorded maximum yield (3.54 kg plant^{-1} and 49.56 t ha^{-1}) in brinjal hybrid Arka Anand under open conditions. Poly house soilless cultivation recorded higher values for plant growth parameters and yield (3.83 kg plant^{-1} and 53.62 t ha^{-1}) compared to open soilless conditions. With respect to substrates, brinjal plants raised on Arka Fermented Cocopeat registered maximum plant height, number of leaves, total plant dry biomass, number of fruits, fruit length, fruit girth, fruit weight and yield compared to soil under open-field soilless culture.

Growth and fruit setting of brinjal var. Arka Anand under soilless culture

Ridge gourd

Soilless cultivation: Ridge gourd variety Arka Prasan was evaluated with different levels of NPK under soilless cultivation. Application of 166, 33 and 207 ppm of N, P and K recorded higher values for plant growth characters and yield (2.32 kg plant^{-1}) compared to other treatments. Polyhouse soilless cultivation of ridge gourd performed better than open-field soilless cultivation in terms of growth and yield. The highest fruit numbers (9.22), fruit length (43.25 cm), girth (45.10 mm), average fruit weight (251.76 g) and yield (2.32 kg plant^{-1}) was recorded with crop grown on Arka Fermented Cocopeat than the plants grown in soil under open field soilless conditions.

Ridge gourd growth and fruit setting in open and polyhouse soilless culture

Rhizobacterial strains for production of bio-encapsulated vegetable seeds

The field performance of okra, chilli and onion seeds that were subjected to different types of seed bio-encapsulation treatments using anhydrobiotically dried plant growth promoting bacterial strains were determined under field conditions. Four treatments viz., untreated seeds (control), film coating with anhydrobiotically dried bacterial consortium, film coating with wet cell bacterial consortium and seed treatment with lignite based bacterial consortium (conventional) were tried. In general it was observed that the inoculated treatments recorded higher yields compared to uninoculated control. In okra it was observed that film coating with an anhydrobiotically dried bacterial consortium and film coating with a wet cell bacterial consortium, were at par with each other in terms of yield and nutrient uptake parameters of the crop under field conditions.

Chilli

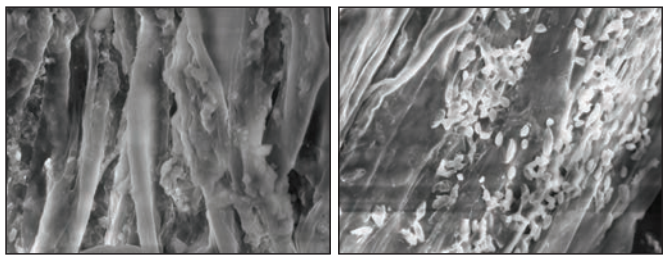
Rootstock-scion interaction: To study the effect of grafting on nutrient content, chilli variety Arka Harita was grafted on chilli rootstock 4550. The concentration of N, P and K showed marginal difference between grafted and ungrafted plants. The concentration of Ca and Fe was higher in grafted plants than ungrafted plants at initial stages. The mean Fe concentration was 180 ppm in grafted plant and 116 ppm in ungrafted plants. With advancing age, K concentration increased, while Ca and Fe decreased in grafted and ungrafted plants. Zinc concentration increased two-fold during fruiting stage in grafted plants. The concentration of Ca (3.25%) and Mg (1.75%) was relatively high in grafted plants compared to ungrafted chilli plants.

Grafted chilli plant under field condition

Grafted chilli plant under pot culture

Growth parameters influenced by microbial inoculants

The effect of different concentrations of microbial inoculants like Arka Microbial Consortium (AMC) from 10^5 to 10^9 CFU ml^{-1}, JL5 (*Trichoderma* spp.) from 10^4 to 10^6 CFU ml^{-1} and JL4 (*Trichoderma* spp.) from 10^4 to 10^6 CFU ml^{-1} on growth parameters of tomato seedlings was studied. Observation on plant height, number of branches, fresh weight, dry weight and leaf area were recorded for 28 days after transplantation at weekly intervals (0, 7, 14, 21 and 28 days). With increase in the concentration of AMC, there is a significant increase in plant height and biomass, while JL5 and JL4 did not show any significant difference. The growth regulatory hormones IAA and salicylic acid were higher in AMC treated plants compared to untreated.



AMC and JL5 treated roots after 30 days

Pesticides residues

Coriander: Uptake of soil applied pesticides (chlor -pyrifos, carbendazim and carbofuran) in coriander resulted in higher residues of these pesticides in shoots than in roots. The residues persisted for more than 15 days. The uptake was 50 to 500 times higher in shoots than the roots. No effect of AMC treatment or genotypic variation on uptake of these pesticides from soil to the crop was seen.

Moringa: In studies on pesticide residues in moringa and its processed product, the dynamics of three pesticides, viz., deltamethrin, lambda cyhalothrin and chlorpyriphos were studied. Washing under running water did not dislodge pesticides to any significant extent. Dry leaf powder from fresh moringa leaf was done by using three drying processes, air drying, oven drying (40-50 °C), and sun drying. During drying, a slow degradation of pesticides (5 to 30%) was observed, and no differences were observed among the different drying processes. However during air drying, degradation was more as it was a slower drying process, i.e. longer contact with water. A hot water treatment of dry leaf powder for 10 min could remove >85% of deltamethrin and chlorpyriphos. Of six commercial moringa dry leaf powder samples from different companies, four samples were contaminated with pesticides like deltamethrin, imidacloprid, spiromesifen and buprofezin.

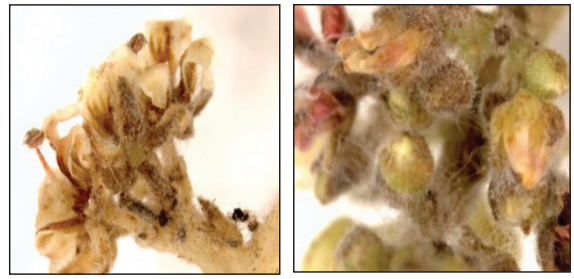
3.4. CROP PROTECTION

3.4.1. FRUIT CROPS

Mango

Mango powdery mildew at different stages of flower opening: Earlier reports observed that the first two stages of flower opening (i.e.) bud break and mouse ear stages were not susceptible to infection by powdery mildew under field conditions. All seven stages of the flower formation and flower opening in both early flowering var. Lazzat Baksh and mid-flowering variety Alphonso were studied for their susceptibility to powdery mildew pathogen *Oidium mangiferae* under artificial inoculation. In Lazaat Baksh except the first stage of bud break, all stages of flower formation were infected when artificially inoculated with the conidia of *O. mangiferae*. The infection started 24 hours after inoculation. In Alphonso, all stages were susceptible to the infection and spread of the disease was faster than that observed in Lazzat Baksh. The entire inflorescence was covered within 36 hours after inoculation.

A **B** **C**



D **E**

Response of different stages of flower bud and flower opening to inoculation with powdery mildew conidia (closer view) in early flowering variety Lazzat Baksh

A

B

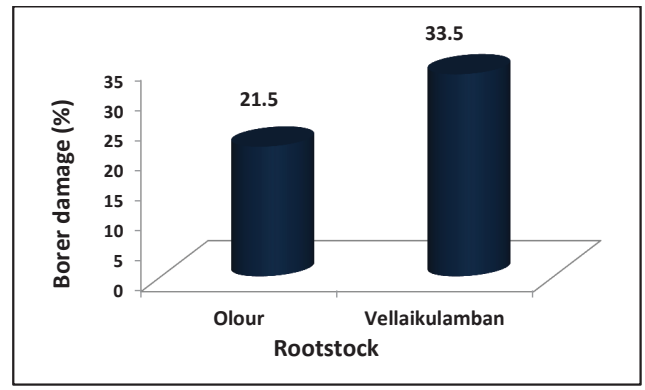
Response of different stages of flower bud and flower opening to inoculation with powdery mildew conidia (A - At time of inoculation; B - 4 days after inoculation) in Lazzat Baksh

Effect of weather parameters on spread: Spread of powdery mildew in Lazzat Baksh (early flowering), Alphonso (mid-flowering) and late flowering (Neelam) was studied. Due to flowering, in Lazzat Baksh the severity of powdery mildew was relatively higher in Jan (PDI 21.8), while it was just starting in Alphonso and not observed in the inflorescence of Neelam in February. However, in Feb there was no significant difference in powdery mildew incidence in both Lazzat Baksh (PDI 38.4) and Alphonso (PDI 42.1). There was a positive correlation (r = 0.68) between relative humidity (average of preceding 7 days) with powdery mildew severity while with temperature there was negative correlation (r = -0.52). The powdery mildew incidence did not coincide with days of precipitation.

Management of mango fruit borer, *Citripestis eutraphera*: A spray module including insecticides and botanicals to manage mango fruit borer was standardised. It involves first spray of an insecticide, (either indoxacarb (0.5 ml) or spinetoram (1.25 ml) or deltamethrin (1 mL L^{-1}), followed by a second spray with IIHR Neem Soap @ 10 g L^{-1} or azadirachtin 1% (3 mL L^{-1}) after two weeks. Spraying should commence when fruits are lemon size. This has brought down borer infestation by 85-90%.

Efficacy of EPN against mango stem borer: IIHR strains of entomopathogenic nematode, *Steinernema* spp. were evaluated in the field. Of the 12 trees treated with EPN solution, borer feeding stopped in 10 trees, resulting in 83.33% reduction in stem borer damage. EPN solution was injected into borer holes @ 10 ml per hole three times, at five days interval.

Stem borer infestation in relation to rootstock: Mango (cv. Alphonso) grafted on two rootstocks viz., Olour and *Vellaikolumban* was evaluated for stem borer incidence. Observations recorded over the last 5 years indicated that rootstocks had significant influence on borer infestation. Alphonso grafted on *Vellaikolumban* rootstock had suffered higher stem borer damage (33.5% cumulative damage) compared to Olour (21.5%).



Infestation of mango stem borer in relation to mango rootstocks

Guava

Screening of guava germplasm for resistance to *Meloidogyne incognita*

Among the guava germplasm screened for resistance to root knot nematode, *Meloidogyne incognita*, *Psidium cattleianum* showed immune reaction without any galls (Gall index 0), while *P. friedrichstalianum* had high resistance to *M. incognita* with gall index of 1.0.

P. friedrichsthalianum **(Highly resistant to *M. incognita*)**

P. cattleianum **(Immune to *M. incognita*)**

Reaction of guava germplasm to *M. incognita*

Analysis of root exudates of nematode resistant *Psidium cattleianum* cv. *lucidum*

Root exudates of lemon guava, *P. cattleianum* cv. *lucidum*, an immune host to *M. incognita*, was analysed in GC-MS. The compounds *p*-benzoquinone, 2-hydroxy-1,8-cineole, phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl-, benzoic acid, 4-ethoxy-, ethyl ester, 2,6,10-trimethyltetradecane, n-hexadecane, 1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester, 10-methylnonadecane, 1,2-benzenedicarboxylic acid, dicyclohexyl ester were relatively high upon inoculation with nematodes; while 1,4-benzenediol, *p*-hydroxy-m-methoxybenzaldehyde, 4-methoxy-3-tert-butylphenol, n-dodecanoic acid, tetradecanoic acid, 1-(3-hydroxy-3-methyl-4-pentenyl)-

2,5,5,8a-tetramethyldecahydro-2-naphthalenol were more in uninoculated control.

Management of guava shoot borer: Different spray modules involving an insecticide (Lambda cyhalothrin @ 1 mL L^{-1}) and IIHR neem soap @ 10 g L^{-1} were evaluated. Treatments of a first spray of lambda cyhalothrin followed by a second spray of neem soap after 15 days resulted in 73% reduction and were at par with two sprays of insecticide. Keeping in view the essentiality of minimizing synthetic insecticide sprays, this module is considered effective and safe to manage guava shoot borer.

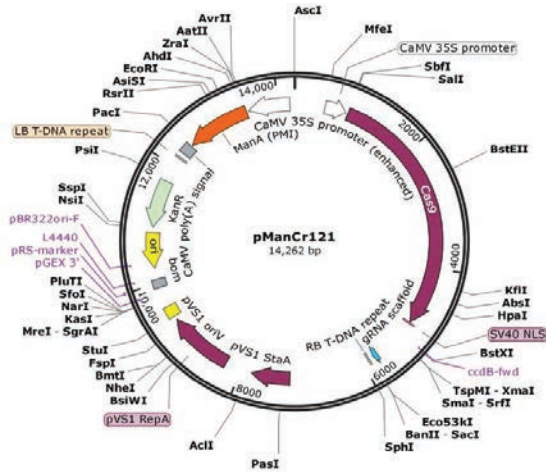
Papaya

Population dynamics of aphids and PRSV spread: Based on trap catches, the melon aphid, *Aphis gossypii*, cowpea aphid, *A. craccivora* and green peach aphid, *Myzus persicae* were the major aphid species. The highest number of aphids trapped were *A. gossyppi* (50-55 $inch^{-2}$ $week^{-1}$), followed by *M. persicae* (40-45 $inch^{-2}$ $week^{-1}$), and *A. craccivora* (15-20 $inch^{-2}$ $week^{-1}$). *Aphis gossypii* was the predominant spp. and was recorded throughout the year. Aphid population had positive correlation with maximum temperature, minimum temperature and wind speed; negative correlation was observed with rainfall, morning and afternoon humidity. Correlation between aphids and succeeding two weeks PRSV incidence showed positive correlation in multiple stepwise regression analysis. The rate of spread of PRSV varied in different varieties, faster spread was observed in Arka Surya (r: 0.127) and slower in Red Lady (r: 0.081).

Mechanism of ISR/ SAR in papaya using chemicals and PGPR: PSRV infection in papaya cv. Red Lady showed significant reduction in GA3 and IAA, with no appreciable changes in ABA in inflected plants. Significant increase in GA3, IAA, ABA and SA in treatments of spray of sea weed extract (Sagarika) @ 2 mL L^{-1}, drenching of Actino Plus @ 5 mL L^{-1} and spray of AMC (20 mL L^{-1} at 15 days intervals), spray of *Bacillus amyloliquefaciens* @ 5 mL L^{-1} at weekly intervals, spray of Kaolin @ 2 g L^{-1} at 10 days interval and foliar application of micronutrients (5 g L^{-1}) at 15 days interval. Activity of the enzymes POD, SOD, PAL and peroxidase, and levels of salicylic acid increased in treatment with Sagarika, ActinoPlus, *B. amyloliquefaciens* and Kaolin.

Effect of PRSV on photosynthesis and growth of papaya: Treatments of spray with Kaolin @ 2 g L^{-1} at 10 days interval and drenching of Seed pro @ 5 g L^{-1} at 15 days interval, Sagarika @ 2 mL L^{-1} at weekly intervals, salicylic acid @ 1 g L^{-1} at 10 days interval and *B. amyloliquefaciens* @ 4.0 mL L^{-1} (or) at 10 days interval till flowering and fruiting has resulted in significant increase in photosynthesis and chlorophyll fluorescence, chlorophyll content, Relative Water Content (RWC) and malondialdehyde (MDA) content compared to control and unsprayed plants.

CRISPR/Cas9 mediated genome editing of papaya eIF4E gene: Efficient single guide RNA was selected based on *in silico* methods. Three single guides were prepared by oligonucleotide synthesis CPSG1, CPSG2 and CPSG3 covering three regions identified to interact with VPG protein of PRSV. These guides were ligated under the control of an U6 promoter and upstream of scaffold RNA and a terminator. The whole sgRNA forming cassette was transferred to the CRISPR/Cas9 vector for transformation. pBI121 binary vector was employed as the backbone and following changes were made. The GUS gene in the pBI121 binary vector was replaced by the 4107 bp Cas9 gene obtained from the pDeCAs9 vector. The antibiotic selection marker was removed and PMI phosphomannose isomerase gene ligated in place of the NPTII gene in the pN-BI121 vector for mannose-based selection and to do away with antibiotic selection marker. The sgRNA forming cassette was ligated in the MCS region of the pBI121 vector containing Cas9 gene and was designated as pManCR121. A total of seven gene constructs were prepared for transformation of papaya. Three sgRNA in to two selection backgrounds and an RNAi vector for gene silencing of papaya eIF4E for academic comparison of knockdown/knockoff mutants of eIF4E.



CRISP/Cas9 Vector

Litchi and Avocado

Insect pollinator diversity in Litchi and Avocado: Insect pollinator diversity in litchi (*Litchi chinensis*) and avocado (*Persea americana*) was determined. Hymenopteran pollinators were dominant followed by dipteran pollinators. *Apis cerena*, *A. florea, A. dorsata* and *Tetragonula iridipennis* were major pollinators. Maximum foraging was observed during early period of

the day (8.00 to 11.00 am) compared to later period of the day (3.00 to 6.00 pm).

In avocado, Hymenopteran pollinators were dominant followed by dipteran and coleopteran pollinators. *A. cerena, A. florea, A. dorsata, T. i ridipennis, Camponotus sericeus, C. compressus,* Wasp *Vespa cincta* etc., were the major pollinators. The peak foraging activity was observed between 8.00 am to 12.00 noon.

Wasp, *Vespa cincta* visiting avocado flowers

Ant, *Camponotus sericeus* visiting avocado panicle

Fire bush *Hamelia patens, Antigonon leptopus,* soap nut *Sapindus mukorossi* etc., were the major alternate flora observed for the pollinators of litchi and avocado.

Avocado diseases incidence and management: The disease incidence in 40 fungal infected samples (fruits, and twigs) of avocado collected from ranged from 20 to 50% on fruits, 5% on leaf and 20-30% on twigs dieback. Forty fungal isolates were isolated from fruits, twigs, leaves and stem of avocado and their pure cultures are being maintained for identification. Twenty fungal isolates were isolated from dead bark of avocado trees, and soil, from different locations in Kodagu, and pure culture of the fungal pathogens was re-inoculated into avocado seedlings to confirm the pathogenicity of pathogen.

Seven systemic fungicides were evaluated *in vitro* against scab and anthracnose diseases of avocado. All seven systemic fungicides (Fenamidone 10% + Mancozeb 50%, Tebuconazole 50% + Trifloxystrobin 25%, Captan 70% + Hexaconazole 5% , Benalaxyl-M 4.0% + Mancozeb 65.0% WP , Boscalid 25.2 + Pyraclostrobin 12.8% WG, Fluopyram 17.7 % + Tebuconazole 17.7% SC, Improvalicarb 5.5% + Propineb 61.25% WP) @ 0.05% were effective against both scab and anthracnose diseases of avocado.

Occurrence of fruit chafer beetle on fig: Severe infestation of a fruit chafer beetle, identified as *Protaetia alboguttata* (Vigors) (Coleoptera: Scarabeidae: Cetoniinae) was recorded on fig (*Ficus carica* L.). The adults of beetle fed on matured fruits of fig (cv. Poona) gregariously (2-12 fruit^{-1}). Out of 68 plants in fruiting stage, 31 (45.58%) had been attacked by the chafer beetles. The number of beetles feeding on a single fruit ranged from 2 to 12 (mean 4.56) and 75.8% of ripened fruits were affected by this beetle. Findings highlight the expanding host range of *P. alboguttata* as there are no previous records of it infesting fig fruits.

Fruits attacked by *Protaetia alboguttata*

Variety/rootstock evaluation for resistance to stem borer in fig: Variety Deana grafted on self was most susceptible (66.66%) and suffered highest damage due to stem borer while Poona was least susceptible (7.40%) and is considered to be resistant to stem borer. Preference of stem borer to Deana over Poona was also confirmed through laboratory screening by artificial infestation. When stem twigs of both the varieties were exposed to adult of stem borer (*Batocera rufomaculata*), the beetle was attracted more to Deana and laid eggs while avoiding Poona stem, thus, Poona could be a potential source of resistance either as rootstock or parental line for breeding to manage stem borer in fig.

3.4.2. VEGETABLE CROPS

Tomato

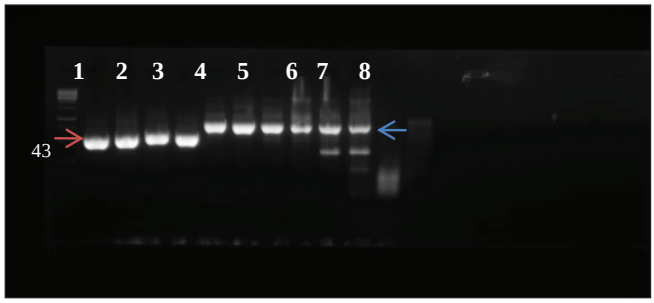
***In vitro* screening of endophytes for bioactivity against selected pathogens:** *In vitro* screening of *Trichoderma* isolates JL5, GJ16B, LA and *Bacillus subtilis* against *Alternaria solani* (causal agent of early blight of tomato) through the dual culture assay showed the involvement of volatile organic compounds (VOCs) on inhibition of the pathogen. GC-MS analysis of VOCs from pure cultures and interaction plates revealed compounds with a wide range of biological activities like insecticidal, antimicrobial, antifungal, antibacterial, antioxidant, anti-inflammatory and induction of defense response. Three isolates viz., JL5, GJ16B and UGF were effective in controlling the early blight of tomato *in vivo* with significant reduction in the PDI compare to control and other treatments. The activity of defense enzymes POX, PPO, and SOD and total phenols and flavonoids were enhanced in plants treated with bioagents (JL5 and UGF)

followed by pathogen challenge, indicating the effect of these treatments in inducing systematic resistance and antimicrobial properties in tomato. Bioagents JL5 and UGF were also found to enhance the expression of pathogenesis related genes like *PR1*, *PR2* and *POX* upon pathogen infection in tomato.

Nematode management: Seed treatment with bacterial bioagents, *B. pumilus or B. amyloliquefaciens* at 20 g kg^{-1} seed, substrate treatment at 10 g kg^{-1} cocopeat and soil application of 5 tons FYM enriched with either of them at 5 kg ha^{-1} recorded significantly higher yield (26.37–27.96% increase over control) and lower nematode population in tomato (74.23–74.86% decrease). Cost benefit ratio of 1:1.91 to 1: 1.93 was recorded. In tomato grown under protected conditions, integrated nematode management module with soil application of Fluopyram 400 SC at 500 mL $acre^{-1}$ before planting + soil drenching of neem cake enriched biopesticides suspension once in 30 days in standing crop recorded maximum increase in yield (+21.49%) and decrease in nematode population (-68.4%) compared to control.

Integrated management of tomato pin worm, *Tuta absoluta*: Light cum suction trap based integrated management of *Tuta absoluta* in tomato resulted in less than 1% damage to tomato yield, compared to 32% damage in control. Various IPM components include raising pest free nursery, clean cultivation, use of two light cum suction traps/acre (60 W incandescent bulb), sex pheromone traps @ 15 $acre^{-1}$, release of egg parasitoid, *Trichogramma pretiosum* @ 75,000 ha^{-1} (5 releases at weekly interval), need-based spraying of indoxacarb 14.5 SC @ 1 mL L^{-1} or spinosad 45 SC @ 0.25 mL L^{-1} and spraying of deltamethrin 2. 5 EC @ 1 mL L^{-1} coinciding with the peak adult emergence and encouragement of natural enemies like mirid bug, *Nesidiocoris tenuis*. The IPM package also helped in reduction of pesticide sprays by half the number of sprays in farmers' practice of up to 16 sprays in a crop cycle.

Insecticide resistance in *Tuta absoluta*: Biochemical and molecular assays of insecticidal resistant population of *Tuta absoluta* found the involvement of CYP450, carboxyesterase and *CYP9*, *CYP 4* and *CYP 2* genes responsible.

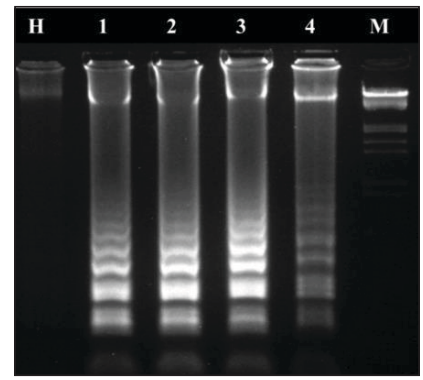


1: 1kb Ladder, 2: CYP42at 24h of expose to flubendiamide,3: CYP42 at 48h expose to flubendiamide,3, 4:CYP42 at72h expose to flubendiamide, 5: CYP42 at 96h expose to flubendiamide, 6: CYP9 at 24h expose to chlorantraniliprole, 7: CYP9 at 48h expose to chlorantraniliprole, 8: CYP9 at 72h expose to chlorantraniliprole, 9: CYP9 at 96h expose to chlorantraniliprole , 10 : CYP 2 at 24h expose to chlorantraniliprole

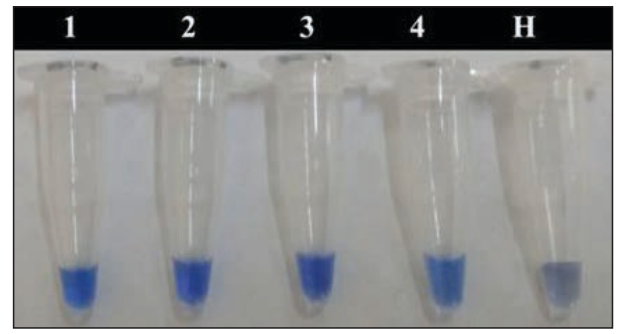
Chilli

Development of RT-LAMP based detection of Chilli veinal mottle virus (ChiVMV)

One step RT-LAMP assay was used to develop a novel nucleic acid amplification assay termed reverse transcription (RT) loop-mediated isothermal amplification (RT-LAMP) for specific and sensitive detection of ChiVMV. Four LAMP primers (i.e. F3, B3, FIP and BIP), together with PCR primers (F and R) were designed on the basis of the Coat protein gene of ChiVMV. LAMP-positive amplicons were confirmed by the dye hydroxynaphthol blue, a sky blue coloration indicated the presence of the virus, and a violet colour in control. The sensitivity of the protocol was 10-fold higher than that of conventional RT-PCR and ELISA.



RT-LAMP detection of ChiVMV in virus infected samples: Lanes 1-3: ChiVMV infected chilli and lane:4 ChiVMV infected tomato, H: Healthy Chilli, M: DNA marker (1 kb DNA ladder)



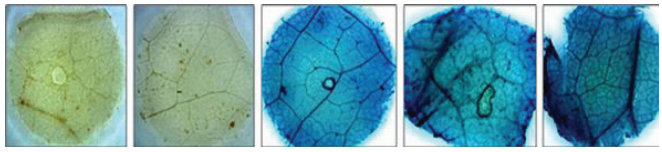
Visual detection and sensitivity of LAMP amplified product

Integrated management of vector borne viruses in chilli: Integrated management of virus diseases of chilli was developed in nursery under nylon net, and seedling spray with systemic insecticides at nursery stage. In the main field border crop with maize, silver mulching followed by spraying of Acephate @ 1.5 g L^{-1} + Neem oil 2 mL/L followed by Thiamethoxam 0.3 g L^{-1}, and Spiromesifen 0.5 ml L^{-1} in rotation, at seven days interval until flower formation significantly reduced insect vector population, virus incidence and increased yield two-fold. The next best treatment was soil application and foliar spray of *T. harzianum*, *Bacillus subtilis*, *B. amyloliquefaciens*, which significantly increased flower yield compared to control.

Vector population and virus incidence in IDM of vector borne viruses

Treatments	Aphids	CMV/ ChiVMV (%)	Polerovirus (%)	White fly	ChLCV (%)	Thrips Population	GBNV (%)	Yield (tons ha^{-1})
T1. AP +AMC	11	22.8	16.0	16.0	31.5	15	11.5	38.49
T2. Sagarika	8.5	20.8	18.8	10.5	23.5	10	8.6	38.31
T3. Potassium silicate	9.5	19.4	11.8	9.5	28.7	13	8.5	29.73
T4. B. amin. + K. Si + Sagarika	5.5	11.5	7.6	11.0	19.5	11	7.9	45.17
T5. Ac+B.am+FP+Imi	6	11.5	9.3	8.5	13.7	9	6.8	41.98
T6. B. amino	8.4	16.15	10.2	12	21.2	13	9.5	35.25
T7. Fight Pro	7.6	15.7	15.2	8	17.1	9.5	7.8	39.7
T8. Salicylic acid	10.5	21.5	14.5	12.5	24.5	12.5	10.3	30.54
T9. Control	15	47.45	17.5	19	35.75	22	11.2	18.41
SEM	0.08	0.05	0.07	0.05	0.07	0.09	0.05	0.27
C.D. at 5%	0.77	1.50	1.11	0.62	1.74	0.52	0.83	1.55
C.V	8.80	4.42	4.04	5.30	3.43	5.43	5.41	4.11

Genome editing of recessive resistance eIF4 genes in chilli for potyvirus resistance: Gene editing was employed to develop resistance against potyviruses in chilli cv. Arka Suphal by introducing mutations in the *eiF4E* gene, also required for the potyviruse for replication. Gene constructs were developed for gene editing and gene edit resources were delivered by both stable transformation by *Agrobacterium* mediated plant transformation and transient Agro-infiltration. Regenerated shoots have been obtained; shoot elongation and rooting are underway. Two guide RNAs were designed viz., sgRNA eIF4E 94 and sgRNA eIF4E 428 RNA. Transient transformation was carried out by Agro-infiltration for the two sgRNA eIF4E 94 and sgRNA eIF4E 428 RNA, Buffer control plants. The sgRNA eIF4E 428 RNA infiltrated plants have shown resistance to the potyvirus. Thus, Agroinfiltration can be employed for rapid screening.



Un-infiltrated Buffer control pBI121 Agro-infiltrated Chilli leaf disc

Integrated management of vector borne viral disease of chilli: The experiment was conducted at CHES, Chettalli, on Integrated Management of vector borne viral disease of chilli.

1. **Monitoring vectors:** Of the different vectors observed during the entire cropping period, only whitefly populations were present in different treatments and control. Among the different treatments imposed to manage the chilli leaf curl disease, growing border crop (maize) + plastic mulch + spraying of 2-bromo-2-nitro-1,3-propanediol, 500 ppm + Neem oil @ 3 mL L^{-1} followed by Imidacloprid @ 0.5 mL L^{-1}, followed by Fipronil @ 2 mL L^{-1}, followed by Neem oil @ 3 mL L^{-1} + Fish oil @ 2 mL L^{-1} at 7 days interval till fruit maturity; and growing of border crop (maize) + plastic mulch + dipping of roots of chilli seedlings in Imidacloprid @ 0.5 mL L^{-1} + spraying Imidacloprid (0.5 mL L^{-1}) at 7 days interval till fruit formation have recorded low whitefly population (4.33 insects $plant^{-1}$) compared to control (15 $insectsplant^{-1}$).

2. **Monitoring virus incidence:** Among the different treatments imposed, growing of border crop (maize) + plastic mulch + spraying of 2-bromo-2-nitro-1,3-propanediol, 500 ppm + Neem oil @ 3 mL L^{-1}, followed by Imidacloprid @ 0.5 mL L^{-1} followed by Fipronil @ 2 mL L^{-1} followed by Neem oil @ 3 mL L^{-1} + Fish oil @ 2 mL L^{-1} at 7 days interval till fruit maturity was highly effective in reducing the disease incidence at 20.5% compared to control (95.0%).

3. **Correlation of weather factors to vector population and virus spread:** During the entire crop period (March to August, 2020), the disease incidence of whitefly population was positively correlated with mean rainfall, temperature and relative humidity.

4. **Assessment of yield loss due to Chilli leaf curl virus infection with time:** The infected plants were tagged at different intervals: 30, 45, 60, 75, 90 days . The observation recorded revealed that the chilli plants infected by virus at 30 days recorded higher yield loss (60**%**), compared to infection at 90 days (40%).

Screening of chilli germplasm against leaf curl disease: Five genotypes (LC-07, Sona, Maya 453, Maya 456, Armur) were screened against leaf curl disease of chilli; of these Armur recorded the least disease incidence (27%) and whitefly count (2 $whitefly\ plant^{-1}$), compared to other varieties.

Brinjal

In brinjal nematode management, combination of seed treatment (10 mL kg^{-1} seed) with nursery treatment (50 mL m^{-2}), soil application (5 t ha-1 of FYM enriched in 5 L) and soil drenching (5 mL L^{-1}) every 30 days with *Bacillus megaterium* -1% A.S. recorded maximum decrease in soil and root nematode population (69.3 -78.7%) coupled with 25.9 % increase in yield.

Bitter gourd

Integrated management of virus diseases of bitter gourd: For the integrated management of virus diseases in bitter gourd, Border cropping with two rows of maize and raising seedlings under nylon net (40 mesh) cover with seedling application of FYM enriched with Seed Pro + AMC, use of yellow sticky traps followed by main field use of agri-silver mulch and rotational spray of insecticides were tried. Among the treatments, spraying of *T. harzianum, Bacillus subtilis*, *B. amyloliquefaciens* + Sagarika (sea weed extract) + Azadractin/ Neem oil in rotation was found to be very effective in the reduction of vector population, virus incidence and increase in yield over all the treatments and resulted in threefold increase in yield over control. In the order of performance, the treatment rotational spray of Acephate @ 1.5 g L^{-1} + Cyzpyr @ 1.8 mL L^{-1} + Fipronil @ 1.0 mL L^{-1} + SEFINA @ 1.0 ml per15 L at weekly intervals until fruit formation were significantly superior with reduction in insect vector population (aphid, thrips, whitefly), virus incidence and increase in yield.

Integrated management of virus diseases of bitter gourd using bioagents and pesticides

Treatments	Aphids	PRSV/ ZYMV (%)	CABYV (%)	White fly	ToLCNDV (%)	Thrips Population	GBNV (%)	Yield (tons ha^{-1})
T1:T0 + Azadirachtin/ Neem oil/ Mineral oil spray	8	12.5	16.0	17.0	21.5	11	7.5	14.49
T2: T0+Application of SAR inducer (PhytonT + Power Plus)	9	10.8	20.5	15.5	20.5	13	7.6	16.31
T3: T0+Application of ISR inducers (AMC/Actino plus)	12	21.5	17.9	12.5	17.5	12	6.5	19.73*
T4: T0+Rotation of Acephate @ 1.5 g/L + Cyzpyr @ 1.8 mL/L + Fipronil @ 1.0 mL/L + SEFINA @ 1.0 ml/15 L	7	9.5	10.5	7.5	12.9	7	3.8	21.45**
T5:T0+Application of *T. harzianum*, *B. subtilis*, *B. amyloliquefaciens*+ Sagarika + Azadirachtin/ Neem oil	7.5	8.5	8.5	9.0	13.5	11	5.9	25.65**
T6: T0+ cartaP hydrochloride @ 3.0 g/L @ weekly intervals	8.4	15.15	13.5	11.0	19.5	9	4.5	19.25*
T7: T0+ Application of *T. harzianum*, *B. subtilis*, *B. amyloliquefaciens*	7.6	12.7	13.2	8	21.1	10.5	5.8	19.9*
T8:T0+Spray of Sagarika @ 2 mL/L	10.5	19.5	15.8	12.5	22.5	9.5	7.3	18.54
T9: Control	16	19.45	28.3	19	41.75	16	10.5	8.41
SEM	0.09	0.06	0.09	0.13	0.18	0.21	0.15	0.57
C.D. at 5%	1.15	2.13	3.11	2.12	1.84	1.05	0.95	2.85
C.V	8.80	6.42	7.04	9.30	5.43	7.43	6.41	7.11

- T0: Border cropping with maize and application of Seedpro/AMC at seedling stages
- Mean of three replications; *: Significant at P0.05, **: Significant at P0.01

Cucumber

Integrated virus disease management in cucumber: The field trial on integrated virus disease management in cucumber was taken with seven different treatments. Among all the treatments, two rows of border cropping with maize, installation of reflective mulches, blue and yellow sticky traps, application of Neem oil @ 3 mL L^{-1}, Arka Microbial Consortium @ 20 g L^{-1} and rotational sprays with Arka Vegetable Special @ 3 g L^{-1}, Fipronil @ 1.0 mL L^{-1}, Thiomethoxam @ 0.5 g L^{-1} and Dimethoate @ 2 mL L^{-1} on weekly basis will protect (up to 95%) the crop from virus incidence (2-5%) compared to 60-90% virus incidence in control plots.

Integrated nematode management in cucumber under protected conditions: Planting African Marigold 45 days before planting cucumber + Application of bio-agents (2 kg each of *B. subtilis, B. pumilus* and *B. amyloliquefaciens*) enriched neem cake (1 ton ha^{-1} + drenching bio-agent enriched neem cake suspension 10% once in 30 days recorded the maximum decrease of *M. incognita* population (70.8–76.1% roots and soil) and increase in cucumber yield (23.3%) compared to untreated control, under protected conditions with cost benefit ratio of 1:2.11.

Technology for polyhouse pollination of cucurbits using native honey bees: A protocol has been standardised using two native bee species viz., Indian honey bee, *Apis cerana* and stingless bee, *Tetragonula iridipennis* for pollination of muskmelon (cv. Arka Siri) and cucumber grown under polyhouse. The technology involves placing a honey bee hive (of eight frames strength) at the border of polyhouse in such a way that half of box with main entrance faces inside the polyhouse and the other half (back of box) remains outside the polyhouse. This box is provided with two exits at front and back of the hive so that bees can move in either direction. The hive are to be placed when the crops are about to flower. In case of stingless bee, two hives of *T. iridipennis* must be hung from the top at crop canopy level. Studies were conducted consecutively for three crop cycles during 2019-20. Both the species foraged efficiently on flowers of muskmelon and cucumber and the worker bees visited both male and female flowers thus effecting pollen transfer to stigma.

Fruit set, fruit yield and quality in plants exposed to bees were compared with those excluded from insects and hand pollinated. There was zero fruit set in plants excluded from bees thus proving that honey bees contributed to pollination solely. The mean fruit set, number of fruits per plant and fruit weight of musk melon due to bee pollination were 92.5%, 1.85 and 1.60 kg respectively. In cucumber, these values were 88.6%, 21.4 and 375.5 g respectively and were on par with hand pollination. The estimated yield was 50 t ha^{-1} for muskmelon and 80 t ha^{-1} for cucumber with honey bee pollination. There was no significant difference in fruit weight and quality parameters between hand pollinated and bee pollinated plants thus proving that bees are a substitute to hand pollination which is labour intensive. This technology helps in overcoming the pollination problem of cross pollinated vegetables under polyhouse without the need for exotic pollinator species.

Honey bee hive placed in polyhouse

Hive of stingless bee inside polyhouse

Indian honey bee foraging on cucumber flowers

Stingless bee foraging on muskmelon flowers

Spine gourd

Insect pollinator diversity: *Apis cerena*, *A. florea, A. dorsata*, *Tetragonula iridepennis* and bumble bee *Xylocopa* spp. were the major pollinators recorded in spine gourd. The peak foraging activity was observed between 8.00 am to 11.00 am.

Bumble bee *Xylocopa* spp. on spine gourd flower

Detection of Cucurbit viruses: Using primers specific to Cucumber green mottle mosaic virus (CGMMV) coat protein, total RNA isolation followed by RT-PCR using CGMMV specific primer resulted in positive amplification of 0.6 kb DNA fragment from CGMMV infected sample but not from healthy control samples of bottle gourd, cucumber, ivy gourd and snake gourd. Using begomovirus specific primer, *Squash Leaf Curl China* virus was detected in bottle gourd, cucumber and *Tomato Leaf Curl New Delhi* virus in cucumber.

Pointed gourd

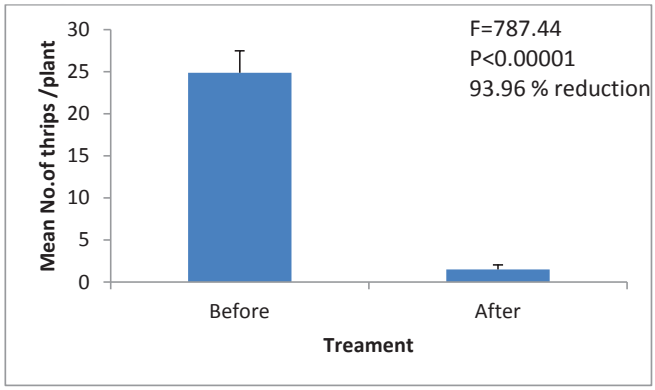
The pathogen causing collar and root rot of pointed gourd has been identified as *Phytophthora melonis* based on morphological, cultural and pathogenic characters together with DNA sequence analysis of ribosomal internal transcribed spacer (ITS rDNA) regions, fragments of the β–tubulin, translation elongation factor 1-alpha and mitochondrial cytochrome c oxidase subunit I (CoX) genes. Of the native *Trichoderma* isolates *viz.*, IIHR-B-TR1, IIHR-B-TR-2, and IIHR-B-TR-3, isolated from acidic rhizosphere soil (pH 4-2-4.5) in horticulture ecosystem of Odisha, IIHR-B-TR1 outperformed other strains by inhibiting the major soil borne pathogen *Sclerotium rolfsii* infecting pointed gourd. In addition, two fungicides difenconazole 25EC and tebuconazole 25.9 EC at 0.1% inhibited pathogen growth by 95%, when screened by poisoned food technique followed by detached leaf assay. Under nursery conditions, IIHR-*T. harzianum* was superior to other native *Trichoderma* strains, by reducing the mortality of cuttings and promoting growth in terms of increased vine length and root growth of pointed gourd cuttings. The IIHR- *T. harzianum* treated vine cuttings were ready for planting 20-25 days after planting compared to 30-35 days in untreated control.

Moringa

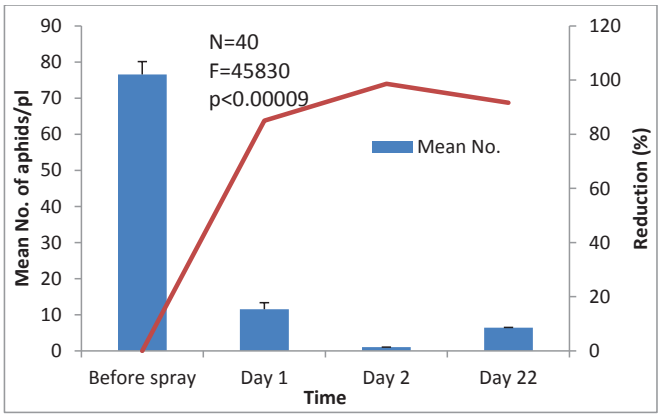
Management of tea mosquito bug: Tea mosquito bug *Helopeltis antonii* caused severe damage (74-100%) to drumstick, *Moringa oleifera* Lam. The feeding damage by adult as well as nymphal stages of *H. antonii* led to wilting of shoots and typical damage symptoms on drumstick included necrotic/ silvery patches on tender shoots and fruits, leaf loss and die back of tender shoots that led to complete drying of plants. Yellow colour sticky traps were found to attract a significantly higher number of adult *H. antonii* (7± 2.26; $P<0.001$) compared to the blue traps (2.37±0.75).

Incidence of tea mosquito bug (TMB) *H. antonii* Sign. on drumstick (a) adult TMB, (b) Necrotic feeding lesions of TMB on tender shoots, (c) Die-back of tender growing shoots, (d) White silvery feeding patches on pods, (e & f) Complete die-back and wilting of plants due to TMB

Effect of botanical pesticides on sucking pests of vegetable crops: A formulation developed from seed extract of *Annona Squamosa* was found effect on aphids (*Aphis craccivora*) (94% mortality) on bitter gourd, *Myzus persicae* (94% mortality) and *Scirtothrips dorsalis* (93.96%), whiteflies (*Bemisia tabaci*) (96% mortality) on chilli and capsicum. The formulation developed from seed extract of soap nut was found to have acaricidal effect on mite, *Tetranychus urticae* (97% mortality).



Effect of *A. squamosa* seed extract on *Scirtothrips dorsalis* Hood in capsicum



Effect of *A. squamosa* seed extract on Aphids (*Myzus persicae)* in chilli

3.4.3. ORNAMENTAL CROPS

Crossandra

Identification of *Phytophthora*: The total genomic DNA of 23 *Phytophthora* isolates from crossandra was amplified by PCR using universal ITS region-specific primers. The sequence analysis showed that 19 of 23 *Phytophthora* isolates belonged to *P. nicotianae* with nucleotide identity of more than 98%. The identity of remaining isolates needs to be confirmed. Through cross inoculation studies, it was proven that *P. nicotianae* isolated from crossandra can infect chrysanthemum, but does not infect carnation, gladiolus or betel vine.

Screening of crossandra var./ lines for resistance to *Meloidogyne incognita:* Among the three crossandra var./ lines screened for root knot nematode resistance, M-4 was found to be resistant to *M. incognita* and Arka Ambara was moderately resistant. Arka Kanaka was susceptible and Arka Shravya and Arka Shreya were highly susceptible.

Nematode resistant crossandra var./ lines [M-4 (resistant) and Arka Ambara (moderately resistant)]

Gladiolus

Biomanagement of root knot nematode in gladiolus cv. Arka Ayush: Treatment of gladiolus (cv. Arka Ayush) with biocontrol bacteria, *Bacillus pumilus* IIHR Bp-2 significantly reduced root knot nematode, *M. incognita* population and increased flower and corm yield in all the doses tested. Soil application of 5 tons of FYM enriched with 5 kg of *B. pumilus* recorded the highest spike yield (14.65) and the lowest nematode population in soil (220.25 J2 per 250 cc soil) and roots (4.5 females per 10 g root). It also yielded the maximum number of corms (1.75) and cormels (52.5). It was on par with chemical nematicide (Carbofuran 3G @ 33 kg ha^{-1}) in reducing the nematode population in soil (226.75 J2 per 250 cc soil) and roots (5.25 females per 10 g root) of gladiolus cv. Arka Ayush.

Biomanagement of nematodes in gerbera cv. Arka Ashwa: Soil application of FYM enriched with biocontrol bacteria, *B. amyloliquefaciens* at 5 t ha^{-1} before planting and further soil drenching of neem cake enriched with bioagents at 2 l m^{-2} at three monthly intervals reduced population of *Meloidogyne incognita* in soil by 69.4% of gerbera (cv. Arka Ashwa) and increased spike yield by 20.3%.

Effect of *B. amyloliquefaciens* in gerbera

Field evaluation of gladiolus lines for nematode resistance: Twenty lines of gladiolus were scored for gall index caused due to root knot nematodes under natural field conditions. There were no galls observed in the lines 215, 105 and 12. In other lines, gall index ranged from 0.4 to 1.4.

Marigold

Effect of marigold (*Tagetes* spp.) on *M. incognita*: Root exudates of five marigold varieties/ lines suppressed egg hatching in *M. incognita* by 62.8-91.9% and caused mortality of 38.9-69.7%. Arka Honey exhibited maximum nematicidal activity followed by Arka Agni, Arka Pari, Arka Bangara II and Arka Bangara.

China aster, Chrysanthemum and Marigold

Transmission of aster yellows by *Hishimonas phycitis* in China aster was confirmed. Similarly, transmission of GBNV by *Thrips palmi* in tomato was confirmed by RT-PCR

Excretion of honeydew by *T. palmi* feeding on French bean pods has been documented. HPLC analyses of the honeydew has revealed the presence of inositol as the predominant sugar (43.82 µg ml^{-1}) followed by fructose (31.87 µg ml^{-1}), maltose (20.19 µg ml^{-1}), glucose (17.936 µg ml^{-1}), sorbitol (9.32 µg ml^{-1}), and lesser quantities of lactose, mannose, galactose, arabinose, ribose. The honeydew has both ecological and biocontrol potential in the management of *T. palmi*.

With respect to genome editing, the single guide RNAs (sgRNAs) for *B. dorsalis*, *H. armigera and S. litura* were identified using the software CHOP-CHOP2. About five sgRNAs were designed for each target gene in the spermatogenesis related genes of *B. dorsalis*. Micro injection parameters have been optimized for needle type, pressure, RNP, egg age. Cloning of the eye colour gene, white and eight other spermatogenesis related genes were cloned from appropriate stages of *B. dorsalis*. The sequences were further deposited with GenBank-NCBI A vector has been constructed for *in vitro* sgRNA synthesis and cleaving of the target gene. Additionally six more genes such as to*pi*, *transformer, transformer2, doublesex, fruitless, tssk-1* and *tectin* genes were cloned from *B. dorsalis* and sgRNAs are being identified.

Medicinal crops

Velvet bean (*Mucuna pruriens* var. *utilis*) as a rotational crop in polyhouses suppresses nematode population: Growing velvet bean in polyhouse and incorporation of its residues at 45 DAS significantly reduced the plant parasitic nematode population in soil to the extent of 49.1-61.9%, respectively. GC-MS analysis of the root exudates revealed that the compounds sclarene, 4,5-dichloro-1,3-dioxolane-2-one, n-hexadecanoic acid, 2,2-dimethyl propanoic acid and dibutyl phthalate are induced more in nematode inoculated plants compared to control which might possess nematode antagonistic action that prevent nematode invasion. Some compounds like carane, butylated hydroxytoluene and 2-tert-butyl-4-hydroxy anisole were lower in concentrations after nematode inoculation.

***Mucuna pruriens* as rotational crop in polyhouses**

3.5. CROP UTILIZATION & FARM MECHANIZATION

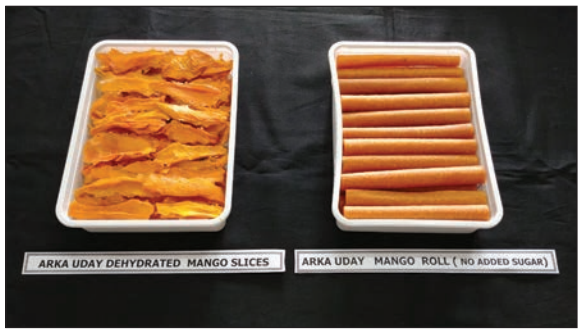
3.5.1. CROP UTILIZATION

Mango

Integration of Quarantine Irradiation treatment (400 Gy) with HWT (52-55 °C for 5-10 min) did not have any adverse effect on the internal quality of Alphonso mango stored for 12 and 25 days at RT and 13 °C respectively. However delayed surface colour development due to irradiation treatment was observed at both storage temperatures.

Protein fortified fruit roll using Whey Protein Concentrate (WPC, 2 and 5%) was made from mango

hybrid Arka Uday without added sugar, having shelf-life of six months. There was reduction in carotenoids content after addition of protein and values ranged from 6.5-11.2 mg 100 g^{-1}. The fruit roll yield were 25.7 and 27.4% respectively in 2 and 5% WPC fortified samples, compared to 22.8% in control bar. However, there was an increase in non-enzymatic browning during storage.



Guava

Guava fruits exposed to 500 ppb of 1-MCP and MA packed using non-perforated PP film could be kept in unripe condition for 3 weeks at 12 °C and 4 weeks at 8 °C with minimum weight loss and without affecting the quality.

Insecticidal compounds in annona seeds

The insecticidal properties of annona seeds and seed oil are attributed to acetogenins among other bioactive compounds. The yield of oil in 14 var./ collections of annona seeds ranged from 13.0% (var. Bullocks heart) to 32.9% (*Annona glabra*). The fatty acid composition of the seed oil revealed large variations among the var./ collections, but were predominantly palmitic, linoleic, linolenic and stearic acids, in addition to 13 other fatty acids. Linolenic acid, a major component in all other samples, was absent in Arka Sahan, Barbados and Washington, while stearic acid was high in these three var./ lines. Analysis of the seed oils by HPLC, revealed the presence of several phytochemicals including acetogenins. The insecticidal property of protic solvent extracts of seeds of 14 var./ collections were tested on *Aphis gossypii*, highest mortality was recorded for *Annona glabra* (55–100%), followed by Rayadurga collection (40–95%) and Arka Sahan (40–90%). The solvent extracts of defatted seeds of Balanagar variety yielded 0.9 to 3.8% extractives; the outer rind, pulp and receptacle contained 11.9% phenols, 5.9% flavonoids and antioxidant activity (12.9 g 100 g^{-1} AEAC units). This study is proof that fruit rind can also be exploited for its insecticidal property and for the extraction of bioactive components.

Pomegranate

Pomegranate, Selection A4/2, was found suitable for both fresh and dehydrated arils. Dehydrated arils are dark red with good taste and aril recovery (24%).

Fresh arils of selection A 4/2

Dehydrated arils selection A 4/2

Pineapple

Probiotic pineapple juice: Process for preparation of probiotic pineapple juice, with 2 months shelf life at refrigerated temperature was standardized.

Packaging for extending the shelf life: Passive and active modified atmosphere packaging (MAP) suitable for extending the shelf life of fresh-cut pineapple was optimized. Passive MAP resulted in 6 days shelf life, while Active MAP extended the shelf life to 12 days. The optimized MAP prevented significant loss of vitamin C, carotenoid and total antioxidants throughout the respective storage period.

Control Optimized active MAP

Effect of active modified atmosphere packaging on shelf life of fresh-cut pineapple during storage at 5 °C for 12 days

Biodegradable plate: The biodegradable plates developed from paddy straw with the addition of natural additives, coated with food grade coating had a thickness of 1.93 mm, and density of 0.14 g cm^{-3}. The biodegradable plate with coating had good compression (3.36 KN m^{-2}) and shear strength (7.47 KN m^{-2}) and less water absorption characteristics compared to biodegradable plate without coating.

Garden Pea

Five var. of green peas - Arka Pramodh, Arka Priya, Arka Karthik, Arka Ajit and Arka Apoorva - including one whole pod variety, were screened for processing into frozen peas and quality was evaluated during storage period of six months. High moisture content was observed in Arka Apoorva (whole pod) (85.7%) and least in Arka Karthik (74.4%); TSS ranged between 11.23-16.03 °B in fresh peas, whereas after blanching and freezing for six months, TSS reduced to 7.07-12.87 °B. Arka Pramodh showed least change in TSS, i.e., from 15.37 to 12.87 °B, followed by Arka Priya. Total polyphenol content ranged between 67.08-89.74 mg GAE 100 g^{-1} in fresh peas, which after blanching reduced by 48 to 60%, and at end of storage period 20.4-24.5% of polyphenols only was retained. Arka Apoorva retained the highest total polyphenol content (17.67 mg GAE/100 g) and Arka Karthik retained highest total chlorophyll content (0.11 mg 100 g^{-1}).

Garden pea processing and storage analysis

Muskmelon

The storage life of musk melon could be extended to 3 weeks at 10 °C with 1-MCP exposure compared to 2 weeks in control without affecting the appearance and internal quality.

Suitable pre-treatment using calcium salt for extending the shelf life of musk melon was standardized. The pretreatment helped to retain the sensory, nutritional quality and microbiological quality of fresh cut musk melon cubes till 10 days at 5 °C storage.

Fruit beverages with incorporated millets

To incorporate essential amino acids, phenols and iron from millets into fruit beverages, three types of germinated millets – foxtail millet, little millet and barnyard millet - were extracted with water and ethanol at different time intervals. In all three millets, higher total free amino acids, iron and zinc were found in water extracts after 24 h, compared to ethanol extraction.

Crossandra

In crossandra var. Arka Shreya, flowers harvested at half open stage, could be stored for up to 5 days after harvest, and flowers at three-fourth open and fully opened stages could be stored up to 4 days after harvest at 4-5 °C. At ambient conditions, harvesting at fully developed bud stage resulted in shelf life of three days, half and three-fourth open flowers for two days whereas fully open flowers had a shelf life of only one day.

S1- Immature flower bud
S2- Mature flower bud
S3- Half-open flowers
S4- Three-fourth open flowers
S5- Fully open flowers

Centella asiatica

A beverage has been standardized from the medicinal plant *Centella asiatica*; quality evaluation during storage revealed a total polyphenol content between 90.87 and 146.25 mg GAE 100 g^{-1} and DPPH activity between 0.142 and 0.279 mg AEAC g^{-1}.

3.5.2. FARM MECHANIZATION

Tractor operated broad bed former cum onion bulb planter

A tractor operated raised bed former cum onion bulb planter was designed and developed. It had the main components of raised bed former, onion bulb hopper, onion bulb metering unit, ground wheel, furrow opener and furrow closer. The machine formed a bed of 90 cm width and 18 cm height. Onion bulbs were filled in the hopper and regulated to fall in the singulation and conveying mechanism. Link chain with optimized cups was fitted at the specified intervals to achieve plant to plant spacing depending on the forward speed. The cups were used to pick up the onion bulbs from the hopper and drop in the bulb tube fitted along with furrow opener. The onion bulbs were dropped in the furrows and closed by furrow closer. It could plant four rows on the raised bed at 15 cm row to row distance and 7.5 cm plant to plant distance. The field capacity was 0.12 ha h^{-1} and bulb distribution 98%. It saves labour and time by 40%; and cost of the machine was Rs.75,000/-.

Chilli harvester

An engine operated chilli harvester was designed and developed, with the main components of prime mover, rotary harvesting drums, collecting chamber and power transmission mechanism. Power was taken from prime mover engine through bevel gears and belt and pulley mechanism to rotate a standardized rotary drum with combing pegs. A collecting chamber with mesh separator was fitted below the rotary drums. The harvester was driven through the row of chilli plants and the plant was passed between a rotating harvesting drum. The rotating pegs created combing action and the chilli fruits were separated from the branches of plants and collected in the collecting chamber. Most of the leaves and twigs were separated in the mesh separator and the fruits collected were cleaned through a blower to further clean the produce. The estimated harvesting capacity is 0.2 ha h^{-1}.

3.6. ECONOMICS OF PRODUCTION, MARKETING & TRADE, STATISTICAL RESEARCH AND COMPUTER APPLICATIONS IN AGRICULTURE

3.6.1. Economics of Production, Marketing and Trade

Economics of production and marketing of guava: The total cost incurred by the sample farmers in cultivation of guava crop was Rs.1,18,986.40 per acre. The share of total variable cost was 62.69% (Rs.74597.25 $acre^{-1}$) of the total cost. The allocation of operational cost indicated that the marketing cost accounted for the highest share (26.99%) followed by machine labour (8.47%), human labour (7.28%), FYM (6.66 %), chemical fertilizer (3.66%), PPC and growth regulators (2.25%), organic fertilizer (1.75%) and bullock labour (0.99%). The interest on working capital calculated @ 8% accounted for 4.64%. Results indicated that the average yield in Dharwad district was7.24 ton $acre^{-1}$ while net profit was Rs.68993.65 $acre^{-1}$. The cost of production was Rs.16,798.32 ton^{-1} and profit was Rs.9,274.17 ton^{-1}. The marketing efficiency index was 1.35 in local market and 1.44 in distant market sale model. Investment feasibility analysis indicated that cultivation of guava in Dharwad was financially feasible with NPV of Rs.372412, economically viable with IRR of 82% and profitable in the long run (over a period of 20 years) with a BCR of 2.32. The post-harvest loss (PHL) affected the marketing efficiency adversely thereby indicating the need for minimizing the PHL.

Economics of High Density Planting (HDP) in guava: Data collected from two types of high density spacing viz., 3 m x 3 m (440 plants $acre^{-1}$) and 4 m x 4 m (250 plants) followed by the farmers from Ayakudi, Dindigul, Tamil Nadu. The details on the costs and returns on these HDP under different subheads:

Establishment cost: The costs of establishments of 3 m x 3 m and 4 m x 4 m systems of HDP were Rs.1,79,640 $acre^{-1}$ and Rs.1,21,400 $acre^{-1}$, respectively. The higher cost of establishment in 3 m x 3 m HDP was mainly due to high planting material costs and associated pit digging and pit filling materials costs. The major cost of establishment was on pit filling materials like fertilizers, neem cake and other required inputs, followed by the cost of drip installation and planting materials costs.

Annual costs of maintenance: The production costs incurred was on the maintenance of the garden like labour, nutrients, PPC, pruning, etc. The annual costs was Rs.1,53,390 $acre^{-1}$ and Rs.95,050 $acre^{-1}$ for 3 m x 3 m and 4 m x 4 m HDP plantations, respectively. Near double cost in 3 m x 3 m HDP gardens was due to higher productivity (hence higher commission paid) and more labour required for the harvest. Thus, the gardens with 3 m x 3 m spacing incurred total annual costs of Rs.3,84,394 $acre^{-1}$ compared to Rs.2,34,947 $acre^{-1}$ with 4 m x 4 m spacing because of higher costs required for cultivating with higher planting density (74% higher).

Returns and economics feasibility: Farmers who had grown guava at 3 m x 3 m spacing had reaped higher gross returns of Rs.9,24,000 $acre^{-1}$ and net return of Rs.5.39 lakhs owing to higher productivity of 30.8 ton $acre^{-1}$ compared to gross return of Rs.5,25,000 $acre^{-1}$ and net return of Rs.2.90 lakhs $acre^{-1}$ realised by the farmers

who had raised the garden on 4 m x 4 m spacing with productivity of 17.5 ton acre^{-1}. The BC ratio of 3 m x 3 m and 4 m x 4 m HDP gardens were 2.40 and 2.23, respectively. Due to the higher productivity/yield, the cost of production in HDP (3m x 3m) was lower at Rs.12.48 kg^{-1}, though the cost of cultivation was very high. By adopting the methodology (policy) accepted by the GoI for calculation of minimum support price (MSP), the suggestive MSP of guava will be Rs.19.2 kg^{-1}

Marketing of guava: Farmers had adopted three major marketing practices in the study region of Ayakudi, Dindigal, Tamil Nadu. Many farmers directly sold produce to pre-harvest contractor (PHC) in the field itself. Second set of farmers produces, harvests, packs it and takes it to the Ayakudi market in the region (local market) and sells it to the traders. The third set of farmers who are risk takers, take it to distant markets or sell it to the distant market wholesalers. The net return realised by the farmers was highest when the produce is sold in distant markets i.e., Rs.6,93,606 acre^{-1} in 3 m x 3 m gardens and Rs.3,77,553 acre^{-1} in 4 m x 4 m gardens compared to farmers who had sold produce to PHC (Rs.2,42,000 in 3 m x 3 m gardens and Rs.1,37,500 in 4 m x 4 m gardens) and sold at local market in Ayakudi (Rs.2,42,000 in 3 m x 3 m gardens and Rs.1,37,500 in 4 m x 4 m gardens). Selling produce at distant market emerged as the most profitable strategy. Still farmers prefer and sell produce at Ayakudi market because of the lesser risk and convenience.

3.6.2. Statistical Research

Multi-dimensional scaling approach for stability analysis in banana multi-location trials: Stability models for identifying ideal lines based on banana trials were conducted during years 2016 to 2018, across five locations (Arabhavi, Bhubaneswar, Coimbatore, Kovvur, Mohanpur) for 12 lines (KB-8, Grand Naine, H-531, KC keli, Manjeerara Nendran-II, Nendran, NRCB sel. 8, NRCB sel.7, BCB-2, Kovvur, Bontha, BCB-1, Budubale). Stability models developed individually for six different yield and attributing traits (plant height, stem girth, number of leaves, hands/bunch, fingers/bunch, bunch weight) resulted in three groupings, based on measures of stabilities so as to identify the group of ideal lines for each of the traits and the best location based on measure of ecovalence. For bunch weight, 6 lines (Manjeerara, Nendran-II, BCB-2, Kovvur, Bontha, Budubale) were selected as ideal and suitable for all locations. Perusal of estimate of measure of variability in comparison to average performance of different lines for bunch weight, revealed that most of the lines evaluated in the locations Arabhavi, Bhubaneshwar and Mohanpur had the stability index within 10%, showing the consistency of the lines over the period of study. Further, based on the environmental index value (λ_i), least instability was observed for the location Bhubaneshwar for all the traits over all the periods of study

Stability models for vegetable crops multi-location trials: Data pertaining to four different crops across locations for various traits and lines were considered for developing crop stability models in order to identify the suitability of IIHR entries across locations.

Peas: Eight different lines (VP1409, VP1422, IIHR2-9, IIHR5-13, GP912, VRPE103, AP3 and Kasji Udai) were evaluated across six locations during 2016-17, 2017-18, 2018-19 (IET, AVT-I, II) for yield, shelling (%), pod width and average pod weight. Both the IIHR entries (IIHR 2-9 and IIHR 5-13) were grouped into ideal group (stable across locations) for three traits. Tested measures of stability revealed that IIHR 2-9 for average pod weight, shelling (%) and pod width; IIHR 5-13 for shelling (%), suitable for all locations with high measure of ecovalence.

Cowpea, Dolichos bean & French bean: In cowpea, five lines (VRCP 49-5, Palam long bean, Jawahar cowpea, Kashi Nidhi and Arka Garima) were evaluated across 9 locations, in Dolichos bean, eight lines (GJIB 13-03, VHF DV-1, IS 2016-9, IS 2016-10, Arka Adarsh, DB-3, DB-5, Kashi Haithma) were evaluated across six locations,and seven lines (VLFB-1307, VLFB-1405, Kashi Rajhans, VRFBB-9, CITH FB-1, Swarna Priya, Arka Suvidha) in French bean were evaluated, across eight locations during 2016-17,2017-18,2018-19 (IET, AVT-I, II) for yield, pod length, pod width and average pod weight. Results showed that for cowpea, Arka Garima is grouped under ideal category for all the four evaluated traits, suitable for all locations with least environmental index value. In Dolichos bean, Arka Adarsh is ideal for pod width across all locations, but is grouped into the poor environment group (i.e. unfavorable environmental condition like stress) for other three traits suggesting that it could be a potential line when there is any stress operating across locations.In French bean, Arka Suvidha was ideal (stable across locations) for all the above traits with least environmental index.

Principle component analysis in Karonda accessions

Fifty-four germplasm accessions (core collection from different parts of Gujarat and Karnataka) were evaluated at ICAR-IIHR for vegetative growth, flowering, and fruiting, morphological characters of leaves, flowers and fruits for two years (2016 and 2017), and subjected to PCA to identify the significant traits. With the Eigen values greater than 1.0, the first four principal components together explained 76.2% of the total variation of

morphological traits. Fruit-related traits such as fruit weight, fruit length and fruit diameter largely contributed to variation for this principal component. Seed weight and seed number explained most of the variation. Based on the PCA constructed for biochemical traits, traits responsible for fruit taste viz., reducing sugars, total sugars and DPPH contributed strongly to the variation of the principal component. PCA results obtained could be useful for the breeders working on this future crop for characterization, genotype identification, and selection of parents.

BLUP model for estimation of breeding values (genetic merit) in Mango

Best Linear Unbiased Prediction (BLUP) approach was used to estimate and compare the breeding values (expected average performance of progeny derived using a parent when crossed with many other parents) of pollen parents Kerala Dwarf, Alphonso, Arka Anmol and Arka Puneet (estimated based on offspring produced from respective hybrids cross) individually for eight different traits (fruit weight, length, breadth and thickness, TSS, pulp (%), stone weight and skin weight), along with the estimate of heritability (broad sense). Results showed that the high estimate of heritability in the range 0.83 (skin weight) to 0.998 (stone weight) enabling us to proceed for BLUP estimate based on progeny information for each trait. Results of BLUP estimates showed that for the traits fruit weight, breadth, thickness, stone weight and pulp (%) offspring when Alphonso was used as a pollen parent over the years has resulted in higher breeding value than other three. However, Arka Puneet as a pollen parent resulted in higher breeding value for fruit length and TSS; while the breeding value was high for skin weight for pollen parent as Arka Anmol derived offspring. The study indicates that BLUP methods may be efficient in predicting the clonal performance in the four hybrid populations investigated and identify better pollen parent for use in future crop hybridization program. Selection of parents based on their breeding value can enhance the average value of the trait in the progeny and finally for trait improvement with higher proportion of progenies for the desired trait (targeted hybridization).

Diversity analysis in jamun collections based on morphological, chemical, flower, fruit and seed traits

Diversity analysis was carried out for 21 jamun accessions based on 32 traits (morphological, chemical, flower, fruit and seed traits) revealed that seed length alone contributed for 90.9% variability. Ward's minimum variance method resulted in three distinct clusters. Maximum genetic distance (based on all traits) was observed in particular, between the pairs (Collection 12 and Collection 2; MP-5 and Collection 2; KHA-1 and Konkan Bahadoli), which could be used for further hybridization trials in jamun. In general MP-5 with all lines have high genetic distance.

Probit models in mango rootstocks

Probit models were constructed for germination (%) for three rootstocks viz., Bappakai, Nekkarai and Kurukkan to estimate the LD50 values. The probit model for Bapakkai (Y=15.62-7.75x) with R^2=0.88) resulted in LD50 value as 22.39 and that of Nekerre (Y=9.13-3.15x) with R^2-0.90 resulted in LD value as 0.195.

Biometrical studies in tomato

Components of variance (GCV, PCV, h2, Genetic Advance, Genetic Gain as % mean) were worked out for 49 tomato diverse stocks. It was inferred that selection based on phenotypic performance will be reliable due to narrow difference between GCV and PCV estimates for all the 11 traits. High heritability estimates (>75%) coupled with high genetic advance in percentage of mean was recorded for number of flowers/ inflorescence, pericarp thickness and number of fruits/ plant. High heritability estimates were recorded in most of the traits under study and indicated that these traits are controlled by additive gene action. The characters exhibiting high heritability along with high estimates of genetic advance are highly effective for selection program. Moderate heritability with low genetic gain was observed for days taken for first fruit maturity, average fruit weight (g) and yield per plant (kg) which indicated that these traits are under the control of non-additive gene action, therefore, the improvement in these characters can be achieved by partitioning the genetic variance further and making selection for suitable types in segregating generations.

Nonlinear models and diversity analysis in gladiolus genotypes against Solan and ICAR-IIHR isolates and estimation of AUDPC

Cluster analysis of nine gladiolus genotypes namely Arka Aayush, Arka Amar, Arka Darshan, Arka Gold, Arka Kumkum, Pink Friendship, IIHRG-12, *Gladiolus callianthus* and *Psittacinus* hybrid for resistance against two geographically different isolates of *Fusarium oxysporum* f. sp. *gladioli* (FOG) i.e. FGS-SOL isolate and FOG IIHR-1 isolate performed based on six traits resulted in three distinct clusters. The dendrogram deduced from various characters showed high similarity between Arka Aayush and Arka Darshan in FGS-SOL isolate inoculation and between Arka Amar and Arka Kumkum in FOG IIHR-1 isolate inoculation. Nonlinear regression models were developed to compute area under disease progression curve (AUDPC) and highest AUDPC value was recorded in Pink Friendship inoculated with FOG IIHR-1 isolate.

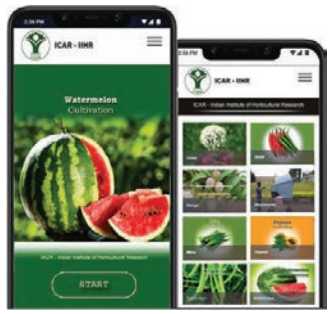
3.6.3. Computer applications

Mobile app for Watermelon and French bean cultivation

Mobile app for watermelon and French bean cultivation were developed and integrated with fruits and vegetables mobile app for smart phones which could be installed from Google play store and as also from ICAR-IIHR website. These apps included crop management solutions for watermelon and French bean cultivation. The following features are available in the mobile app.

- Crop cultivation aspects
- Disease management
- Pest management
- FAQs
- Contact us

The Crop production aspects viz. land preparation, sowing time, transplanting seedling etc., are available under crop production link of the specific crop.Further, precision farming aspects of water melon viz., variety, soil type, season and seed requirement, FYM application, neem cake application, fertilizer dose, basal application, irrigation, fertigation, water soluble fertilizers and foliar nutrition details are also available.



The Disease and pest management feature includes various diseases and pests affecting the crop describing its symptoms and control measures for better management. A query window for farmers related to crop cultivation is available to post the cultivation problems on watermelon and French bean. All the farmers' queries are received by mail and reply is communicated by Email by domain experts. Further, the released varieties and hybrids of watermelon and French bean with salient features are also available. The IDM and IPM strategies and nematode management in watermelon and French bean are also provided in the app.

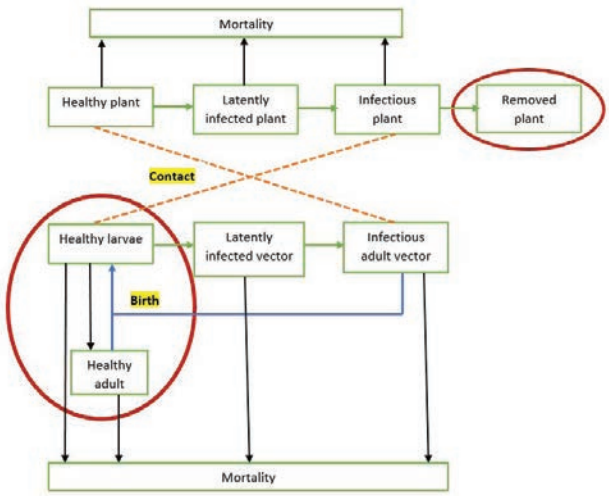
Decision Support System for horticultural crops (flower crop management)

The web-based floricultural crop management application was designed for all major flower crops viz., carnation, China aster, chrysanthemum, crossandra, gerbera gladiolus, jasmine, marigold, rose, tuberose, etc., using web technologies. This web application was developed at ICAR-IIHR, Bangalore, to help farmers and other users in making more appropriate decisions while managing the flower crops and to provide information on cultural practices of different flower crops. With the user interface design, the navigation to different web pages is made user friendly and attractive. Different modules provide information about the cultivation process, management practices for disease and pest control, flower crop varieties released from the Institute etc. Images help the users to visualize the information. The web applications are available at ICAR-IIHR website main page, under web applications link, where users can easily access through the web browser the flower crop management information. Potential users of the applications are mainly farmers and other stakeholders who can benefit from the timely and valuable information.

Simulation model and graphical user interface (GUI) developed for watermelon bud necrosis (WBNV) disease

The general viral disease simulation model based on plant (SEI) and vector (SEI) population categories was revised for watermelon bud necrosis virus (WBNV) disease as plant (SEIR), larvae (SE) and adult vector (EI) population model. The removed category has been introduced for the plant population. The healthy vector category was split into healthy larvae and healthy adult categories, since the vectors get infected only at the larvae stage and the adult vectors are responsible for infecting healthy plants. A GUI was developed for the WBNV disease development simulation model in Matlab®.

** (S: Susceptible, E: Latently infected, I: Infectious, R: Removed)



The WBNV disease model representation

3.7. AGRICULTURAL EXTENSION RESEARCH

Spread and acceptance of ICAR-IIHR crossandra varieties

The study on spread and acceptance of ICAR-IIHR crossandra varieties among farmers indicated that more than 75% of farmers accepted Arka Chenna followed by Arka Shreya (25%) and Arka Ambara (25%). Of the farmers, 50% indicated that ICAR-IIHR varieties have medium size flowers. Majority of farmers (65%) are aware of orange flowers of Arka Chenna and orange red flowers of Arka Ambara. Majority of the farmers sold at local markets (75%), and 25% to distant markets at mandies. The wholesale rate varied from Rs.800/kg during festivals and Rs.400/kg during lean season. Lack of awareness about crossandra production technologies (75%), depending on local, fragmented and incoherent markets for flower selling (65%), lack of farm gate marketing (65%), lack of awareness about marketing costs and exploitation by middlemen and commission agents (12%), lack of keeping quality, lack of timely supply of terminal cuttings and lack of awareness about improved packing material (30%) were the constraints faced by the crossandra growers.

Spread, acceptance and profitability of guava, Arka Kiran and Annona, ArkaSahan

Arka Kiran: Surveys were conducted in Vijayawada, Prakasam and Krishna districts of Andhra Pradesh, Ahmednagar and Rahata, of Maharashtra, Thiruvannamali, of Tamil Nadu, where 30 adopters and non-adopters of Arka Kiran growers were interviewed. The spread of Arka Kiran in Andhra Pradesh is 0.98%, 0.17% in Maharashtra, and 0.68% in Tamil Nadu of the total guava growing area. The average yield obtained was 8 ton acre^{-1} (5th year), with a profit of 1.61 lakhs acre^{-1} and B:C ratio 1.67:1, whereas in L-49 guava the B:C ratio was 1.45:1 (Amortization method).

Arka Sahan: Survey conducted in Bellary, of Karnataka, Aruppukotai, of Tamil Nadu, on 30 adopters and non-adopters of Arka Sahan, revealed that spread of Arka Sahan in Karnataka was 9.78% and 12.5% in Tamil Nadu of the total annona growing area. The average yield recorded was 4.5 ton acre^{-1} (5thyear), with a profit of 2.28 lakhs acre^{-1} and B:C ratio of 2.73:1, whereas in custard apple the B:C ratio was 1.3:1 (Amortization method).

Spread, acceptance of ICAR-IIHR released selected vegetable hybrids in South India

The spread and acceptance of ICAR-IIHR released brinjal and chilli hybrids (Arka Anand, Arka Haritha and Arka Meghana) were studied based on the hybrid seed production and distribution. Survey carried out in Tamil Nadu, Andhra Pradesh and Karnataka, revealed that awareness of farmers towards selected ICAR-IIHR vegetable hybrids (brinjal- Arka Anand and Arka Haritha, and Arka Meghana in chilli) ranged from 1.2-7.5% in South India. To create awareness about ICAR-IIHR released brinjal and chilli hybrids at farmers' field, during Kharif and Rabi seasons, more than 15 demonstrations and 10 scientist/farmers interaction meetings were conducted in Tamil Nadu, Andhra Pradesh and Karnataka.The reasons for spread and acceptance of brinjal hybrids based on farmers (adopters) opinion are:

(i) High yielding capacity
(ii) Cluster and continuous bearing
(iii) Good fruit quality
(iv) Resistance to bacterial wilt
(v) Good field establishment
(vi) Suitable for ratoon crop.

The main reasons for non-adoption of brinjal hybrids in farmers' field are:

(i) Less market demand (Colour and shape)
(ii) Less consumer preference
(iii) Ignorance about this hybrid
(iv) Non-availability of seeds at their locality
(v) Poor storage life.

In case of chilli, it was observed that 70-83% of the farmers have accepted ICAR-IIHR released chilli hybrids, Arka Haritha and Arka Meghana, because of its high pungency, high yield, combined with attractive dark green fruits suitable for green as well dry chilli market. The reasons for non-adoption are:

(i) Availability of commercial private hybrids at doorstep
(ii) Not aware of this hybrid
(iii) Non-availability of seeds at their location

(iv) No local consumer preference

(v) Greater incidence of pest and diseases.

Impact study on ICAR-IIHR released brinjal and chilli hybrids in farmer's field revealed that improvement in yield (11%) was noticed in Arka Anand in brinjal and 5-10% yield enhancement was noticed in Arka Meghana and Arka Haritha in chilli, compared to private hybrids. Highest B:C ratio was noticed in IIHR chilli hybrids (3.2-3.55), compared to private hybrids (2.90-3.17).

Assessment of horticultural–based farming system for enhancing profitability of small and marginal farmers:

Enhancing the profitability of small and marginal farmers through integrated farming systems through horticultural interventions was undertaken in Kolar and Ramanagara districts of Karnataka. In each district, eight villages (4 treatments + 4 control) were selected, and a basic survey conducted, 6 farmers were selected (3 rainfed + 3 irrigated) from each village. ICAR-IIHR technologies (chilli – Arka Meghana, tomato- Arka Rakshak, bhendi –Arka Nikitha and Anamika, brinjal – Arka Anand, papaya –Arka Prabhat and Drumstick-PKM-1; and technologies: Arka Mango Special, Arka Vegetable Special and Arka Neem Soap) (48 Demonstrations) were introduced. The results of the existing farming system in both the districts are:

Existing farming system model of Kolar district (n=24+24)

Model	Total income (Rupees per acre)			
	Participating farmers		Control farmers	
	R F	IRR	R F	IRR
Horti.+ Agri. + Dairy (Mango+Ragi/Pulse+ Fodder+ cows)	1,08,850	1,58,820	95,880	1,39,720
Horti.+ Agri. + Seri.+ Dairy (Mango+Ragi/Pulse+Mulberry+ Fodder+ cows)	1,51,470	2,10,300	1,31,390	1,99,830
Horti.+ Agri. (Mango+ Veg.+ Ragi/Pulse)	74,360	92,100	67,350	96,860

Existing farming system model of Ramanagara district (n=24+24)

Model	Total income (Rupees per acre)			
	Participating farmers		Control farmers	
	R F	IRR	R F	IRR
Horti.+ Agri. + Dairy (Mango+Ragi/Pulse+ Fodder+ cows)	1,11,200	1,55,620	1,00,500	1,38,060
Horti.+ Agri. + Seri.+ Dairy (Mango+Ragi/Pulse+ Mulberry+ Fodder+ cows)	1,21,400	1,77,200	97,680	1,66,300
Horti.+ Agri. (Mango+ Veg.+ Ragi/Pulse)	80,250	91,610	83,700	77,900

RF-Rainfed; IRR-Irrigated

Introduction of Arka Meghana chilli hybrid in mango based system in Kolar District

Introduction of Arka Nikitha bhendi hybrid in mango based system in Ramanagara District

Role of farmers and institutions in marketing of horticultural products during lockdown period

A project was initiated to assess the role of formal and informal institutions and farmers involved in marketing of horticultural products during the COVID lockdown period and to suggest strategies for successful handling of horticultural produces during similar situations. Different models that operated successfully during the lockdown period in marketing of horticultural produce, especially fruits and vegetables were studied. The formal and informal institutions as operators of these models; and the sellers (farmers/ FPOs) (66), who supplied the produce were contacted to share their experience in terms of benefits realized during the lockdown period in comparison to the previous periods. The models thus contacted were Village Story (mostly vegetables), Shenoy Fruits, WOOLEY Vegetables, TENESIRI Vegetables, UDAN, direct marketing of dragon fruit, HOPCOMS, Karnataka State Mango Development and Marketing Corporation Limited (KSMDMCL), Palamner FPO, UAS Alumni Association model etc.

Roles played by the farmers and formal and informal institutions during the lockdown period are as follows:

- Formal and informal institutions effectively utilized social media (WhatsApp, Facebook, Instagram etc.) to communicate among the farmers (sellers) and consumers i.e. for both B2B and B2C business models
- Formal and informal institutions identified appropriate sellers (Farmers groups or FPOs) for procurement of the produce such as fruits and vegetables
- The formal or informal institutions targeted hostels, business organizations, restaurants and apartments for both the B2B and B2C models
- Some of the formal or informal institutions made contracts/ agreements with sellers (farmers/ FPOs) for fixation of price of the produce
- In some cases, common online platforms operated by the formal or informal institutions (e.g. UDAN) connected the stakeholders of both B2B and B2C models such as sellers (farmers/ FPOs) and consumers, so that they can interact and operate their business activities
- Some of the formal or informal institutions started grading and packing the produce in their own brand name and distributed to create trustworthiness among the consumers
- The sellers (farmers/FPOs) were given assured and better price than the prevailing market price by the formal or informal institutions and consumers, and the consumers were assured of supply of quality fruits and vegetables
- The formal or informal institutions fixed the sale price after thorough discussion with the sellers (farmers/FPOs) and the consumers
- The sellers (farmers/ FPOs) were also benefitted by elimination of middlemen and their commission charges
- Apart from the use of social media commonly by almost all the formal or informal institutions, print and electronic media such as television were also utilized to popularize the business activities of the models

Based on the analysis of the different successful models, a common strategic model was arrived-at, which can be suggested for effective role play by formal and informal institutions and farmers towards marketing of horticultural produces during situations similar to COVID 19 lockdown period. It was inferred from these models, that the net benefits realized by the sellers (farmers/ FPOs) was maximum for dragon fruit (Rs.58 kg^{-1}) among fruits, and chilli (Rs.16 kg^{-1}) among vegetables.

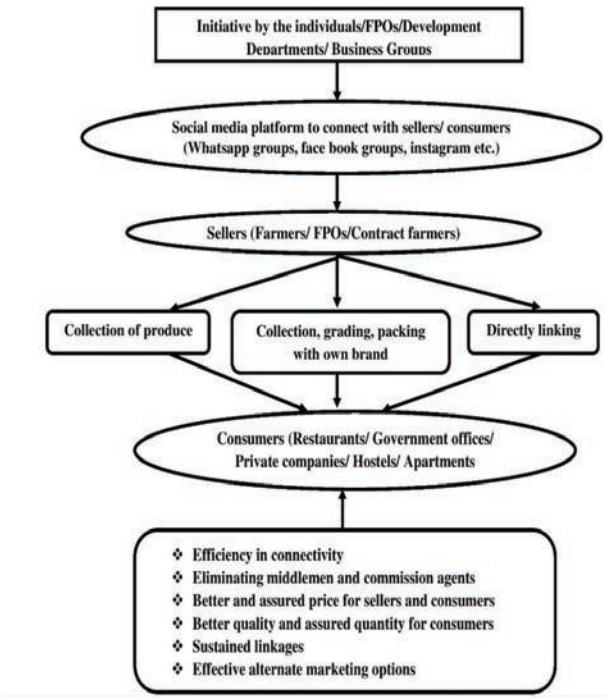


Fig.1. Strategic model for effective role play by stakeholders for marketing of horticultural produce during similar situations of COVID 19 lockdown period

FRUITS

The Institute houses the Project Coordinating unit of ICAR-All India Coordinated Research Project (AICRP) on Fruits, which is coordinating and monitoring the research and development, administrative & financial activities of the mandated crops, namely, banana, citrus, grapes, guava, jackfruit, litchi, mango, papaya and sapota, across 50 participating centers. Coordinated research efforts are being made for the recommendation of appropriate region-specific technologies for different agro-climatic regions of the country and also for effective dissemination to the stakeholders using NARS network. The ICAR-AICRP on Fruits aims to achieve the goal of improving crop productivity and the profitability of the stakeholders involved in growing the mandated crops. The coordinated project's VII Group Discussion was held at PAU, Ludhiana, during 16-19, January 2020, in which the work carried out during 2018-19 and technical program for 2020-21 was finalised, besides recommending 11 technologies from the completed trials. The project envisages becoming a technology hub for stakeholders, and a platform for wider exposure and interaction of scientists engaged in the project. The AICRP centre at ICAR-IIHR, Bengaluru, is the National Active Germplasm Conservation Site for papaya and guava. It is involved in assessing the performance of different entries of guava in multi-location trials to identify the best performing entry.

Mango

In mango rootstock breeding trial, 1957 hermaphrodite flowers of Vellaikolumban were crossed with Olour and 8 F_1 progeny raised. Similarly, 328 hermaphrodite flowers of Vellaikolumban were crossed with Terpentine, and two F_1 progenies were raised during the reporting period. The studies on climatic variability indicated that flowering was sparse and delayed in Alphonso, Totapuri and Amrapali varieties with negligible fruit yield during the year that had more rainfall and number of rainy days compared to long term average, Banganapalli variety was unaffected however.

When assessing the effect of climatic variability on mango flowering and yield, normal flowering was not observed in any of the varieties studied. Roving survey of different diseases of mango conducted in major mango growing areas by CHES, Bhubaneswar, indicated that maximum powdery mildew severity (PDI of 32.5) was recorded during the pre-monsoon period. Of the foliar diseases, anthracnose severity was recorded (PDI of 3.9 to 4.7) during pre-monsoon, monsoon and post monsoon seasons.

Coorg mandarin

Among the 20 clones evaluated in CHES, Chettalli, Clone-8 was found superior with respect to the number of fruits per tree (211.5), average fruit weight (124.52 g) and fruit yield (22.41 kg/tree) followed by Clone- 20.

Grapefruit

The data on initial growth observations (from trials initiated in September 2018) revealed that Flame seedless recorded a maximum height of 1.97 m, and lowest in Foster (0.91 m). The union girth ranged from 6.32 to 12.25 cm. The maximum union girth, stock girth and scion girth were observed in Red Blush (12.25 cm, 11.86 cm and 10.81 cm respectively), followed by Star Ruby (11.85 cm, 11.37 cm and 10.55 cm respectively). Canopy spread also showed a similar trend across the treatments.

Litchi

In litchi, flowering is observed in mid-September, and fruit sets during the 1st week of October. We observed that 6 mm wide girdling required a maximum healing period of 152.33 days, while 2 mm girdling required a minimum period of 128.34 days; maximum flowering (58.37%) and average fruit weight (17.65 g) was observed in trees with 4 mm girdling, followed by 6 mm girdling (32.77%). The fruit weight was lowest (14.28 g) in 2 mm of girdling. Further, the fruit parameters *viz*. pulp recovery and TSS: acid ratio did not differ significantly.

ARID ZONE FRUITS

Varietal trial in annona

The custard apple varieties, Balanagar, Raidurg, APK-1, Red Sitaphal, and Arka Sahan, were evaluated for yield and proximate analysis of fruits. A higher yield was recorded in Arka Sahan (80.4 fruits per plant) and minimum in Red Sitaphal (36.3 fruits per plant). The hybrid, Arka Sahan has registered the highest per plant yield of 40.4 kg whereas the cultivar Red Sitaphal recorded the minimum yield of 9.5 kg. Maximum fruit weight (482.5 g) was recorded in Arka Sahan, followed by Balanagar (263.6 g), and minimum fruit weight of 234 g was recorded in Raidurg. TSS ranged from 21.7 °B (Red Sitaphal) to 30.7 °B (Arka Sahan); APK-1 registered low acidity (0.24%) and higher acidity was recorded in Arka Sahan (0.50%). Number of seeds per fruit was more in APK-1 (31.13) and less in Red Sitaphal (24.57). Thus, custard apple hybrid, Arka Sahan excelled in terms of yield and quality compared to other varieties.

From field trials it is recommended to apply biofertilizer consortium consisting of 10^9 to 10^{10} CFU/g of *Azotobacter tropicalis, Bacillus aryabhattai* and *Pseudomonas*

taiwanensis along with 100 g AM fungi (mixture of three *Glomus* spp. @ 100 spores/ g of substrate) incubated in 10 kg FYM for 48 h per plant, without affecting fruit yield and quality in the cv. Arka Sahan. This can supplement 25% RDF in the form of chemical fertilizers. Fertigation of 50% RDF during flowering, fruit set and fruit development phases (March–June) + soil application of 50% RDF coinciding with monsoon rains was not beneficial for fruit yield, but the combination of fertigation and biofertilizer application recorded the highest population of beneficial soil microorganisms compared to non-fertigated treatments

ORNAMENTALS

Marigold

Arka Bangara, Arka Bangara-2 and Arka Agni have been approved by the Central Variety Release Committee (CVRC) for commercial cultivation based on trials conducted under AICRP. Arka Bangara has been recommended for Zone 5; Arka Agni for Zones 1, 2, 5, 7 and 8, while Arka Bangara-2 was recommended for Zones 1, 2, 4, 5 and 8. French marigold varieties, Arka Madhu and Arka Pari have been approved by the Central Variety Release Committee (CVRC) and recommended for Zones 1, 5, 7 and 8.

Tuberose

Tuberose for cut flower: Performance evaluations were carried out at Bangalore conditions for the tuberose genotypes *viz*., Bidhan Rajani-19, Bidhan Rajani-24, Arka Vaibhav, Arka Suvasini as commercial check and Kolkata Local Double as Local check for cut flower purpose. The maximum flower yield in terms of number of spikes per clump/ year was registered in Arka Vaibhav (4.50), followed by Bidhan Rajani-19 which recorded better rachis length (42.26 cm), number of florets per spike (63.50) and number of spikes per clump (4.30), compared to check varieties.

Tuberose for pot culture: Performance evaluations were carried out at Bengaluru conditions for the tuberose genotypes Arka Sugandhi and Pratap Rajani–7, with the local check of Arka Shringar, Phule Rajani and Bidhan Ujwal for suitability as pot plant. Among the genotypes evaluated, Arka Sugandhi recorded minimum days to spike emergence (121.13 days) and days to open first floret (18.4 days) and maximum number of florets per spike and higher number of spikes per plant (3.20) with attractive upward looking florets and shorter internode.

Fertigation trials: Fertigation in tuberose var. Arka Prajwal @ 200:200:200 kg NPK/ha/year in split doses of 45:30:30% NPK at vegetative phase, 45:60:60% NPK at flowering phase and 10:10:10% NPK at dormancy recorded flower yield of 21.58 t ha^{-1} over 16.02 t ha^{-1} in conventional practice of soil application of fertilizers and registered 34.7% increase in yield.

Gladiolus

Performance evaluation was carried out in Bengaluru condition for gladiolus genotypes Pusa Sinduri, DFR GH-1, DFR GH-2, Arka Manorama and Punjab Glad-2 for cut flower purpose. Pusa Sinduri recorded the maximum number of florets per spike (15.07) and number of spikes per plant (2.33), followed by Arka Manorama (13.13 and 1.20, respectively).

Jasmine

The evaluation of *Jasminum nitidum* Acc. and JN-1 was carried out with *J. grandiflorum* var. Arka Surabhi as the check. Acc. JN-1, recorded minimum number of days for emergence of first flower (55.69 days), maximum flower bud breadth (1.95 cm), number of flowers per plant (1976.92), 100 flower weight (19.65 g), flower yield per plant (388.53 g) and shelf life (1.46 days) and was superior over the check for these characters. In Acc. JN-1 flower colour on opening was pure white (White NN155C), flowers were fragrant and the season of flowering was June-February.

China aster

Fertigation in China aster var. Arka Kamini @ 135:90:45 kg NPK ha^{-1} $year^{-1}$ (75% RDF) in three equal split doses at vegetative phase, bud phase and flowering phase produced 12.79 t ha^{-1} of flowers resulting in input saving of 25% of fertilizer.

Crossandra

In crossandra, two varieties Arka Shreeya and Arka Shravya have been recommended for zones 5, 6 and 8.

Gerbera

Gerbera varieties Arka Ashwa and Arka Nesara have been proposed for trials in five centres.

MAP & BETELVINE

Germplasm characterization and evaluation

Germplasm lines (74) were characterized for adventitious roots and orthotropic shoot traits. The data on plagiotropic shoot traits was recorded in 64 lines and inflorescence traits in 40 clones. Variability for many traits has been noted in the germplasm, IIHR BV67, Sirugamani-1, IIHR BV 53 were profuse flowering types among the female clones. Among male clones, Dobbesepet Ambadi, Kapoori Bihar and CARI 6 were found to be profusely flowering. The lines Banavalli, Hirehalli Local, CARI 6 have produced dark green colored orthotropic leaves. It was observed that all the germplasm lines had acuminate leaf apex except Banavalli which recorded acute leaf apex. Leaf shape of the germplasm was elliptic, wide elliptic or ovate.

In general, Kapoori clones produced narrow leaves whereas wider leaves were observed in Khasi Pan. Plagiotropic leaf length/breadth (l/b) ratio was lowest in

IIHR BV 26 (1.09) and maximum in Kapoori Chittikavata (2.29). Number of plagiotropic shoots per meter length of vine is maximum (7.0) in IIHR BV 71 and IIHR BV 34 (6.33). Longer plagiotropic shoots were recorded in IIHR BV 37 (56.43 cm) followed by Tellaku Chithalpudi (55.50 cm) and Dabaspet Ambadi (53.13 cm).

Anatomical, phytochemical and flow cytometry Studies on male and female clones

Anatomical studies: The sections of leaf, petiole, stem and inflorescence were studied in male and female clones. Significant differences were found among male and female clones for secretory cells, thickness of lower and upper epidermis, stomatal number, stomatal index, stomatal length and breadth. But, there were no significant differences between genders except for stomatal index.

Phytochemical studies: The clones were screened for various qualitative and quantitative phytochemical estimations and antioxidant potential like DPPH and FRAP activity. The qualitative estimations showed the presence of steroids and terpenoids among all the clones. The leaf chlorophyll a, b and total chlorophyll content were significantly different among the male and female clones with an average of 1.158, 0.215, 1.373 mg g^{-1} respectively. There were no significant differences between genders. Content of phenols, flavonoids and tannins were significantly different within and between the genders with an average of 6.66, 6.06 and 1.62 g 100 g^{-1} DW respectively. The phytochemical profiling of sugars using HPLC recorded an average total sugar content of 9.30 mg g^{-1} FW. The average content of individual sugars fructose, glucose and sucrose was 1.76, 3.88 and 3.63 mg g^{-1} FW of leaf respectively. But there were no significant differences found within and between genders among the sugars. The organic acid profiling through HPLC has led to the identification and quantification of seven organic acids like gluconic acid, oxalic acid, lactic acid, tartaric acid, malonic acid, citric acid and succinic acid. The average total organic acid was recorded to be 9.26 mg 100 g^{-1} of fresh leaf. There were significant differences within male and female clones for all the organic acids, but not between the genders, except for lactic acid.

HPLC analysis revealed the presence of phenolic acids (caffeic acid, salicylic acid, *t*-ferulic acid, sinapic acid, *p*-coumaric acid, *t*-cinnamic acid, gallic acid, *p*-hydroxybenzoic acid, chlorogenic acid), vitamins (ascorbic acid, pyridoxin, folic acid, thiamine and riboflavin); flavonoid profile through UPLC-MS/MS and elemental analysis of leaves did not show any significant variations between the male and female clones. However, antioxidant potential studied through DPPH, FRAP activity showed significant differences within and between male and female clones.

Flow cytometry studies: Flow cytometry analysis helped to estimate the 2C nuclear DNA content and ploidy status among the male and female clones. The genome size varied between 0.92 to 1.80 pg among the twenty clones; 12 clones were tripliod, 4 tetraploid, 1 pentaploid and 3 hexaploid. No specific ploidy status was found associated with gender of the clones and majority of them were triploids. The results show that many different ploidy levels exist among betelvine as reported earlier.

Crop improvement: Among the seven inter varietal crosses carried out, fruit setting was recorded in all the crosses. The germination per cent in seven crosses ranged from 34.48 (IIHRBV 66/ Dobaspet Ambadi) to 92.21% (Gujarat local/ Dobaspet Ambadi). Seven interspecific crosses were carried out between *Piper betle* and the *Phytophthora* resistant *P. colubrinum*, using seven betel vine clones as female parents; fruit set was observed in all seven crosses. Establishment of seedlings was very poor in the interspecific crosses. In the seven crosses with *P. colubrinum,* germination ranged from 10% (IIHRBV 66/ *Piper colubrinum*) to 97.29% (IIHR BV71/ *Piper colubrinum)*. Around 723 hybrid seedlings were raised from different crosses and are being established in poly bags in the polyhouse. IIHRPBH 09-16 is a female hybrid, producing very attractive, elliptic, light green leaves resembling Kapoori type, with high leaf yield (380 leaves $vine^{-1}$) with resistance to powdery mildew and field tolerance to leaf spots. This hybrid is under multilocation testing.

VEGETABLES

Chilli

Eight AICRP (VC) trials 2020 *viz.*, germplasm evaluation (chilli & paprika), varietal trials (IET, AVT I & AVT II) and hybrid trials (IET, AVT I & AVT II) on chilli are in progress.

Okra

Under Hybrid Trial (AVT-I), seven genotypes were evaluated along with check varieties, and among them 2018/OKHYVRES-6 recorded the highest fruit yield of 97.26 q ha^{-1} followed by check variety Shakti (88.26 q ha^{-1}). Under Hybrid Trial (AVT-I), nine entries were evaluated, among them 2017/OKHYVRES-2 recorded the highest fruit yield of 110.3 q ha^{-1} followed by check variety Shakti (108 q ha^{-1}).

Dolichos Bean

Five trials *viz*., Dolichos (bush) AVT-I & AVT-II, Dolichos (pole) IET, AVT I & AVT II are under progress.

Onion

In the late Kharif–AVT-I trial, the following gave significantly higher Indeterminate: of the 6 lines evaluated, three lines namely OBV-23 (334.4 q ha^{-1}), OBV-21 (312.60 q ha^{-1}) and Arka Kalyan (311.10 q ha^{-1}); AVT-II trial, three lines namely OCV-54 (360.70 q ha^{-1}), OCV-42 (330.73 q ha^{-1}) and OCV-38 (318.87 q ha^{-1}); White onion trail,

three lines namely Arka Kalyan (312.60 q ha^{-1}), OBV-32 (311.10 q ha^{-1}) and OBV-36 (288.53 q ha^{-1}); Red onion hybrid-IET trial, three lines namely OAH-11 (362.20 q ha^{-1}), OAH-08 (356.27 q ha^{-1}) and Arka Kalyan (311.13 q ha^{-1}); and under Varietal performance trial, three lines namely OBV-70 (379.63 q ha^{-1}), OBV-62 (377.97 q ha^{-1}) and OBV-66 (375.17 q ha^{-1}).

Under Rabi–IET the following gave significantly higher yield: (Red onion) trial, out of 10 lines evaluated, three lines namely ORVA-19-14 (399.53 q ha^{-1}), ORVA-19-07 (384.23 q ha^{-1}) and ORVA-19-16 (376.57 q ha^{-1}); in Red onion AVT-I trial, three lines namely ORVB-19-27 (364.80 q ha^{-1}), Arka Niketan (340.93 q ha^{-1}) and ORVB-19-22 (312.37 q ha^{-1}); in Red onion AVT-II trial, three lines namely ORVC-19-33 (379.37 q ha^{-1}), Arka Niketan (360.03 q ha^{-1}) and ORVC-19-30 (355.70 q ha^{-1}); in Red onion hybrid-IET trial, three lines namely ORHA-19-59 (386.33 q ha^{-1}), Arka Niketan (371.37 q ha^{-1}) and ORHA-19-53 (363.47 q ha^{-1}); in White onion–IET, three lines namely OWVA-19-72 (396.40 q ha^{-1}), Arka Niketan (381.63 q ha^{-1}) and OWVA-19-68 (286.83 q ha^{-1}); in White onion–AVT-I, three lines namely Arka Niketan (366.73 q ha^{-1}), OWVB-19-77 (341.70 q ha^{-1}) and OWVB-19-75 (286.97 q ha^{-1}); in White onion HTSS- IET trial, three lines namely Arka Niketan (403.00 q ha^{-1}), OWTA-19-98 (401.17 q ha^{-1}) and OWTA-19-96 (388.00 q ha^{-1}).

Radish

Under AVT–I, among seven entries evaluated, highest root yield was observed in 2018/RAD VAR-1 (263 q ha^{-1}), followed by 2018/RAD VAR-2 (256.10 q ha^{-1}).

Carrot

Of the 7 lines evaluated, check variety Pusa Rudhira (274.40 q ha^{-1}) gave the highest root yield followed by IPC-3 (266.75 q/ha) and VRCAR-186 (264.42 q ha^{-1}).

Ridge gourd

The results of germplasm evaluation trials of ridge gourd: of the 18 ridge gourd germplasm lines, RG-158 (230.38 q ha^{-1}) and RG-164 (212.83 q ha^{-1}) and RG-131B (196.49 q ha^{-1}) were found superior out of six entries tested in Ridge gourd varietal (AVT-II) trial, two entries namely, 2017/RIGVAR-4 (358.44 q ha^{-1}) and 2017/RIGVAR-5 (267.47 q ha^{-1}) recorded highest yield; Hybrid trials (AVT-II) - out of four entries tested, two entries namely, 2017/RIGHYB-1 (367.08 q ha^{-1}) and 2017/RIGHYB-2 (216.01 q ha^{-1}) recorded highest yield; Hybrid trials (AVT-I) - out of seven entries tested, two entries namely, 2018/RIGHYB-7 (338.46 q ha^{-1}) and 2018/RIGHYB-6 (269.73 q ha^{-1}) recorded highest yield.

Bitter gourd

Hybrid trial (AVT-II) - of seven bitter gourd hybrids evaluated, two entries namely, 2017/BIGHYB-10 (85.37 q ha^{-1}) and 2017/BIGHYB-9 (70.35 q ha^{-1}) recorded highest yield.

Cucumber

Varietal Trial (AVT-1)–2018/CUCUVAR-1 recorded the significantly superior fruit yield of 329.7 q ha^{-1} followed by 2018/ CUCUVAR-4 (304.25 q ha^{-1}); Hybrid trial (AVT-II)-2017/CUCUHYB-2 recorded the significantly superior fruit yield of 422.9 q ha^{-1} followed by Malini (Check) (350 q ha^{-1}).

Pumpkin

Varietal trial (IET) - 2019/ PUMP/VAR-6 recorded the highest yield (553.8 q ha^{-1}) followed by 2019/PUMP/VAR-5; Varietal trial (AVT-I) - 2018/PUMP/VAR-4 recorded the highest yield (573.4 q ha^{-1}), followed by 2018/PUMP/VAR-6; Hybrid trial (IET)-2018/PUMP/HYB-3 recorded the highest yield (579.2 q ha^{-1}) followed by 2018/PUMP/HYB-6; Hybrid trial (AVT-1)-2019/PUMP/HYB-4 recorded the highest yield (520.79 q ha^{-1}) followed by 2019/PUMP/HYB-6.

Drumstick

Twelve genotypes were evaluated along with two popular check varieties, PKM-1 and PKM-2.

Seed production

Okra: Pooled data of three years revealed that sowing okra during the third week of June resulted in highest seed yield and quality in all three varieties tested namely, Arka Anamika, Punjab 8 and Kashi Kranti. Among these varieties, Punjab-8 (Pb-8) recorded higher seed yield and quality over all three sowing times of February, March and June. Among interactions sowing time and variety, Punjab-8 (Pb-8) sown in the third week of June recorded best quality seeds with higher seed yield in okra in IIHR, Bangalore conditions.

Pumpkin seeds: Based on the pooled data of three years in pumpkin cv. Arka Suryamukhi, physiological maturity was attained at 45 days of harvest and 10 days of pre-storage before seed extraction, for optimum seed yield and quality, in ICAR-IIHR, Bangalore conditions. These seeds with physiological maturity could be stored even after 12 months with prescribed germination standards.

Protected cultivation trials

Tomato: Five indeterminate tomato hybrids evaluated in a naturally ventilated polyhouse showed that Pant PTH-1 recorded the highest yield of 89.5 t ha^{-1} in 9 months, which was on par with other hybrids tested.

Parthenocarpic cucumber: The five hybrids tested did not show significant difference in the marketable yield among themselves, however highest yield was recorded in PPC-2 (82.1 t ha^{-1}).

Thirteen entries of IET trials and 8 entries of AVT-I trials were evaluated at CHES, Bhubaneswar, during 2020-21, on yield and horticultural traits of chilli/ hot pepper.

5. Transfer of Technology

The Institute has a multi-dimensional approach in extension for effective transfer of technologies to various stakeholders. Accordingly, during the year 2020, the Division of Social Sciences and Training, ICAR-IIHR, Bengaluru, organised need based advanced trainings on horticultural technologies and large scale demonstrations. It has also disseminated and popularized various technologies through mass media, group approaches, exhibitions, field days, interfaces, seminars, stakeholders meet, interaction meetings, consultations etc. The Agricultural Technology Information Centre (ATIC) at the Institute also provided extension services through its single window concept.

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

5.1. Trainings

Types of Training	Number of Trainings	Number of Participants
ICAR IIHR, Bengaluru		
On Campus	35	1509
Off Campus	13	779
Total	**48**	**2288**
CHES, Bhubaneswar		
On Campus	2	65
Off Campus	8	312
Total	**10**	**377**
CHES, Chettalli		
On Campus	1	20
Off Campus	-	-
Total	**1**	**20**
KVK, Gonikoppal		
On Campus	43	1426
Off Campus	16	365
Total	**59**	**1791**
KVK, Hirehalli		
On Campus	8	227
Off Campus	27	782
Total	**35**	**1009**

5.2. Demonstrations

Place	Mode of Demonstration	Number
ICAR-IIHR	Field demonstrations	55
	Field days	9
	On farm trails	2
	Front line demonstrations	6
	Technology demonstration in NE States (Assam, Mizoram, Nagaland, Meghalaya, Tripura, Sikkim, Arunachal Pradesh)	7
	Under SCSP program	18
	Under TSP Program	3
CHES, Bhubaneswar	Field days	1
KVK, Gonikoppal	On farm trails	3
	Field demonstrations	10
	Field days	1
KVK, Hirehalli	Field days	1

5.3. Farmer–Scientist Interface Meetings

Organizations	Number of Meetings	Number of Participants
ICAR-IIHR, Bengaluru	37	1636
KVK, Gonikoppal	1	97
Total	**38**	**1733**

5.4 Exhibitions

Organizations	Number of Exhibitions
ICAR-IIHR, Bengaluru	11
CHES, Bhubaneswar	2
ICAR-KVK, Hirehalli	1
KVK, Gonikoppal	1

5.5. TV and Radio Programs

Scientists of the Institute presented 27 radio and 27 television programs on the technologies developed by the Institute and other related topics in horticulture.

5.6. Agricultural Technology Information Centre (ATIC)

An income of **Rs.85,82,439/-** was realized through sale of technology products, publications and other services. Agricultural Technology Information Centre (ATIC) was visited by 4200 stakeholders (growers, entrepreneurs, trainees and students). Further, about 1910 telephone/ internet queries regarding crop cultivation, availability of technology products, research literature, training programs, pest and disease problems in crops were answered.

5.7. Vegetable Breeder Seed Production Programs and Seed Village Concept

During this period, a revenue of **Rs.3.03 Crores** was earned under RFS-Fruit, Vegetable and Flower Crops Units of ICAR-IIHR, Bengaluru.

Vegetable Seed Production

During the year (January to December 2020), Breeder Seed and Truthful Label seed production programs were organized at both ICAR-IIHR campus and in farmers' field under Seed Village Concept. During this period, 11557.985 kg of seeds was produced, of 67 vegetable varieties/ hybrids. The seed production program in Rabi season is expected to provide around 25000 kg seeds of 60 vegetable varieties/hybrids. In the year 2020, 10453.319 kg vegetable seeds were sold to public and private sector organizations and farmers. Breeder seed production was taken up in the ICAR-IIHR field and 324.705 Kg of seeds were distributed to different state horticulture departments, Universities, and private seed companies.

Vegetable seed production at farmer's field

Vegetable seed production at farmer's field

Seed Village Concept

To meet the increasing demand for seeds of ICAR-IIHR varieties/ hybrids, large scale seed production program has been undertaken in Davanagere, Haveri, Koppal, Bengaluru Rural and Chikkaballapur districts of Karnataka, and Ananthpur district of Andhra Pradesh under the seed village concept. In this program, 6575 kg seeds was produced during Kharif season, and 25000 kg seeds is expected from Rabi season program. Thus, this program is highly successful, and the Institute can meet the demand for seeds from farmers, KVK's, public and private organizations.

Vegetable seed production at farmer's field

5.8. Sale of Quality Seeds and Planting Material

5.8.1. ICAR-IIHR, Bengaluru

Crop	Variety & Quantity (kg)
Bitter gourd	Arka Harit (4.705), Arka Bahar (21.44)
Brinjal	Arka Harshita (10.024), Arka Keshav (27.09), Arka Kusumakar (1.175), Arka Neelkanth (4.015), Arka Nidhi (4.345), Arka Shirish (2.03), Arka Anand [F1] (22.565)
Bush squash	Patty Pan (0.11)
Capsicum	Arka Atulya [F1] (2.269), Arka Basant (0.442), Arka Gaurav (1.486), Arka Mohini (5.13)
Chilli	Arka Abhir (8.767), Arka LCV (1), Arka Lohit (52.808), Arka Suphal
Chilli hybrid	Arka Haritha [F1] (45.676), Arka Kyati [F1] (39.203), Arka Meghana [F] (39.203), Arka Meghana [F1] (79.688), Arka Meghana [M] (0.01), Arka Swetha [F1] (15.773)
Coriander	Arka Isha (356.04)
Cowpea	Arka Garima (207.72), Arka Samrudhi (51.27), Arka Suman (31.12),
Dolichos (bush type)	Arka Amogh (319.21), Arka Jay (40.04), Arka Sambhram (49.93), Arka Soumya (2)
Dolichos (pole type)	Arka Adarsh (22.68), Arka Krishna (6.87), Arka Pradhan (0.08), Arka Prasidhi (67.345), Arka Swagath (35.89), Arka Visthar (51.04)
French bean (bush type)	Arka Arjun (1420.29), Arka Komal (232.35), Arka Sharath (559.96), Arka Suvidha (57.98)
French bean (pole type)	Arka Sukomal (13.375)
Garden pea	Arka Ajith (0.35), Arka Apoorva (67.03), Arka Chaitra (6.42), Arka Harini (0.13), Arka Karthik (14.39), Arka Nirmal (0.1), Arka Pramodh (6.03), Arka Priya (66.43), Arka Sampoorna (19.9), Arka Uttam (10.16)
Muskmelon	Arka Jeet (3.916), Arka Siri (12.416)
Okra	Arka Abhay (117.89), Arka Anamika (394.325), Arka Nikita [F1] (1633.39)
Onion	Arka Bheem [Synth] (0.25), Arka Bindu (463.314), Arka Kalyan (490.4), Arka Niketan (1.982), Arka Pragathi (17.683), Arka Ujjwal (101.824), Arka Yojith (139.805), Arka Kirthiman [F1] (1.504), Arka Lalima [F1] (22.696)
Palak	Arka Anupama (734.23)
Pumpkin	Arka Chandan (10.355), Arka Suryamukhi (425.941)
Radish	Arka Nishant (99.84)
Ridge gourd	Arka Prasan (366.604), Arka Sujat (0.01), Arka Sumeet (0.01), Arka Vikram [F1] (135.783)
Round melon	Arka Tinda (1.81)
Tomato	Arka Abha (0.013), Arka Alok (0.02), Arka Meghali (0.088), Arka Saurabh (2.599), Arka Vikas (10.924), Arka Abhed [F1] (12.811), Arka Apeksha [F1] (4.465), Arka Rakshak [F1] (134.452), Arka Samrat [F] (0.05), Arka Samrat [F1] (99.118), Arka Samrat [M] (0.04), Arka Vishesh [F1] (0.772)
Veg. Amaranth	Arka Arunima (39.565), Arka Samraksha (11.155), Arka Suguna (199.59), Arka Varna (0.075)
Water melon	Arka Manik (8.277), Arka Muthu (1.828), Arka Shyama (0.385), Arka Akash (F1) (0.177)
Yard long bean	Arka Mangala (684.945)
Grand Total (kg)	**10453.319**

Ornamental and Medicinal Crops Seed/Planting Material Distribution

Crop	**Total** (Numbers)
Aromatic plants	1378
Ashwagandha plants	167
Bougainvillea plants	29
China aster seedlings	620
Crossandra rooted cuttings	55289
Chrysanthemum plants	50
General plants	51
Gerbera plants	483
Gladiolus corms	30267
Heliconia rhizomes	800
Marigold cuttings	107691
Rose plants	28813
Medicinal plants	10214
Flower Seed Kit	1116
Urban Horti Kit	2827
Total (Numbers)	**239795**
Seeds/bulbs	**Total** (kg)
Marigold seeds	19.504
Tuberose bulbs	16286.84
China aster seeds	27.09
Medicinal seeds	4087
Total seeds (kg)	**20420.434**

Fruit crops planting material distribution

Planting material	**Total** (Numbers)
Mango Alphonso	3330
Mango Banganapalli	4047
Mango Thothapuri	1182
Mango Raspuri	1841
Mango Arka Uday	1482
Mango Arka Suprabhath	1856
Mango Arka Aruna	23
Mango Arka Anmol	12
Mango Arka Punith	18
Mango Mallika	3610
Mango Dashehari	146
Mango Amarapalli	49
Mango Kessar	129
Mango Scion	190
Guava Arka Mridula	5277
Guava Arka Kiran grafts	10937
Guava Arka Kiran rooted cuttings	4642
Guava Arka Rashmi	1498
Guava Arka Poorna	819
Guava scion	580
Annona Arka Sahan	13330
Annona Balanagar	472
Annona scion	4462
Papaya Arka Surya plants	6932
Papaya Arka Prabhat plants	13299
Jamun	2837
Drumstick	57692
Fig plants	49
Grapes plants	777
Lime plants	275
Curry leaf plants	2990
Other foliage	344
Dragon fruit plants	291
Mango Appemidi	17
Butter fruit	37
Pomegranate	6
Pomelo Arka Anantha	25
Little gourd	51
Total income	**Rs.5286621**

5.8.2. CHES, Chettalli

Crop	**Quantity** (Kg)
Planting materials of fruit and vegetable crops (mango, guava, bael, custard apple, aonla, cucurbits, etc.)	32620
Seeds of vegetable crops (brinjal, chilli)	1 kg each

5.8.3. KVK Gonikoppal

Crop	**Variety & Quantity** (Numbers)
Pepper	Arka Coorg Excel (7500)
Coffee	274 (600)

5.9. Supply of Farm Machinery

Technology Transferred	Name of Firm/ Organization
Supplied to ATIC – ICAR-IIHR Mango harvesters – 50 numbers Lime harvesters – 50 numbers Sapoto harvesters – 25 numbers	ATIC, ICAR-IIHR, Bengaluru.
Arka Solar integrated Autoclaves	Director of Research Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar
Arka Mushroom spawn machinery – One set	Assistant Director of Horticulture Bio-Centre Halladakeri Horticulture Farm, Bio-Centre, Dept of Horticulture, Bidar Govt of Karnataka
Arka Vending Van – 4 numbers	Managing Director Karnataka State Co-operative Horticulture Marketing Federation, (KHF), Binny Mill Road, APMC Yard, Bangalore

5.10. Sale of Mushroom Spawn

5.10.1. ICAR-IIHR, Bengaluru

Spawn sold during the period Jan to Dec 2020: 37.03 tons	
Socio-Economic & Nutritional Impact	
Cash revenue generated for the Institute Rs.26,07,450/-	
	Estimated Impact
Mushroom produced from 37.03 tons spawn @ 3 Kg fresh mushroom per Kg spawn	111.09tons
Employment generated @ 150 man-days/ ton/ annum	16663 man-days (45 people employed for one year)
Protein produced @ 4% of fresh weight	4.44 tons
Non-cultivable land used for production @ 0.1ha / ton	11.10ha
Estimated Environmental Impact	
Paddy/ wheat straw recycled @ 0.5 kg fresh mushrooms/ 1 kg dry straw	222.18 tons
Spent mushroom substrate (SMS) produced after crop harvest for organic manure @ 60% of dry straw used	133.30 tons
Prevention of air pollution	
Prevented the release of particulate matter @ 3kg/ton straw	666.54 kg
Of carbon monoxide @ 60 kg/ton straw	13330.8 kg
Of carbon dioxide @ 1460 kg/ton straw	324382.8 kg
Of ash @ 199 kg/ ton straw	44213.82 kg
Of sulphur dioxide @ 2 kg/ton straw	444.16 kg

5.10.2. KVK, Gonikoppal

Technology Aspect	Quantity/ Value
Oyster mushroom spawn	500 kg
Arka Microbial Consortium	15.5 tons

6. Education, Training and Capacity Building

6.1 Post Graduate Education

The major activities of PG cell include offering Ph.D. (Horticulture) and Ph.D. (PHT of Horticultural Crops) courses as an outreach program of IARI, New Delhi, and facilitating research guidance and course work for students of various universities as per MOU. ICAR-IIHR has MOU with reputed universities such as UAS, Bengaluru; TNAU, Coimbatore; JNKVV, Jabalpur; Acharya N.G. Ranga Agricultural University (ANGRAU), A.P; UHS, Bagalkot; Dr. Y.S.R. Horticultural University, V.R. Gudem, Andhra Pradesh; Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chattisgarh; Kerala Agricultural University, Thrissur, Kerala; Jain University, Bengaluru; Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad; Graphic Era University, Uttarakhand; Siddaganga Institute of Technology, Tumkur, Karnataka; Karnataka Science and Technology, Bengaluru, Karnataka etc., for offering higher education in horticultural sciences. Scientists of the Institute have been recognised as faculty/ guides for offering course work and to guide the students for research.

Award of M.Sc and Ph. D. degrees

Student	University	Degree	Thesis Title	Guide
Sajana, S	IARI, New Delhi	Ph.D	Somatic embryogenesis mediated micro propagation of polyembryonic mango and marker assisted confirmation of maternal or zygotic origin of embryos	Dr. Reju M Kurian
Manish Kumar	IARI, New Delhi	Ph.D	Incorporation of *Phytophthora* root rot resistance genes into cytoplasmic and genetic male sterile (CGMS) line through marker assisted selection in chilli (*Capsicum annuum* L.)	Dr. K. Madhavi Reddy
Kavitha	Jain University	Ph.D	Diversity and foraging behaviour of pollinator on onion (*Allium cepa* L.) and their impact on onion seed production	Dr. P. Venkata Rami Reddy
V. Varun Rajan	Jain University	Ph.D	Plant pollinator interactions in mango with special reference to dipterans	Dr. P. Venkata Rami Reddy
Neethu K. Chandran	Jain University	Ph.D	Proteomic analysis of rose-powdery mildew (*Podosphaera pannosa* (Wallr.: Fr.) de Bary) interaction and mining of resistance mechanism	Dr. S. Sriram

Courses offered to IARI-IIHR Students

61 courses were offered for IARI-IIHR Ph.D students during the 2019-20 academic year.

Year	Trimester	No. of courses
2019-20	First	16
2019-20	Second	20
2019-20	Third	25

Allotment of PG students to research guides

A total of 24 students from various agriculture and horticulture universities and seven students from different traditional universities were allotted to scientists of ICAR-IIHR for M.Sc/ M.Tech/ Ph.D. project work in various disciplines during the period under report.

Shimna, K.	Kannur University	Ph.D	Investigations on the nutraceutical properties of *Cinnamomum* species	Dr. Shamina Azeez
Sunisha, C	Jain University	Ph.D	Transformation and evaluation of anti-apoptosis gene in banana cv. Rasthali for Fusarium wilt resistance	Dr. T.R. Usha Rani
Manpreet Kaur	IARI, New Delhi	Ph.D	Genetic analysis and validation of molecular markers linked to Tomato Leaf Curl New Delhi Virus (To LCNDV) resistance in ridge gourd [*Luffa acutangula* (I.) Roxb]	Dr. B. Varalakshmi
Jasmitha	Dr. Y.S.R. Horticultural University	M.Sc	Phenotyping for nitrogen use efficiency and nitrogen deficiency tolerance in tomato (*Solanum lycopersicum* L.)	Dr. H.C. Prasanna
Soumya Patil	University of Agricultural Sciences, GKVK, Bengaluru	M.Sc.	Evaluation of tomato and its wild relative genotypes for phosphorus acquisition and use efficiency	Dr. Laxman R.H.
Supriya Mandal	UHS, Bagalkot	M.Sc	Genetic divergence and stability analysis in leaf yield and quality traits in drumstick	Dr. Raja Shankar
Varsha	UHS, Bagalkot	M.Sc	Development of F1 hybrids in bell pepper (*Capsicum annuum* var. Grossum)	Dr. Smaranika Mishra
Tanuja	UHS, Bagalkot	M.Sc. (PSMAC)	Evaluation of velvet bean (*Mucuna pruriens*) genotypes for yield and nutrient recycling potential at different nutrient levels	Dr. S. Sujatha
Smita Maske	Shivaji University, Kolhapur	Ph.D (Biochemistry)	Proteomic analysis of rachis and berry elongation in response to GA_3 application in Thompson Seedless grapes	Dr. J. Satisha
Mahesh Kamate	University of Agricultural Sciences, GKVK, Bengaluru	M.Sc.	*In-vitro* synthesis and validation of double stranded RNA against Cucumber mosaic virus infection in *Cucumis sativus* L.	Dr. T.R. Usha Rani
Santhosh	University of Agricultural Sciences, GKVK, Bengaluru	Ph.D.	Genome editing by CRISPR/ Cas 9 for potyvirus resistance in tomato	Dr. R. Ashokan

Hemanth	University of Agricultural Sciences, GKVK, Bengaluru	M.Sc.	CRISPR/Cas 9 based editing of some important genes of mango fruitfly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae)	Dr. R. Ashokan
Parvathy	University of Agricultural Sciences, GKVK, Bengaluru	M.Sc.	CRISPR/Cas 9 mediated genome editing in mango fruitfly, *Bactrocera dorsalis* white gene	Dr. R. Ashokan
Deepika, V.	University of Agricultural Sciences, GKVK, Bengaluru	M.Sc.	Preliminary studies of apomixis in papaya (*Carica papaya* L.)	Dr. Vageeshbabu Hanur
Andonissamy Daniel, G.	University of Agricultural Sciences, GKVK, Bengaluru	M.Sc.	Metabolite diversity studies in ovaries of monoembryonic and polyembryonic mango (*Mangifera indica* L.)	Dr. Shivashankara K. S.
Joytirmayee Lenka	OUAT, Bhubaneswar	Ph.D.	Effect of micronutrients and plant growth regulators on yield and quality of guava under warm and humid climate of Eastern India	Dr. G.C. Acharya
Sharat Sanshi	OUAT, Bhubaneswar	M.Sc.	Crop regulation in guava (*Psidium guajava* L.) through foliar application of chemical defoliants	Dr. Deepa Samant
Nischay, P.K.	OUAT, Bhubaneswar	M.Sc.	Molecular analysis and grafting studies for bacterial wilt resistance in chilli	Dr. Ponnam Naresh
Abhishek Padhy	OUAT, Bhubaneswar	M.Sc.	Studies on flowering behaviour, reproductive biology and fruit set of sugar apple (*Annona squamosa* L.) in eastern coastal region	Dr. Kundan Kishore
Pratichee Mohapatra	OUAT, Bhubaneswar	M.Sc.	Scope of value addition in Wood Apple	Dr. G.C. Acharya
Nihar Ch Das	OUAT, Bhubaneswar	M.Sc.	Nutritional profiling and morphological characterization of dolichos bean	Dr. Meenu Kumari
Lellapalli Rithesh	OUAT, Bhubaneswar	M.Sc	Characterization of *Phytophthora* species infecting pointed gourd and its management	Dr. G. Sangeetha
Mukesh Ranjan Sethi	OUAT, Bhubaneswar	M.Sc	Characterization and biocontrol of *Sclerotium rolfsii* (*Athelia rolfsii*) the incitant of collar rot of solanaceous crops	Dr. P. Srinivas

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

Scientific staff

- Dr. P. C. Tripathi attended on-line training on "IP and technology valuation", organized by NAARM, Hyderabad, from 1-5 Sep 2020
- Dr. A.K. Jha attended on-line "Management Development Program (a pre-RMP Program) on Leadership Development", organized by ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, from 8-19 Dec 2020
- Dr. Safeena, S.A., attended online training of e-office and e-file module, on 25 Jun 2020, organized by ICAR-Indian Agricultural Statistics Research Institute, New Delhi
- Dr. Safeena, S.A., attended one day virtual Online Experts Meet/ Workshop on "ICAR-KRISHI Geoportal Spatial Data Infrastructure and Applications - A Way Forward", on 2 Jun 2020, at ICAR-National Bureau of So il Survey and Land Use Planning (NBSSLUP), Nagpur, under the aegis of ICAR Research Data Repository for Knowledge Management (KRISHI)
- Dr. Safeena, S.A., attended National Workshop on "Research Methodology: Concepts and Applications", organized by Directorate of Students Welfare, MPUAT, Udaipur, on 26, 27 Jun 2020
- Dr. Safeena, S.A., attended training on "Sensitization on uploading data in KRISHI Repositories" for KRISHI Nodal Officers organized by ICAR-Indian Agricultural Statistics Research Institute, KRISHI Team (ICAR Research Data Repository for Knowledge Management), on 15 Jul 2020
- Dr. Safeena, S.A., attended online training program on "Effective Health Management for Enhancing Work Efficiency of ICAR Employees", on 22 Oct 2020
- Dr. Safeena, S.A., attended "Young Scientists Conference", during 6th India International Science Festival (IISF 2020), organized by Ministry of Science and Technology, Ministry of Earth Sciences, Ministry of Health & Family Welfare, Govt. of India, in collaboration with Vijnana Bharati (VIBHA) by Council of Scientific and Industrial Research (CSIR), from 22-25 Dec 2020
- Dr. Safeena, S.A., attended national workshop on "Modern Interventions in Environmental Management", organized by ICAR-Indian Institute of Agricultural Biotechnology (IIAB), Ranchi, on 30 Dec 2020
- Dr. T. Usha Bharathi attended "International Webinar on DUS testing data management/ Automation/ Image Analysis", held at PPV&FRA, New Delhi, on 6, 7 Oct 2020
- Dr. T. Usha Bharathi attended the XXIX Annual Group Meeting (AGM) of AICRP on Floriculture, from 14-17 Dec 2020
- Dr. Safeena, S.A., attended national webinar on "Avenues in Horticulture in Post Covid Scenario" organized by College of Horticulture and Forestry, Jhalawar, Rajasthan, on 8 Jun 2020
- Dr. Safeena, S.A., attended national webinar on "Harnessing the Potential of Indigenous Ornamentals: Post Covid 19 Pandemic", on 18 Jun 2020, organized by Horticultural Sciences Division, ICAR and ICAR-Directorate of Floricultural Research, Pune
- Dr. Safeena, S.A., attended technical lecture on "Covid-19 and Agriculture - Global and Indian Challenges", by Prof. R. Ramakumar, School of Development Studies; Tata Institute of Social Sciences, Mumbai, during 25th Institute Foundation Day of ICAR-IISR, Calicut, on 1 Jul 2020
- Dr. Safeena, S.A., attended webinar series on Floriculture, organized by Faculty of Agriculture, Department of Horticulture, Annamalai University, Tamil Nadu, from 17 Jul to 4 Aug 2020
- Dr. Safeena, S.A., attended webinar on "Approaches and Strategies for Augmenting Export of Bananas", organized by ICAR-National Research Centre for Banana, on 21 Aug 2020
- Dr. Arivalagan, M., attended online training program on "Analysis of Experimental Data using R", from 5-11 Aug 2020, organized by ICAR-NAARM, Hyderabad
- Dr. Partha P. Choudhury attended on-line training on "Basic approach to manage risk in chemical laboratories", on 2 Jun 2020, organized by National Accreditation Board for testing and calibration Laboratories (NABL)
- Dr. Partha P. Choudhury attended on-line training course on 'ISO/IEC 17025: 2017 Main changes', on 20 Jun 2020, conducted by Asia Pacific Accreditation Cooperation (APAC)
- Dr. Debi Sharma attended online training on "Integrated Assessment: Importing Countries and Domestic Regulation Requirements" on 18, 19 Jul

2020, organized by National Accreditation Board for Testing and Calibration Laboratories (NABL)

- Dr. Laxman, R.H., attended online training program on "Climate Change: Challenges and Response" (for Scientists & Technologists), from 14-18 Dec 2020, organized by Centre for Disaster Management (CDM), Lal Bahadur Shastri National Academy of Administration, Mussoorie
- Dr. V.K.J. Rao attended ICAR-NAHEP sponsored online training program on "Science Communication for Smart Scholars", organized by ICAR-Central Institute of Fisheries Education, Mumbai, during 26 May to 8 Jun 2020
- Dr. Meenu Kumari attended online training program on "Analysis of Experimental Data using R" organized by ICAR-NAARM, Hyderabad, from 5-11 Aug 2020

Technical staff

- Dr. Lokesha, A.N., attended online workshop on "ABC of Scientific Writing", from 18 Aug to 2 Sep 2020, organized by Krishi Vignan Kendra, Santhapur, (ICAR-National Rice Research Institute) Cuttack, Odisha
- Dr. Lokesha, A.N., attended online training program on "Analysis of Experimental Data using SAS", from 9-17 Nov 2020, organized by ICAR-NAARM, Hyderabad
- Dr. Lokesha, A.N., attended "Generic Online Training in Cyber Security" for Central Government Ministries/ Departments, on 16 Dec 2020, organized by Ministry of Electronics and Information Technology (Meit Y), GoI
- Ms. Malarvizhi, M., attended online training program on "Advanced Bioinformatics Tools and its Applications in Agriculture", from 7-11 Dec 2020, conducted by ICAR-NAARM, Hyderabad

6.3. Attachment training to ARS Probationers at ICAR-IIHR

Scientist	Parent Institute	Guide
Dr. Amrutha, T.	ATARI, Umiam, Meghalaya	Dr. T.M. Gajanana
Dr. Ramya, H.R.	CSSRI, Karnal	Dr. V.K. Jayaraghavendra Rao
Dr. Ramya, H.R.	ICAR-NAARM	Dr. V.K. Jayaraghavendra Rao & Dr. B. Balakrishna
Ms. Jaya Lakshmi		
Mr. Sona Charles		
Ms. Manisha Saini		
Mr. Dilip Kumar		
Mr. Devendra Singh		
Mr. Nagesh Kumar		

7. Awards and Recognition

7.1. Awards

- Deepa Samant was conferred with 'The Excellence in Research Award-2020', by Vigyan Varta, an International E - Magazine for Science Enthusiasts
- G Karunakaran received 'Outstanding Horticultural Scientist Award-2017', from Society of Horticulture Research and Development, Ghaziabad, UP, during Indian Horticulture Summit-2020, held from 14-16 Feb 2020, at the Mahatma Gandhi Chitrakoot Gramodya Vishwavidyalaya, Chitrkoot, MP
- Kanupriya received 'Eminent Scientist Award-2020', during International Web-Conference on 'New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development (NTAEBSID-2020)', held during 21-22 Jun 2020, at Agro Environmental Development Society, Rampur, UP
- P C Tripathi was conferred with Fellow of Society for Horticultural Research and Development, Ghaziabad, UP, Feb 2020

7.2. Best Paper/ Poster/ Presentation Awards

- Analysis of extreme rainfall events over Kodagu District, in 'AGMET-2020', by Sahana Hegde, 2nd best oral presentation award in National Seminar on 'Agrometeorological Interventions for Enhancing Farmers' Income', at Thrissur, Kerala, 19-22 Jan 2020
- Phenotyping techniques for assessment of abiotic stress tolerance in banana, by Laxman R H, best oral presentation in International Conference on 'Banana 2020: Innovations in Sustainable Production and Value Chain Management in Banana', at NRCB Trichy, Tamil Nadu, 22-25 Feb 2020
- H S Megha, Best Ph. D thesis award (Guide: Dr. K V Ravishankar): International Conference on 'Banana 2020: Innovations in Sustainable Production and Value Chain Management in Banana', at NRCB, Trichy, Tamil Nadu, 22-25 Feb 2020
- Expression of anti-apoptotic gene At Bag 4 enhanced tolerance to *Fusarium* wilt disease in banana cv. Rasthali, by Sunisha C, Umesha M, Sowmya H D, Usharani T R, and Sriram S, best poster in International conference on 'Banana 2020: Innovations in Sustainable Production and Value Chain Management in Banana', at NRCB, Trichy, Tamil Nadu, 22-25 Feb 2020
- Tamarind for improving rural livelihood security through sustainable integrated farming, by Kanupriya - best oral presentation in International Web-Conference on 'Food Security through Sustainable Agriculture (FSSA), VAKSANA – 2020, 21-22 Sep 2020
- Ploidy determination and 2 C nuclear DNA contents in sexually dimorphic clones of betel vine (*Piper ~~b~~ tel* L.): A study by flow cytometry, by Mangesh G N, Hima Bindu K, Mallikharjuna Gowda A P, Halesh G K, best oral presentation in International E-Conference on 'Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity', 24-27 Nov 2020, at UHS, Bangalore
- Topical application of dsRNA targeting multiple genes of Cucumber Mosaic Virus (CMV) in *Cucumis sativus* L., by Usharani T R, Sowmya H D, Kamate M, Manmohan M and Reddy K M, best oral presentation award in International E-Conference on 'Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity', at UHS, College of Horticulture, Bengaluru, 24-27 Nov 2020

7.3. Recognitions

7.3.1. Professional Societies

- Anjani Kumar Jha - Executive Council Member, Indian Society for Spices
- Deepa Samant - Member of Editorial Board of *Bagwani'*
- Gajanana T M - Member, Editorial Board, Indian Journal of Agricultural Marketing, Hyderabad
- Hima Bindu K - Associate Editor in Editorial Board of Journal of Horticultural Sciences
- Kalaivanan D - Executive Member of Bangalore Chapter of Indian Society of Soil Science, UAS, Bangalore
- Kalaivanan D - Member of Editorial Board of Journal of Applied Biology and Biotechnology, Agro Plus Journal and Glacier Journal of Scientific Research
- Partha P Choudhury - Associate Editor of Asian-

Pacific Weed Science Society (Australia) News Letter

- Patil B L - Editor of PLOS ONE, Frontiers in Plant Science (Review Editor), Virus Research Newsletter (IVS)
- Prakash Patil - Nominated as Honorary Fellow (FSBER/402/2020) of Society for Biotic and Environmental Research (SBER), Ganki, Tripura
- Rajasekharan P E - Member of editorial board of Journal of Traditional and Folk Practices
- Rupa T R - Member of Editorial Board, Journal of Spices and Aromatic Crops, Kozhikode, Kerala
- Selvakumar G - Member of editorial board of World Journal of Microbiology and Biotechnology (Springer)
- Selvakumar G - Member of technical guidance committee on Solid Waste Management of Bruhat Bengaluru Mahanagara Palike (BBMP), Bengaluru
- Smitha G R - Honorary Editor of Journal of Plant Developmental Sciences
- Smitha G R - Section Editor of Open Access Journal of Medicinal and Aromatic Plants,
- Smitha G R - Member of Editorial Board of Medicinal Plants - International Journal of Phytomedicines and Related Industries
- Sridhar Gutam - Inducted into committee of CABI's agri Rxiv, agricultural preprint service for agricultural research
- Sridhar Gutam - Recognized as AGRIS data contact by ICAR, India
- Vageeshbabu S Hanur - Editor of International Journal of Life Sciences
- Venkataravanappa V - Member in Editorial Boards of Archives of Phytopathology and Plant Protection Journal
- Venugoplan R - Editor, Journal of Horticultural Sciences

7.3.2. Membership in Institute Management Committee/ Others

- Acharya G C - Judge in Annual Garden Competition, organized by Plant Lovers Association
- Acharya G C - Member for reviewing RKVY sponsored projects, Govt. of Odisha
- Acharya G C - Member of 'Expert Committee for Selection of Technical Products for Pest Management', Directorate of Agriculture and Food Production, Odisha
- Acharya G C - Member of 'Implementation of Schemes of Coconut', Directorate of Horticulture, Govt. of Odisha
- Acharya G C - Member of District Monitoring Committee, for Attracting and Retaining Youth in Agriculture (ARYA) project, to be implemented in Ganjam District, Odisha
- Acharya G C - Member of State Level Research-Extension Interface Committee, Govt. of Odisha
- Acharya G C - Member of Technical Support Group Meeting, Directorate of Horticulture, Govt. of Odisha
- Acharya G C - Member of Vyapar Initiative in Krishi and Agri-Startups-RKVY Agribusiness Incubator (VIKAS-RABI), for selection of Startups for ICAR-NRRI
- Acharya G C - Subject expert for selection of Assistant Professors in different disciplines of agriculture, C V Raman Global University, Odisha
- Anjani Kumar Jha - Member of Board of Studies, Department of Horticulture, School of Life Sciences, Sikkim University
- Anjani Kumar Jha - Member of Technical Expert Committee (DBT-NER), Department of Biotechnology, Ministry of Science and Technology, Govt. of India, New Delhi, in the area of Agricultural Biotechnology & Allied Sciences for North Eastern Region
- Anjani Kumar Jha - Member, Recruitment Committee for Scientific positions at Bio-Resources Development Centre (a Meghalaya Govt. Institution, under Science & Technology Cell, Planning Department), Shillong
- Aswath C - Co-chaired a session in the International Conference on Banana – 2020, 22 Feb 2020, Hotel Breeze Residency, Tiruchirapalli, Tamil Nadu
- Aswath C - Judge for Republic Day horticultural show, Dr. M H Marigowda Memorial Hall, Lalbagh, Bengaluru, on 17 Jan 2020.
- Debi Sharma - Moderated a session on 'Food Safety and Quality', in Global e-Summit of 'Vertical-16, (Agroeconomy and Food Security), and the

Horizontal 3 (Food Safety and nutritional security)', Vaishwik Bharatiya Vaigyanik (VAIBHAV), 14 Oct 2020

- Deepa Samant - Member of DPC, for Coconut Development Board, Odisha, for the post of Technical Officer and Field Assistant, on 3 Jul 2020
- Gajanana T M - Member of DPC for promotion of Technical Officers, ICAR-CRIDA, Hyderabad
- Gajanana T M - Recognized as member of IMC, National Institute of Agricultural Economics and Policy Research, New Delhi.
- Kalaivanan D - Reviewer by Science and Engineering Research Board (SERB), Department of Science and Technology, Government of India
- Laxman R H - Convener of technical Session 'Advances in Abiotic Stress Management', in International Conference on 'Banana-2020-Innovations in Sustainable Production and Value Chain Management in Banana', 22-25 Feb 2020, NRCB, Tiruchirappalli, Tamil Nadu
- Laxman R H - Member of Advisory Board of the Bengaluru S&T (BeST) Cluster, IISC, Bengaluru
- Laxman R H - Member of the technical sub-committee for 'Formulating Risk Wise Indicator Matrix and Thresholds for Enabling a Technology Driven Two-Step Yield Estimation Approach to Conduct Need based Crop Cutting Experiments (CCES)' under Pradhan Mantri Fasal Bima Yojana (PMFBY), Credit Division, Ministry of Agriculture and Farmers Welfare
- Laxman R H - Panelist in session on 'Sensors and Sensing in Precision Agriculture', on the topic 'High throughput Phenotyping for Precision Agriculture', 5 Oct 2020, in Vaishwik Bharatiya Vaigyanik (VAIBHAV) Summit
- Laxman R H - Panelist in the session on 'Growth, Development and Value Addition' in the '7th Group Discussion of ICAR-AICRP on Fruits', held at Punjab Agricultural University, Ludhiana, 16-19 Jan 2020
- Laxman R H - Panelist in the session on 'Impacts on Agriculture, Mitigation and Adaptation Strategies', in conference 'Approaches to Shaping Climate Resilient Agriculture', hosted by The Energy and Resources Institute (TERI) and The Associated Chambers of Commerce and Industry of India (ASSOCHAM), 28 Feb 2020, at Bengaluru
- Manjunath B L - Member of Horticulture Technical Committee of Watershed Development Department, Government of Karnataka and Tender scrutiny committee, KHF, Benglauru
- Meenu Kumari, - External member of selection committee for YPs under DUS projects and AICRP on tuber crops at ICAR-CTCRI, Bhubaneswar
- Narayanaswamy B - Executive Committee Member, Board of Karnataka State Mango Development and Marketing Corporation (KSMD & MC)
- Narayanaswamy B - Executive Committee Member, State Media Committee, Karnataka
- Narayanaswamy B - Nodal Officer, ICRISAT-IIHR Bhoo-Samruddhi Projects of IIHR
- Narayanaswamy B - Nodal Officer, NEMA Projects of IIHR.
- Narayanaswamy B - Nodal Officer, RKVY Projects of IIHR
- Rajasekharan P E - Member Research Advisory Committee, CSGRC, Hosur, by Central Silk Board;
- Rajasekharan P E - Research Council Member, Malabar Botanical Garden and Institute for Plant Sciences, Calicut
- Rajiv Kumar - Member for formulation of Technical Programme (2021-24) of 'Crop Improvement' and Convener for Plenary Session during XXIX Annual Group Meeting of AICRP on Floriculture, 14-17 Dec 2020
- Rajiv Kumar - Member of Editorial Board of Rajbhasha Patrika 'Bagwani' for 2020-21
- Rajiv Kumar - Member of Task Force (06/2020) constituted by PPV & FRA, New Delhi for 'Development of DUS test Guidelines for Gerbera
- Ravishankar K V - Convenor of technical session 'Biotechnology and Omic Approaches' during International Conference on 'Banana-2020-Innovations in Sustainable Production and Value Chain Management in Banana, 22-25 Feb 2020, NRCB, Tiruchirappalli, Tamil Nadu
- Reju M Kurian - IMC member for NRCB, Trichy, Tamil Nadu
- Sankaran M - External expert of Institute Research Council, Directorate of Cashew, Puttur, Karnataka
- Satisha J - Member in revising the syllabus for

Horticulture Diploma for Department of Horticulture, Government of Karnataka

- Shivashankara K S - Chairman of Theme 8: Advances in Molecular Biology of Abiotic Stress Tolerance', in International E-Conference on 'Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity', 24-27 Nov 2020, at College of Horticulture, Bengaluru, UHS, Bagalkot
- Shivashankara K S – Member of Institute Management Committee of ICAR-Central Institute for Subtropical Horticulture, Lucknow, Uttar Pradesh
- Sreenivasamurthy D - Recognized as Member of Board of Studies (UG), UAS, Bangalore
- Tejaswini Prakash - Convener of Technical sessions in World Regional Rose Society Conference, at Kolkata, 9-12 Jan 2020
- Upreti K K - Chairman of Hindi Incentive Scheme committee, ICAR-IIHR, Bangalore
- Upreti K K - Coordinator for conducting Online Interview for the post of Directors at ICAR-IIHR, Bangalore
- Upreti K K - Member of Editorial board of Bagwani magazine
- Upreti K K - Member of FAD/Panel IV for review of Standards by Food & Agriculture Division, Bureau of Indian Standards, New Delhi
- Vageeshbabu S Hanur - BOS and Advisory Committee Member of KLE Society, Bangalore
- Vageeshbabu S. Hanur - Member in IIHR IBSC
- Venkattakumar R - Expert in International Webinar on 'Back at Work Plan (BAWP)', presentation by FTF ITT trainees, jointly organized by MANAGE, Hyderabad and USAID, India
- Venkattakumar R - Expert member in 34th Institute Research Council meeting for ICAR-Indian Institute of Soybean Research, Indore, in the field of Extension and Social Sciences, 16-17 Jun 2020
- Venkattakumar R - Co-Chairman for the oral presentation & Evaluator for online poster presentation in Theme No. 5. on 'Policy Reforms in the Field of Agricultural Extension' during the National Conference on 'Transformation of Agricultural Extension-Strategies for Effective Reformation' TAESERE 2020 Online, organized by Department of Agricultural Extension, Agricultural College, Bapatla, 20-21 Aug 2020
- Venkattakumar R - Invited member in 5th Extension Education Council (EEC) meeting of UAHS, Shimoga, (online), 7 Dec 2020
- Venkattakumar R - Member in DPC, for Personal Assistant Steno Grade-III, at KVK, Hirehalli
- Venkattakumar R - Member in MACP Screening Committee for a case in ATARI, Bengaluru, 3 Oct 2020
- Venugopalan R - External member in Doctoral Committee of Department of Biostatistics, NIMHANS, Bangalore
- Venugopalan R - RAC member of NHRDF, New Delhi

7.3.3. Invited Lectures

- Acharya G C conducted a session on 'Horticulture based entrepreneurship', and presented a lecture on 'Potential horticultural crops', during Technology Based Entrepreneurship Development Program (TEDP), at ICAR-NRRI, 20 Dec 2019
- Acharya G C delivered a lead lecture on 'Food Security', in national e-conference on 'Future of Strategic Technological Innovation and Entrepreneurship Development in Agriculture and Allied Sector', organized by Institute of Agril Sciences, Siksha Anusandhan University, 14-16 Sep 2020
- Acharya G C delivered a lecture on 'Disease/pest and physiological disorders in coconut and their management' in webinar organized by Coconut Development Board, Bhubaneswar, 7 Oct 202**0**
- Acharya G C delivered a lecture on 'High-tech PHM in fruit crops and value addition in fruit crops', in the 'Entrepreneurship Development Course on High Tech Horticulture', organized by OUAT and NAHEP, 24 and 27 Jan 2020
- Acharya G C delivered a lecture on 'Integration of horticulture under IFS', in training program on 'Management of Rice Crop under Integrated Farming System for Farmers', at ICAR-NRRI, on 12 Mar 2020
- Acharya G C delivered a lecture on 'Package of organic vegetable cultivation', in online training program on 'Organic Farming', organized by Regional Centre of Organic Farming, Bhubaneswar

- Acharya G C delivered a lecture on 'Potential of horticultural crops during skill development program', organized by ICAR-NRRI and ASCI, 4 Mar 2020
- Acharya G C delivered a lecture on 'Production technologies of important vegetable crops' during the training program 'Tuber Crops and Allied Agricultural Technologies for Livelihood and Nutritional Security', organized by RC-CTCRI, 06-10 Jan 2020
- Acharya G C delivered an invited lecture on 'High-tech horticulture', in 5th Annual National Agri-Enterprise Conclave', held at Sri Sri University, Cuttack, 5 Feb 2020
- Acharya G C participated in technical session and panel discussion on scientific cultivation practices of vegetable, fruit, flower and crop diversification in climate change situation in Ganjam District, Odisha, organized by Tata Steel Rural Development Society, 27 Feb 2020
- Anjani Kumar Jha delivered a lead talk on 'Underutilized crops from NE region for nutritional and income security', in 'Indian Horticulture Summit-2020', organized by Society for Horticultural Research and Development, Ghaziabad, at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, MP, 14 Feb 2020
- Aswath C delivered a lecture on 'Planting materials in flower crops', (online), organized by CCS National Institute of Agricultural Marketing, 22 Oct 2020
- Debi Sharma delivered a talk on 'Monitoring pesticide residues in vegetable crops for safe consumption and their waiting periods', in National webinar on 'Protected Cultivation of Vegetable Crops-Way Forward', organized by ICAR-IIHR, Bengaluru, 28 Aug 2020
- Deepa Samant delivered lectures on 'Hi-Tech fruit nursery raising' and 'Maintenance of hi-tech fruit nursery', in an Entrepreneurship Development Course, organized by Department of Floriculture and Landscaping, College of Agriculture, OUAT, Bhubaneswar, 13 Jan 2020
- Kalaivanan D delivered invited lecture on 'Soilless terrace cultivation of vegetables', in the training program on 'Soilless Terrace Gardening', organized by BESST-HORT, ICAR-IIHR, Bengaluru, 19th December 2020
- Kalaivanan D delivered invited lecture on 'Substrates suitable for homestead farming' in the training programme on 'Homestead farming' organised by BPD of ICAR-IIHR, Bengaluru, 17 Dec 2020
- Kalaivanan D delivered invited online lecture on 'Potential of soilless culture/hydroponics for enterprise development in horticulture vis-à-vis medicinal and aromatic plants', during 'Entrepreneurship Development Program', 7 Nov 2020, at ICAR-DMPAR, Anand in association with Medi-Hub TBI
- Kalaivanan D delivered invited online lecture on 'Soilless vegetable production' for B.Sc (Agri.) students of Kumaraguru Institute of Agriculture, Coimbatore, 12 Aug 2020
- Laxman R H delivered a lecture on 'Grafting technique in vegetable crops as a climate resilient technology for flooded situations of Assam', in Special training program for the farmers of Barpeta district, Assam, and NHB Officers of Assam under NHB program 'Training Under Exposure Visit of farmers (Outside State) & Technology Development and Transfer for Promotion of Horticulture (EDPs) for Assam' held from 17 Feb to 10 Mar 2020
- Laxman R H presented a talk on 'Activities of ABI at ICAR-IIHR', in Rural India Business Conclave, at CPCRI, Kasaragod, 2 Mar 2020
- Patil B L delivered a talk on 'Clustered regularly interspaced short palindromic repeats (CRISPR)/ Cas9 system for Indian agribiotech', in '4th Annual Agri-Biotech India Summit', by Inventicon Business Intelligence, Hyderabad, 22-23 Sep 2020
- Patil B L delivered a talk on 'miRNA-Induced Gene Silencing (MIGS): For control of multiple pests and pathogens', in International E-Conference on 'Advances & Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity', at UHS, Bagalkot, 25 Nov 2020
- Patil B L delivered invited talk on 'The evolution and emergence of emaraviruses: Pigeonpea sterility mosaic emaraviruses as classic examples', in VIROCON-2020 at INSA, New Delhi, 18-20 Feb 2020
- Rajiv Kumar delivered lecture on 'Advances in production technology of chrysanthemum and China aster', on 28 Jan 2020, in the special training programme for farmers of Morigoan district, Assam, and NHB Officers of Assam, under the NHB program 'Training under Exposure Visit of Farmers (outside state) & Technology Development and Transfer for

Promotion of Horticulture (EDPs) for Assam', from 20 Jan to 11 Feb 2020

- Ravishankar K V delivered a talk on 'Application of genomics tools in improvement of tomato' at International E-conference on 'Advances and Future Outlook in Biotechnology and Crop improvement for Sustainable Productivity', 24-27 Nov 2020, organised by UHS, Bangalore
- Ravishankar K V delivered a talk on 'Genomics and marker assisted breeding to mitigate Abiotic stress tolerance in crop plants' in National Web Conference on 'Impact of Environmental Factors for Plant and Human Genetics: Mitigation Strategies', 13 Oct 2020, jointly organized by: UHS, Bagalkot, CoH, Kolar, and Sri Devaraj Urs Academy of Higher Education and Research (SDUAHER), Kolar, Karnataka
- Ravishankar K V delivered a talk on 'Genomics approaches for crop improvement against abiotic stresses', in online training program on 'Abiotic Stress Management of Horticultural Crops', organised by SKUAST-Kashmir, Srinagar, 11-17 Sep 2020
- Rohini M R delivered lecture on 'Cultivation of medicinal herbs in home garden', in the Webinar 'Common Medicinal Plants for Immunity Boosting' organized by BESSTHORT, ICAR-IIHR, 25 Sep 2020
- Rohini M R delivered lecture on 'Good agricultural practices of Ashwagandha' in the farmers training on 'Good Agricultural and Collection Practices for Medicinal Plants', at Trans Disciplinary University, Bangalore, 18-20 Feb 2020
- Rohini M R delivered lecture on 'Terrace cultivation of medicinal herbs for a healthy living', in the training program on 'Soilless Terrace Cultivation', at ICAR-IIHR, 19 Dec 2020
- Rohini M R served as course-coordinator and delivered lecture on' Crop improvement and improved varieties of medicinal plants', in the online training program 'Prospects of medicinal plants cultivation in Karnataka', on 20 Nov 2020, at ICAR-IIHR, Bengaluru
- Vageeshbabu S Hanur delivered a talk on 'Bridging the gap between Academia, Research and Industry for Local & Global Competency', in IQAC Initiated UGC STRIDE sponsored two days International e-Conference, 27-28 Oct 2020, organised by KLE Society, Bangalore
- Venkattakumar R presented an invited lecture on 'Successful case studies of Farmers Producers Organizations (FPOS) in India' through online mode on 21.10.2020 in the NABARD Sponsored 'Capacity Building Programme for Board of Directors for Sustainable Functioning of Farmers Producers Companies' held at KVK, Needamangalam
- Venkattakumar R presented lead paper on 'Reforms recommended for effective functioning of Farmers Producers Organizations (FPOs) on horticulture', in 'Policy Reforms in the Field of Agricultural Extension', during the National Conference on 'Transformation of Agricultural Extension-Strategies for Effective Reformation' TAESERE 2020 Online, organized by Department of Agricultural Extension, Agricultural College, Bapatla, 20-21 Aug 2020
- Venugopalan R delivered an invited online lecture on 'Application of Statistical Concepts in Horticulture Research: Basics and way ahead', organised by Dr. YSR Horticultural University, Venkataramannagudem, 14 Sep 2020

8. Linkages and Collaborations

The Institute has collaborative research and development linkages with several national (DST, DBT, NABARD, NASF, NMPB etc.) and international (IITA, Bioversity International etc.) organizations and universities. The 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 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 scientists regularly contribute to the publication of package of practices of various horticultural crops published by SAU's. Scientists of the Institute actively collaborate with the state departments of horticulture and agriculture (Karnataka & Odisha) in the implementation of centrally aided schemes like RKVY, NHM, MIDH etc. Following are the externally aided projects under operation at the Institute.

8.1. Foreign Collaborative Projects

Project Title	PI	Funding Agency
"Enhancing the Banana Production through developing *Fusarium* Wilt Resistant Varieties and Benefit Sharing with Small Holder Farmers of Africa" "Improvement of banana for small holder farmers in the Great Lake Region of Africa" [Indian Component-Breeding for improved bananas with *Fusarium* wilt (*Fusarium oxysorum* f.sp. *cubense*) resistance] (NRC-Banana – Main Centre; Collaborating Partners: IIHR, Bengaluru; NBPGR, New Delhi & KAU, Thrissur)	Rekha, A. (CC–PI) Backiyarani (PI – NRC-Banana)	IITA

8.2. National Fellow Project

Project Title	PI	Funding Agency
Studies on Phyto-Semiochemicals Involved in Insect-Plant Interaction of Major Horticultural Pests: Deciphering Chemical Cues	Kamala Jayanthi, P.D.	ICAR

8.3. List of Consortia Research Platform (Initiated in XII Plan)

Projects Title	PI/ CC-PI	Funding Agency
AGRI-CRP on Water (Efficient Water Management In Horticultural Crops)	Anil K. Nair (PI)	ICAR
CRP on Farm Mechanization & Precision Farming	G. Senthil Kmaran (CC-PI)	ICAR
Consortium Research Platform (CRP) on Vaccines and Diagnostics	Krishna Reddy, M. (PI- Plant Component)	ICAR
Consortium Research Platform (CRP) on Hybrid Technology (CRP-HT) Tomato-ICAR-IIHR (Main Centre)	H.C. Prasanna (w.e.f. 01.07.19)	ICAR
CRP on Molecular Breeding for Improvement of Tolerance to Biotic and Abiotic Stress, Yield and Quality Traits in Crops	M. Pitchaimuthu (PI - Cucumber)	ICAR

8.4. National External Funded projects

Projects Title	PI/ CC-PI	Funding Agency
Development and Transfer of Technology from Queensland University of Technology, Australia to India for Bio-fortification and Disease Resistance in Banana Sub Project: Transfer and evaluation of Indian banana with FoC construct	Usha Rani, T.R.	BIRAC
Establishment of Horti-Bioincubator at ICAR-IIHR under BioNEST	D.V. Sudhakar Rao	BIRAC-BioNEST
Investigation on Potential and Feasibility of SIT for Management of South American Tomato Moth, *Tuta ab oluta*	V. Sridhar (PI); P.V.R. Reddy (Co-PI)	BRNS-BARC
Monitoring of Pesticide Residues at National Level	Soudamini Mohapatra (Till 31.3.2020); Debi Sharma (w.e.f 1.4.2020)	CSS, Min. of Agriculture (Network Project)
Standardization of Media, Evaluation of Plant Species and Nutrient Module for Vertical Landscapes Using Coir Based Products	H.P Sumangala (PI); Senthil Kumaran. G. & Selvakumar.G. (Co-PI)	Coir Board, Ministry of MSME
Development of Technologies for Production of Value Added Products from Kiwifruit (*Actinidia deliciosa*) and Pineapple (*Ananas comosus*)	H.S. Oberoi (Up to 29.12.2020); K. Ranjitha (w.e.f. 29.12.2020)	DA&CFW
Ecology of Thrips and Tospovirus Interactions in Tomato and Watermelon Pathosystems	Usha Rani, T.R. (CC-PI)	DBT
Development of Technology for Enhancing Egg Laying in Vanya Silk moths by application of Host Plant Volatiles	Kamala Jayanthi, P.D. (CC-PI)	DBT (Program for NE)
Exploring Diversity, Genomic and Transcriptone Profiling and Phytosemiochemicals of Banana Pest Complex in NER Region – An Ecological and Molecular Approach	Kamala Jayanthi, P.D. (CC-PI)	DBT (Program for NE)
Screening for Resistance to Nematodes in Traditional Banana Cultivars and Wild Species of Tripura and Other NE Region	R. Umamaheshwari (CC-PI)	DBT (Program for NE)
Development of Pre & Postharvest Bunch Care Management Methods for Fresh Banana	Narayana, C.K. (CC-PI)	DBT (Program for NE)
Knocking-Out the Virus: Elimination of the Endogenous Banana Steak Viral Sequences from Banana through Genome Editing with CRISPR-Cas9 System	Manamohan, M. (CC-PI)	DBT (Program for NE)
Screening of Banana Germplasm from the NE for *Fusarium* Wilt Resistance and Molecular Characterization in Contrasting Genotypes	Ravishankar, K.V. (CC-PI)	DBT (Program for NE)

Projects Title	PI/ CC-PI	Funding Agency
Biotechnological Interventions through RNAi Approach for Management of Banana Bunchy Top Virus (BBTV) in Northeast Region of India	Basavaprabhu L. Patil (PI)	DBT (Program for NE)
CRISPR/Cas9 Mediated Control of the Gemini Viruses Involved in Papaya Leaf Curl Disease	Basavaprabhu, L. Patil (PI)	DBT-BCIL
Simulation of Leaf Curl Disease Dynamics in Chilli for Strategic Management Options	Mahesha, B. (CC-PI)	DBT
Morphological, Biochemical and Molecular Characterization of Jamun Genotypes of North-Eastern Region	Rekha, A. (Up to 17.3.2020); K.S Shivashankara (w.e.f 18.03.2020) K.V.Ravishankar	DBT
Bio-Rational Interventions through Entomopathogenic Nematodes to Manage Ash Weevil (*Myllocerus* spp.) Menace in Brinjal (*Solanum melongena* L.)	R. Umamaheswari	DST
Marker Validation and Introgression of WBNV Resistance from a Prebed Line of Watermelon	E. Sreenivasa Rao	DST
Assessment and Understanding Mechanism of Insecticide Resistance in *Tuta absoluta:* A New Invasive Pest in India	Prasannakumar, N.R.	DST-SERB
Establishing Incubation Facility for PHT Technologies and Others at ICAR-IIHR	C.K. Narayana (CEO)	DST - BESST-HORT, a TBI of ICAR-IIHR)
Morphogenetic Characterization of Native Virulent *Phytophthora* isolates Inciting Vine Rot and Fruit Rot of Pointed Gourd Emerging in Odisha and Devising IDM Module in Participatory Mode	G. Sangeetha	DST, Govt. of Odisha
Introgression of Pungency Genes from Wild Species through Marker-Assisted Selection in Chilli (*Capsicum annum* L.) – to Breed Suitable Commercial Pepper Cultivation for Industrial Use	Madhavi Reddy, K.	DST-SERB
Identification and Mapping of ToLCNDV Resistance Loci and Introgression of Resistance Genes through Molecular Assisted Selection in Chilli (*Capsicum annuum* L.)	Lakshmana Reddy, D.C.	DST-SERB
Marker Assisted Breeding for Combined Resistance to Major Soil Borne Diseases (Bacterial Wilt & *Phytophthora* Root Rot) and Root-Knot Nematodes in Chilli (*Capsicum annuum* L.).	Naresh Ponnam	DST-SERB
Undertaking the Changes in Host-Pest Interactions and Dynamics in Mango Under Climate Change Scenario	Kamala Jayanthi. P.D. (CC-PI)	ICAR (NICRA, (Network Project)
National Initiative on Climate Resilient Agriculture (NICRA) for XI Plan	Laxman, R.H.	ICAR (NICRA)

Projects Title	PI/ CC-PI	Funding Agency
National Initiative Climate Resilient Agricultural Technology Package at Village Level	Loganandhan, N. (CC-PI)	ICAR (NICRA)
Genomics-Mediated Taxonomic and Functional Analysis of Endophytic Microbiome in Horticultural Crops and Plant-Microbe Interaction Studies (Main Centre: ICAR-NBAIM)	B.L. Patil (CC-PI)	ICAR AMAAS (Network Project on Application of Microorganism in Agriculture and Allied Sectors)
BIOCLAY – The Novel LDH Nanocarrier System in Increasing the Persistence of Bt Toxins	Asokan, R.	ICAR AMAAS (Network Project on Application of Microorganism in Agriculture and Allied Sectors)
All India Network Project (AINP) on Pesticide residues	Soudamini Mohapatra (Till 31.3.2020); Debi Sharma (w.e.f. 1.4.2020)	ICAR (Network Project)
ICAR-NPTC - Functional Genomics of Plant Type, Maturity and Fruit Quality Traits in Mango	M. Sankaran (PI)	ICAR (Network Project)
Network Project on Transgenics in Crops (NPTC): Functional Genomics: *Fusarium* Wilt Resistance and Drought Tolerance in Banana	Ravishankar, K.V.	ICAR (Network Project)
Network Project on Transgenics in Crops (NPTC): Development of Transgenic Banana Cv. Rasthali Resistant to *Fusarium* Wilt	Usharani, T.R. (CC-PI)	ICAR (Network Project)
Network Project on Agricultural Bioinformatics and Computational Biology: Development of Non-Embryonic CRISPR/Cas9 Based Genome Editing for Precision Guided Sterile Insect Technique (pgSIT)	R. Asokan	ICAR (Network Project)
Policy Imperatives for Promoting Value Chains of Agricultural Commodities in India	Gajanana, T.M.	ICAR-NIAP Network Project
Farmer FIRST: Enriching Knowledge – Integrating Technology and Institutions for Holistic Village Development in Horticulture Based Farming System	Balakrishna, B.	ICAR (Farmer FIRST Program Component of KVK Scheme)
New Extension Methodologies and Approaches (NEMA)	B. Narayanaswamy	ICAR (Extension Division)
Preparation of Peoples Biodiversity Register for Bangalore Rural and Tumkur Districts and Taluks Under Them	P.E. Rajasekharan	Karnataka Biodiversity Board
Front Line Demonstration on IPM Technologies for Protected Cultivation of Capsicum, Tomato and European Cucumber in Farmer's Fields of Karnataka by IIHR	B. Balakrishna	MIDH (NHM), Dir. of Hort., Govt. of Karnataka

Projects Title	PI/ CC-PI	Funding Agency
Establishment of Centre of Excellence on Protected Cultivation of Horticultural Crops at ICAR-IIHR, Bengaluru	S. Shankar Hebbar	MIDH (NHM), Dir. of Hort., Govt. of Karnataka
Micro/ *In Vitro* Propagation of Underutilized Vegetable Crops and Supply in the State of Odisha	Meenu Kumari	MIDH (NHM), Dir. of Hort., Govt. of Odisha
Establishment of a Model Nursery for Production of Quality Planting Materials of Pineapple in Odisha	Kundan Kishore	MIDH, Govt. of Odisha
Vegetable Grafting: Establishment of Model Vegetable Grafting Nursery for Tackling Soil Related Biotic & Abiotic Constraints in Odisha	Acharya G.C. & P. Srinivas (w.e.f 18.09.2020)	MIDH, Govt. of Odisha
Seeds: Social and Economic Empowerment through Dedicated Seed Production Clusters for Vegetable Crops in Odisha	P. Srinivas	MIDH, Govt. of Odisha
XII Plan Scheme, National Agriculture Innovation Fund (NAIF), Component-1: Establishment of Zonal Technology Management Centre (ZTMC)	H.C. Prasanna	NAIF, ICAR, New Delhi
Promotion of Farmer Producer Organizations (FPOs) towards Doubling Farmers Income	Saju George	NABARD, Bengaluru
Horticulture Technology Promotion Program to Enhance Productivity, Quality and marketability of Horticultural Crops in NABARD Promoted Villages	Atheequlla G.A.	NABARD, Bengaluru
XII Plan Scheme, National Agriculture Innovation Fund (NAIF), Component-II: Establishment of Agri-Business Incubation (ABI) Centers	R.H. Laxman	NAIF, ICAR
Enhancing Decomposition Rate and Quality of Bio-Waste through Microbial Consortia for Improving Soil Health	G. Selvakumar (CC-PI)	NASF (National Agricultural Science Fund)
Effective Delivery of Nutrients, Insecticides and Fungicides through Nanoparticulates and its Effect on Uptake and Yield in Groundnut and Chilli	Satisha, G.C. (CC-PI)	NASF
Imparting PRSV Resistance in Papaya by CRISPR-Cas-Mediated Genome Editing and Tilling	M. Krishna Reddy	NASF
Validation and Promotion of Sustainable and Adaptable IPM Technology for Brinjal Crop	V. Sridhar	NCIPM,New Delhi
Training on “Conservation and Cultivation of Medicinal Plants”	Smitha, G.R.	NMPB
Utilization of Pomegranate for Development of Functional Medicinal Ingredients	Debi Sharma (CC-PI)	NMPB
Collection, Characterization and Genetic Improvement of *Eclipta alb*	K. Hima Bindu	NMPB

Projects Title	PI/ CC-PI	Funding Agency
Development of Model Nursery for Highly Traded/ RET Medicinal & Aromatic Crops (National Mission on Medicinal Crops)	K. Hima Bindu (PI)	NMPB
Investigations into Heavy Metal Contamination of Important Medicinal Plants Grown in Wild, in Cultivation, in Raw Drug Materials and in Market Samples in Peninsular India."	L.R. Varalakshmi	NMPB
Species Distribution Modeling and Bioprospecting of Wild Germplasm of *Salacia* species (High Value Anti-Diabetic Plants) across the Western Ghats)	P.E Rajasekharan (Co-PI)	NMPB
Preparation for Plant Variety Protection and DUS Testing through ICAR-SAU System and Conduct of DUS Test on Tomato, Brinjal, Okra and Garden Pea), Cucumber (*Cucumis sativus*), Bottle Gourd (*Lagenaria sinceraria*), Bitter Gourd (*Momordica charantia*), Pumpkin (*Cucurb ta moschata*), Pointed Gourd (*Trichosanthes dioca*), Watermelon and Muskmelon	T.H. Singh	PPV & FRA (Network Project)
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)
Validating Crop Specific DUS Testing Guidelines for Amaranth, Palak and Ridge Gourd	Varalakshmi, B.	PPV & FRA (Network Project)
DUS Testing Centre on Mango	M. Sankaran, Dinesh, M.R.	PPV & FRA
DUS Testing Centre for Papaya and Custard Apple	Vasugi, C. (Papaya), T. Sakthivel (Custard apple)	PPV & FRA (Network Project)
Formulation and Validation of DUS Testing Guidelines for Betelvine (*Piper b tle* L.)	Hima Bindu, K.	PPV & FRA (Network Project)
Establishment of DUS Nodal Centre at IIHR, Bangalore for China Aster Floricultural Crop	Rajiv Kumar	PPV & FRA
Establishment of DUS Nodal Centre at IIHR, Bangalore for Jasmine Floricultural Crop	Sujatha A. Nair	PPV & FRA
DUS Center for Rose and National Rose Repository	Tejaswini	PPV & FRA
DUS Centre for Chrysanthemum	Rajiv Kumar	PPV & FRA
Validation of DUS Testing Guidelines for Marigold	Tejaswini (PI) (Co-Nodal Centre)	PPV & FRA
Establishment of Nodal DUS Center at IIHR, Bangalore for Tuberose and Carnation Floriculture Crop	Usha Bharathi (PI)	PPV & FRA
Development of DUS Guidelines for Gerbera	C. Aswath	PPV & FRA

Projects Title	PI/ CC-PI	Funding Agency
Development of DUS Testing Guidelines, Characterization and Documentation of Farmer's Varieties in Dolichos Bean (*Lablab purpureus* L.)	Raghu, B.R.	PPV & FRA
Formulation and Validation of DUS Testing Guidelines for Curry Leaf (*Murraya koenigii* Spreng)	Raghu, B.R. (PI)	PPV & FRA
Establishment of Live Crop Cafetaria and Organizing Karnataka State Horticultural Farmers Conclave at ICAR-IIHR, Bengaluru	M.V. Dhananjaya	RKVY, Dept. of Hort., GoK
Development of Vertical Farming Technology of Orchids to Increase the Productivity and Farmers' Income	Sujatha A. Nair	RKVY, Dept. of Hort., GoK
Development of Yellow Vein Mosaic Virus (YVMV) Tolerant Okra Cultivars using Marker Assisted Selection	Ravishankar, K.V.	RKVY, Dept. of Hort., GoK
Strengthening the Farmers on Adoption of Improved Horticultural Technologies, through Digital Documentaries (ICT) in Karnataka State	B. Narayanaswamy	RKVY, Dept. of Hort., GoK
Establishment of a Post-Harvest cum Quality Analysis Laboratory for Enhancing Market Value of Fruits	Kundan Kishore (PI)	RKVY, Govt. of Odisha
Establishment of a Virus Indexing Laboratory for Horticultural Industry in Odisha	G Sangeetha	RKVY, Govt. of Odisha

8.5. Linkages with other ICAR Institutions and Private Companies

- Dr. Sujatha A. Nair collaborated in the projects entitled "Effect of Inorganic Nutrients on Growth and Flowering of Orchids", and "Collection, Conservation and Domestication of Native Orchids of Western Ghats" with NRC for Orchids (CHES, Chetalli)
- Dr. Shamina Azeez was associated in the Contract Research on 'Development of Guar Gum Based Products and Processes', with PS & S Agri-Culture Pvt. Ltd., Tumkur, Karnataka, (FSSAI license number L18041952222347)
- Dr. Vageeshbabu S. Hanur was in technical collaboration between ICAR-IIHR and ICFRE-Institute of Wood Science & Technology, Bengaluru, on the biotechnology of sandalwood (*Santalum album* L.)

9. Publications

9.1 Research Papers

1. Amarjeet Kumar Rai, Basavaraj YB, Sadashiva AT, Krishna Reddy M, Ravishankar KV, Zakir Hussain, Venugopalan R, Madhavi Reddy K. (2020). Evaluation of tomato genotypes for resistance to bud necrosis disease caused by groundnut bud necrosis virus (GBNV). *Crop Protection*. **131**:1-8.

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7. Ananda Murthy HC, Nair AK, Kalaivanan D, Anjanappa M, Shankara Hebbar S and Laxman RH. (2020). Effect of fertigation on yield, fertilizer use efficiency and economics in hybrid ridge gourd. *International Research Journal of Pure & Applied Chemistry*. **21**(16): 38-44. DOI: 10.9734/IRJPAC/2020/v21i1630258.

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9.6. Technical Bulletins/ Folders

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5. Senthilkumar R, Tripathi PC and Sankar V. (2020). Black Pepper Cultivation. Guide on Training cum Exposure Visit on ICAR-IIHR Technologies Suitable for Spices, February 5-8, 2020 at ICAR-IIHR, Bangalore, pp: 18-29.

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10. Tripathi PC, Senthilkumar R and Doreyapagowda (2020). Status, Prospects and Future of Garcinia Culivation. Guide on Training cum Exposure Visit on ICAR-IIHR Technologies Suitable for Spices, February 5-8, 2020 at ICAR-IIHR, Bangalore, pp: 7-16.

9.8. E-publications

1. Carolin Rathinakumari, Kalaivanan D, Smitha GR and Senthil Kumaran G. (2020). Vertical Garden - Grow What You Want & Eat What You Grow. e- Manual on 'Terrace Gardening' during One day workshop on Terrace Garden February 5-8, 2020.

2. Smitha GR and Kalaivanan D. (2020). Achieving Health and Nutritional Security of the Household by Growing Herbs in Terrace Garden. e- Manual on 'Terrace Gardening' during One day workshop on Terrace Garden February 5-8, 2020.

3. Sujatha Nair and Smitha GR. (2020). Orchids and Medicinal Plants. e- Manual on 'Terrace Gardening' during One day workshop on Terrace Garden February 5-8, 2020.

10. Research Projects

DIVISION OF FRUIT CROPS

HORTIIHRCIL2015 (Common for all the projects)

010: Genetic improvement of fruit crops for improved productivity, quality and resistance to biotic and abiotic stresses

Project Leader: P.C Tripathi

Sub-Projects & PIs

010(1): Improvement of mango for yield and quality. M. Sankaran

010(2): Improvement of sapota and jamun for yield and quality. P.C Tripathi (w.e.f. 20.3.2020); A. Rekha (Till 20.3.2020)

010(5): Breeding papaya for PRSV tolerance. C. Vasugi

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

010(9): Rootstock and mildew resistance breeding in grapes. Linta Vincent

010(11): Improvement of annona for yield and quality. T. Sakthivel

010(12): Improvement of pummelo and grapefruit for yield and quality. M. Sankaran

010(13-H): Characterization of jackfruit accessions for vegetable and table purposes. G. Karunakaran

010(14): Studies on polyembryony in mango. Reju M. Kurian

010(15): Integrated Disease management for the pomegranate bacterial blight caused by *Xanthomonas axonopodis* pv *punicae*. Linta Vincent

010(16): Collection and characterization of tamarind (*Tamarindus indica* L.) for development of diversity maps. Kanupriya

010(17): Evaluation of under-utilized fruits for yield, quality and adaptability. Anuradha Sane

011: Development and refinement of production technology of fruit crops

Project Leader: Reju M. Kurian

Sub-Projects & PIs

011(3): Exploitation of stock-scion interactions (Mango, annona, jackfruit, fig and grapes). Reju M. Kurian

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

011(5): Fruit based mixed cropping systems (Sapota). B.L. Manjunath

010(6-H): Performance of dragon fruit (*Hylocereus* sp.) cultivars under different training systems in open as well as shade net condition. G. Karunakaran

011(7): Standardization of vegetative propagation techniques in papaya (*Carica papaya* L.) under tropical climatic conditions of Southern India. J. Satisha

011(8): Performance evaluation of guava hybrid Arka Poorna propagules to mineral and organic nutrient sources under high density planting. P.L. Anushma

011(9): Studies on effect of cane, leaf and flower regulation on quality of colour grapes. J. Satisha

011(10): Integrated resource management module for different high density planting systems in mango. S. Sujatha

011(11): Canopy architecture management in pomegranate and guava. Anjani Kumar Jha

011(12): Management of papaya (var. Arka Prabhath) rhizosphere for quality fruit production. Priya Devi

DIVISION OF VEGETABLE CROPS

020: Genetic improvement of vegetable crops for improved productivity, quality and resistance to biotic and abiotic stresses.

Project Leader: K. Madhavi Reddy (w.e.f. 31 July 2020); R. Veere Gowda (Up to 31 July 2020)

Sub-Projects & PIs

020(1): Breeding tomato for resistance to biotic and abiotic stresses and gene pyramiding for ToLCV resistance through MAS. H.C. Prasanna

020(2): Breeding for biotic and abiotic stress resistance and diversification of male sterile lines in chilli (*Capsicum annuum* L.**).** K. Madhavi Reddy

020(3): Breeding brinjal for resistance to bacterial wilt with high yield and quality attributes through marker-assisted selection (MAS). T.H. Singh

020(4): Breeding cucurbitaceous crops (watermelon and muskmelon) for yield & resistance to biotic stresses through marker assisted selection (MAS). E. Sreenivasa Rao

020(5): Breeding okra varieties/hybrids for yield, quality & resistance to biotic stresses through marker-assisted selection (MAS). M. Pitchaimuthu

020(6): Breeding garden pea, French bean and cowpea for resistance to biotic and abiotic stresses through marker-assisted selection (MAS). T.S. Aghora

020(7): Breeding Dolichos and vegetable soybean for resistance to biotic and abiotic stresses through marker-assisted selection (MAS). M. Thangam (w.e.f. 11.9.2020); B.R. Raghu (Up to 11.9.2020)

020(8): Breeding onion for resistance to biotic and abiotic stresses with high bulb yield and quality attributes through marker-assisted selection (MAS). B.R Raghu (w.e.f. 31.07.2020); R. Veere Gowda (Up to 31.07.2020)

020(9): Breeding tropical carrot and radish for yield, quality and resistance to biotic and abotic stresses. K. Padmini (w.e.f. 31.07.2020); R. Veere Gowda (Up to 31.07.2020)

020(11): Breeding ridge gourd and bitter gourd for resistance to biotic stresses integrating maker assisted selection (MAS). B. Varalakshmi

020(12): Breeding cucumber varieties/ hybrids and gherkins for resistance to biotic stresses through marker assisted selection. L.K. Bharathi (w.e.f. 11.09.2020); M. Pitchaimuthu (Up to 11.09.2020)

020(13): Breeding cluster bean (*Cyamopsis tetragonoloba*s L.) for yield, quality and resistance to biotic stresses. Smaranika Mishra

020(15): Breeding ash gourd and bottle gourd for yield, quality and resistance to biotic stresses. M.V. Dhananjaya

020(16): Breeding bell pepper (*Capsicum annuum* L. var. *grossum*) for yield, quality, biotic and abiotic stress tolerance through marker assisted selection. Smaranika Mishra

020(18): Restoration of fertility in interspecific F_1 hybrid between *Solanum melongena* and *Solanum macrocarpon*. K. Padmini

020(19): Breeding varieties/ hybrids for high yield of leaf and pods with high quality in drumstick (*Moringa oleifera* L.). Raja Shankar

020(20): Breeding curry leaf (*Murraya koenigii* (L.) Spreng) for high leaf yield, quality traits and resistance to biotic stresses. B.R. Raghu

020(22): Breeding pumpkin and summer squash for yield, quality and resistance to biotic stresses. Raja Shankar

020(23): Breeding for abiotic stress tolerance in hot pepper (*Capsicum annuum* L.) through marker assisted selection. Ponnam Naresh (w.e.f 13.11.2020)

021: Development and refinement of production technology of vegetable crops.

Project Leader: S.S. Hebbar

Sub-Projects & PIs

021(1): Water management and rainfed production in vegetable crops. Anil Kumar Nair

021(2): Organic farming in vegetable crops. Anil Kumar Nair (w.e.f. 11.09.2020); M. Senthikumar (Up to 11.09.2020)

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

021(4): Grafting studies in fruit vegetables for overcoming biotic and abiotic stresses. M. Senthikumar

022: Development and refinement of efficient seed production and plant propagation technologies in key horticultural crops.

Project Leader: H.S. Yogeesha

022(1): Ultra low and low moisture drying as a cost effective technique to extend seed longevity of horticultural crops under ambient storage. H.S. Yogeesha

DIVISION OF FLOWER & MEDICINAL CROPS

030: Genetic improvement of ornamental crops for improved productivity, quality and resistance to biotic and abiotic stresses.

Project Leader: Tejaswini

Sub-Projects & PIs

030(1): Genetic improvement of tuberose for high concrete yield and resistance to nematode. T. Usha Bharathi

030(2): Genetic improvement of gladiolus for quality and resistance to biotic stresses. Usha Bharathi

030(3): Genetic improvement of rose and marigold for flower and biochemical components. Tejaswini

030(4): Breeding *Dianthus* species (Carnations, Pinks and Sweet Williams) for quality. T. Usha Bharathi

030(5): Breeding gerbera, crossandra, & dahlia for quality & higher yield. C. Aswath

030(6): Breeding chrysanthemum and China aster for quality. Rajiv Kumar

031: Development and refinement of production technology of ornamental crops

Project Leader: Sujatha A. Nair

Sub-Projects & PIs

031(3): Enhancing water and nutrient use efficiency in flower crops under open field (chrysanthemum, crossandra) and protected (gerbera) cultivation. Sujatha A. Nair

031(5): Standardization of precision production technologies in flower crops (marigold, gladiolus and China aster). H.P. Sumangala

031(6): Optimization of resource use for rose under open and protected conditions. S. Sujatha

031(7): Standardization of media, evaluation of suitable plant species and nutrient module for vertical landscapes. H.P. Sumangala

031(8): Eco-friendly pot culture of flowering ornamentals. G.R. Smitha

031(9): Standardization of production protocols for chrysanthemum varieties suitable for protected cultivation. Safeena. S.A

032: Genetic improvement of Medicinal Crops

Project Leader: K. Hima Bindu

Sub-Projects & PIs

032(3): Genetic amelioration of Kalmegh (*Andrographis paniculata* Nees) for yield and quality. K. Hima Bindu

032(4): Genetic Improvement of *Centella asiatica* by polyploidy breeding. Rohini, M.R.

032(5): Augmentation, characterization and conservation of land races and wild relatives of selected horticultural crops (Vegetables - *Solanum* wild gene pool, *Momordica* species; Fruits – mango, pomegranate and custard apple). P.E. Rajasekharan

032(6): Breeding of Gymnema (*Gymnema sylvestre* R.Br.) for biomass and high gymnemic acid content. M.R Rohini

032(7): Assessment of intraspecific variability and genetic improvement of Brahmi (*Bacopa monnieri* (L) Wettst). K. Himabindu

032(8): Development of cryopreservation protocols for wild relatives and resistant genotypes of horticultural crops. P.E Rajasekharan

DIVISION OF POST HARVEST TECHNOLOGY & AGRICULTURAL ENGINEERING

042: Development of sustainable technologies for post-harvest management, processing and waste utilization

Project Leader: C.K. Narayana

Sub-Projects & PIs

042(1): Development of storage protocols for extending the marketable period of fruits (mango, guava, fig and jamun) and vegetables (muskmelon, drumstick, brinjal and bottle gourd). D.V. Sudhakar Rao

042(2): Protocol development to enhance shelf life and maintain quality in fresh- cut fruits**.** K. Ranjitha

042(3): Development of bio composite packages from horticultural wastes. S. Bhuvaneswari

042(4): Development of dehydrated products using alternate sweeteners, protein fortified and millet incorporated fruit bars from fruits and vegetables (mango, papaya, guava, pineapple, aonla and carrot). R.B. Tiwari

042(5): Process optimization for development of probiotic fruit drinks (pomegranate, jamun) and dehydrated fruit products. K. Ranjitha

042(6): Value addition to fruit and vegetable wastes (jackfruit & pumpkin). C.K. Narayana

042(7): Value added products from bitter gourd and avocado fruits. I.N. Doreyappa Gowda (Concluded on 31.3.2020)

042(8): Development of nutritional fruit beverages (mango/guava/ pomegranate) through incorporation of millets and *Centella asiatica.* Pushpa Chethan Kumar

042(9): Development of composite edible coating formulations for mango and capsicum. Vijaya Rakesh Reddy

041: Development of machinery for production and processing of horticultural crops

Project Leader: G. Senthil Kumaran

Sub-Projects & PIs

041(3): Development of tractor operated seeder and seedling transplanter for chilli. G. Senthil Kumaran

041(4): Design and development of precision machinery for guava, grapes, onion and pineapple. Carolin Rathinakumari, A. (Guava, grapes & onion), S. Bhuvaneswari (Pineapple)

DIVISION OF CROP PROTECTION

050: Diagnostics and integrated management of viral

diseases of tropical horticultural crops.

Project Leader: M. Krishna Reddy

Sub-Projects & PIs

050(4): Development of quick detection methods and vector host interaction of *Phytoplasmas* causing big bud disease of tomato and little leaf of brinjal. D.K. Samuel

050(5): Diagnosis and management of viral diseases of cucurbitaceous crops. B. Mahesha

050(6): Diagnosis, epidemiology and integrated management of vector borne viruse diseases of horticultural crops (bitter gourd, chilli, capsicum, tomato and papaya). M. Krishna Reddy

050(7): Integrated approaches for the management of papaya ring spot virus in papaya. M. Krishna Reddy

050(8): Development of integrated diagnostic and management strategies for viral diseases of lilium and gladiolus. D.K. Samuel

051: Integrated management of fungal and bacterial diseases of tropical horticultural crops.

Project Leader: Dr. S. Sriram

Sub-Projects & PIs

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

051(9): Epidemiology and management of *Phytophthora* leaf blight and fruit rot in hot and sweet pepper (*Capsicum annum* L.). G.M. Sandeep Kumar

051(10): Identification and integrated disease management of bacterial leaf spot of tomato and chilli. D.K. Samuel

051(11): Host-pathogen interaction and management of wilt diseases of ornamental crops (crossandra, gladilous and carnation). Priti Sonavane

051(12): Development of forewarning models for the blossom blight and hoppers in mango. S. Sriram

053: Genetic improvement and development of production and utilization technology of tropical mushrooms

Project Leader: Meera Pandey

Sub-Projects & PIs

053(2): Standardization of optimum casing material formulation for production of milky mushroom (*Calocyb indica)*. C. Chandrashekhara

053(3): Development of technology for cultivation and value addition of sub-tropical and tropical culinary medicinal mushrooms. Meera Pandey

053(4): Standardization of liquid spawn production technology. C. Chandrashekhar

060: Integrated Insect pest management in tropical horticultural crops

Project Leader: Shivaram Bhat (w.e.f. 9.9.2020); K. Gopalkrishna Pillai (Up to 17.8.2020)

Sub-Projects & PIs

060(9): Current scenario of arthropod diversity of drumstick (*Moringa oleifera* L.) and management of major pests. Prasannakumar, N.R.

060(11): Ecologically mediated interactions of host plants – Mealy bugs – Natural enemies in fruit crops. B.R. Jayanthi Mala

060(13): Feasibility of enhancing fruit set in Annona (cv. Arka Sahan) and polyhouse grown cucurbits through insect pollinators. P.V.R. Reddy

060(14): Bioecology and integrated management of South American tomato moth, *Tuta ab oluta* (Meyrick 1917). V. Sridhar

060(15): Studies on the invasive whitefly *Aleurothrixes trachoides* (Back) (Hemiptera: Aleyrodidae), in India and development of management strategies. K. Gopalkrishna Pillai (Concluded 31.3.2020)

060(16): Bio-ecology and sustainable management of borers in fruit crop ecosystems with special reference to mango and guava. P.V.R. Reddy

060(17): Monitoring of fall armyworm, *Spodoptera frugiperda* (J.E Smith) and associated natural enemies in Horticultural crops from South India. V. Sridhar

060(18): Evaluation of actinobacteria for pesticidal activity against pests of vegetable crops. T.K. Radha

060(19): Exploration of lesser known botanicals for insect pest management. Prasannakumar, N.R.

060(20): Interventions for management of tea mosquito bug (*Helopeltis antonii*) in guava, annona and drumstick). B.R. Jayanthi Mala

060(21): Dynamics of sucking pests and their management in bell pepper (*Capsicum annum*) and gerbera (Gerbera jamesonni) under protected conditions. V. Sridhar

063: Integrated Nematode Management in tropical horticultural crops.

Project Leader: R. Umamaheshwari

Sub-Projects & PIs

063(4): Exploring nematode host interaction and developing integrated nematode management modules in Horticultural crops (guava, brinjal, cucumber etc.). R. Umamaheshwari

DIVISION OF BASIC SCIENCES

070: Understanding the physiological and biochemical mechanism and their application for improving productivity and quality of mandate horticultural crops

Project Leader: K. S. Shivashankara

Sub-Projects & PIs

070(8): Physiological interventions to induce early and regular flowering in Alphonso mango. K.K. Upreti (w.e.f. 1.8.2020)

070(11): Assessment of floral metabolite profiles and their influence on fruit set in mango. K.S. Shivashankara

070(12): Pesticide residue studies in fruits and related environment. Soudamini Mohapatra (Concluded 31.3.2020)

070(14): Effect of processing on pesticide residues in horticultural commodities. Partha P. Choudhury

070(15): Investigations on salinity tolerance mechanism in guava genotypes/ species. K.K. Upreti

070(16): Evaluation of factors affecting uptake of persistent pesticides in vegetables. Debi Sharma

070(17): Studies on root characteristics of *Capsicum* species for enhancing water stress tolerance. R.H. Laxman

070(18): Understanding the biochemical and molecular mechanisms of flowering in mango. Shamina Azeez

070(19): Biochemical basis of rust (*Uromyces phaseoli* Reben Wint.) resistance in French bean (*Phaseolus vulgaris* L.). M. Arivalagan

070(20): Seed pre-treatments and abiotic stress tolerance (water and high temperature) in chilli. K. Bhanuprakash

070(21): Studies on role of bioagents in excess and deficit moisture stress management in onion. Preethi Singh

070(22): Physiological understanding and mitigation of irregular fruit shape and size in selected jackfruit (*Artocarpus heterophyllus* Lam.) accessions. Sridhar Gutam

070(23): Extraction, evaluation and characterization of insecticidal compounds from Annona seeds. V. Keshava Rao

070(24): Identification of rootstocks for imparting moisture stress tolerance in cucumber and bottle gourd. K.V Ramesh

110: Development, refinement and use of biotechnological approaches for horticultural crop improvement and production

Project Leader: R. Asokan

Sub-Projects & PIs

110(18): Tilling in papaya for enhancing shelf life (Arka Prabhath). H.S. Vageeshbabu

110(19): Identification of elite germplasm line/s for multi-traits by using tightly linked molecular markers in chilli. D.C. Lakshman Reddy

110(21): Micro propagation and field-evaluation of PRSV tolerant papaya of Intergeneric lineage. P. Nandeesha

110(22): Molecular analysis and mode of action of microbial inoculants (MIs) employed for enhancing plant growth and imparting tolerance to biotic stress. K.V. Ravishankar

110(23): Transmission and molecular interaction and management of leaf hopper vectors in reduction of Aster yellows in China aster, chrysanthemum and marigold. R. Asokan

110(24): Biotechnological interventions for inducing rooting in cuttings of certain fruit crops. H.S. Vageeshbabu

110(25): Genome editing of recessive resistance eIF4 genes in chilli for potyvirus resistance. M. Manamohan

110(26): *In vitro* mutagenesis of guava for *Fusarium* wilt resistance. T.R. Usha Rani

110(27): Hybrid embryo rescue in horticultural crops (focus on grapes). P. Nandeesha

110(28): dsRNA-based management of *Colletotrichum gloeosporioides* involved in Anthracnose of Mango. Basavaprabhu L. Patil

110(29): Development of EST-SSRs in *Moringa* and *Murraya*. Poornima K.N

110(30): Development of double haploids in vegetable crops. Poornima K.N

110(31): Exploitation of double haploid technology in fruit crops (papaya, guava and pomegranate). H.S.

Vageesh Babu

161: Application of Bioinformatics in target gene validation for genome engineering of some important insect pests of horticultural crops. R. Asokan (CABin Scheme)

DIVISION OF NATURAL RESOURCES

080: Soil, nutrient and water management in horticultural crops and cropping systems

Project Leader: H.B. Raghupathi

Sub-Projects & PIs

080(1): Micronutrient related constraints in fruit and vegetable crops for correcting nutrient imbalances. G.C. Satisha

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

080(7): Development of nutrient management module for guava under high density planting system. T.R. Rupa

080(8): Nutrient uptake studies in rootstocks of certain fruit crops. T.N. Shivananda

080(9): Influence of rootstock and scion combinations on nutrient acquisition and nutrient utilization efficiency in Solanaceous vegetable crops. H.B. Raghupathi

080(10): Identification of suitable rose rootstocks for tolerating bicarbonate toxicity (high pH) and salinity for poly houses and open field conditions. L.R Varalaksmi (w.e.f. 11.8.2020)

080(11): Standardization of zinc requirement of vegetable crops/ cropping systems for sustainable production. S. Rajendiran

080(12): Apprising soil organic matter regime of different horticultural ecosystems for sustaining crop production. T.N. Shivananda

080(13): Engineered nanoscale nutrient: Synthesis, characterization and their effect on some vegetable crops. G.C Satisha

08(14): Efficiency of green manures on nutrient dynamics in vegetable cropping systems. R. Ramachandra.

08(15): Studying micronutrient constraints and development of foliar formulations in commercial flower crops. Chethan Kumar. G

081: Addressing soil health and environmental safety in horticultural crops and cropping systems

Project Leader: G. Selvakumar

Sub-Projects & PIs

081(9): Development of Actinobacterial liquid inoculants for growth promotion, nutrient and health management in pomegranate. T.K. Radha

081(11): Anhydrobiotic engineering of efficient plant growth promoting Rhizobacterial strains for production of bio-encapsulated vegetable seeds. G. Selvakumar

DIVISION OF SOCIAL SCIENCES AND TRAINING

090: Improving knowledge and skill of stakeholders for improving productivity of horticultural crops and impact assessment of adopted technologies

Project Leader: R. Venkatta Kumar

Sub-Projects & PI

090(11): Spread and acceptance of ICAR-IIHR technologies. K. Achala Paripurna

090(12): Assessment of spread, acceptance and profitability of selected fruit crop technologies. R. Senthil Kumar

090(13): A study on feasibility, spread, acceptance and profitability of selected varieties/ hybrids and technologies of ICAR-IIHR. G.A. Atheequlla

090(14): A study on spread and acceptance of ICAR-IIHR released vegetable hybrids in South India. V. Sankar

090(15): Assessment of horticultural based farming system for enhancing profitability of small and marginal farmers. B. Narayanaswamy

090(16): Assessment of spread and acceptance of selected floriculture technologies. T.M. Reddy

090(17): Role of farmers and institutions in marketing of horticultural produces in lockdown period. R. Venkattakumar

090(18): Identification of extension methodologies and strategies suitable for post APMC environment and study on researchable issues and impact of new policy on horticultural crops. B. Balakrishna

091: Development and application of economic, statistical and ICT tools and strategies for improving and assessing productivity of horticultural crops

Project Leader: T.M. Gajanana

Sub-Projects & PIs

091(1): Assessing the socio-economic impact of horticultural technologies on crop diversification, farm income, employment and trade. T.M. Gajanana

091(2): Economics of factor productivity and production efficiency in selected horticultural crops. D. Sreenivasa Murthy

091(3): Development of statistical models for horticultural crops research. R. Venugopalan

091(4): Development of database and program modules for horticultural crops. M. K. Chandra Prakash

091(5): Development of decision support system for horticultural crops. Reena Rosy Thomas

091(6): Emerging marketing models in horticultural crops to link farmers to market. T.M. Gajanana

091(7): Development of epidemiological models for viral diseases in horticultural crops. V. Radhika

091(8): Designing ICT application interface for strengthening horticultural entrepreneurship in marketing of horticultural products and processes. V.K Jayaraghavendra Rao

CENTRAL HORTICULTURAL EXPERIMENT STATION, CHETTALLI

HORTIIHRCIL2015 170: Development, refinement and popularization of cropping system models for improving productivity of horticultural crops in high altitude regions of Western Ghats of India

Project Leader: Saju George

Sub-Projects & PIs

170(9): Diagnosis of viral and viral-like diseases associated with fruits, vegetables and ornamental crops in high humid regions of Western Ghats of India. V. Venkataravanappa

170(10): Harnessing the genetic potential of *Momordica sahyadrica* through wide hybridization. L.K. Bharathi

170(11): Development of integrated nutrient management module for improving yield and quality of Coorg mandarin. L.R. Varalkshmi

170(12): Improvement of Coorg mandarin and avocado through mutation breeding. A.C. Madhav

170(13): Diagnosis and management of major fungal diseases of avocado in high humid tropic regions of Western Ghats of India. V. Venkataravanappa

170(14): Insect pollinator diversity in potential future crops, their foraging behaviour and conservation measures. P. Shivaram Bhat

170(15): Studies on assessment and standardization of nutrient requirements of avocado. S. Rajendiran

CENTRAL HORTICULTURAL EXPERIMENT STATION, BHUBANESWAR

180: Development and refinement of technologies for improving productivity of fruit and vegetable crops in east coast regions of India (Bhubaneswar)

Project Leader: G.C. Acharya

Sub-Projects & PIs

180(1): Collection, evaluation, characterization, conservation and documentation of germplasms of fruit crops of Eastern India. Kundan Kishore

180(5): Collection, evaluation and improvement in Capsicum spp. for desired characters. Ponnam Naresh

180(6): Collection, evaluation and improvement in *Moringa* and leafy vegetables of eastern region for desired characters. G.C. Acharya

180(7): Collection, evaluation and improvement of legume vegetables for desired characters. Meenu Kumari

180(13): Exploiting the potential of CAM fruits in eastern tropical region. Kundan Kishore

180(14): Improving productivity of fruit crops (custard apple and mango) through application of plant growth regulators. Deepa Samant

180(15): Demonstration and study of impact of IIHR technologies in Eastern coastal regions. P. Srinivas

180(16): Etiology of collar and root rot as well as net blight disease of pointed gourd and their management. G. Sangeetha

180(17): Breeding pole type French bean (*Phaseolus vulgaris* L.) resistant to rust with round and stringless pods. Meenu Kumari

180(18): Development of inbred lines and high yielding F1 hybrids of chilli and brinjal suitable for Eastern coastal region market segment having combined resistance to bacterial wilt and root knot nematodes. G.C. Acharya

11. Patents & Commercialization of Technologies

11.1. Patents

Patent Granted

1. Application No. 3817/CHE/2014 (Application date: 08/04/2014) of Dr. G. Selvakumar

Patent No. 342299; Date of grant: 23.07.2020

Title: **"Method for Mass Production of Soil-Less Arbuscular Mycorrhizal Fungal Inoculum"**

2. Application No. 201641001693 (Application date: 18/01/2016) of Dr. Eugene Sebastian.

Patent No.: 353180; Date of Grant: 07.12.2020

Title: **"A Process for the Production of Alkyl Coumarate Concentrate from *Ipomoea Carnea* Subsp. *Fistulosa*"**

Patents filed

Patent Application	Patent Title	Date of Filing	Status
202041023746 Dr. Kamala Jayanthi	A Novel Synergistic Blend Composition of Para-Pheromones for Increasing Male Trap Catches of Multiple Bactrocera Fruit Fly Species (Arka Bactro+)	05.06.2020	Filed
202041029424 Dr. Debi Sharma	Herbiwash for Fruits and Vegetables	10.07.2020	Filed

11.2 Agreements with National Biodiversity Authority (NBA)

- NBA Agreement for access and benefit sharing (Form-III – For filing application for obtaining any Intellectual Property Rights) was signed with National Biodiversity Authority (NBA) with respect to application on invention titled "Iron Fortified Mushroom and Process of Producing There of.
- NBA Agreement for access and benefit sharing (Form-II – For Transfer of Results of Research) with reference to licensing of a) "Arka Nikita", b) "Arka Meghana" and c) "Arka Samrat" to M/s. Ruchi Hi-Rich Seeds Pvt. Ltd., Indore, Madhya Pradesh, for commercial utilization (sale of seeds after multiplication) was signed with National Biodiversity Authority (NBA).

11.3 Technology commercialized and revenue generated during 1 Jan-31 Dec, 2020

Sl No.	Technology Theme Area	No. of licenses	Technologies licensed	Revenue collected at ICAR-IIHR (Rs.)	Revenue collected at Agrinnovate India Limited (Rs.)
1	Post harvest Technology	16	Arka Jackies Arka Jackolate Osmotically Dehydrated Mango, Pineapple, Papaya and Banana Arka Herbiwash RTS Beverage of Pineapple Onion Paste Shrink Wrap for Capsicum Dried Flower Technology Arka Avocado Powder Arka RTS Probiotic Pineapple Beverage	11,59,400	-

2	Farm Implements and Machinery	10	Solar Power Integrated Outdooe mushroom Growing Unit Solar Power Operated Tricycle Cart for Vending Ready to Harvest Fresh Mushrooms Solar Power Operated Tricycle Cart for Fresh Fruits and Vegetables Vending IIHR Fruit and Vegetable Vending Van Arka High Humidity Storage Box Arka Pomegranate Aril Remover Arka Neelachal Mechanized Raw Jackfruit Peeler Arka Lime Harvester	2,79,660	
3	Seed and Planting Material	8	Arka Samrat, Arka Poorna, Arka Agni, Arka Vikram, Arka Rakshak and Arka Meghana	6,38,500	18,88,000
4	Crop Protection Technologies	12	Arka Microbial Consortium (Solid+ Liquid) Arka Banana Micronutrient Formulation Arka Vegetable Micronutrient Formulation Arka Mango Micronutrient Formulation Arka Citrus Micronutrient Formulation Parapheromone Trap for Mango Arka Neem Seed Powder Pellet Formulation Technology	5,92,000	44,84,000
5	Biopesticides	12	IIHR *Trichoderma viride* 1.5% W.P. IIHR *Pseudomonas fluorescens* 1% W.P. IIHR *Verticilium chlamydosporium* 1% W.P. IIHR *Trichoderma harzianum* 1% W.P.	-	27,13,500
Total				**26,69,560**	**90,85,500**

11.4. Number of activities and revenue generated under professional service function (CPC) during 2020

Type of service	Total revenue generated (INR)
Contract Service (Testing)	25,07,569
Contract Research (Paid-up trial)	40,40,442
Consultancy service (Field visit)	2,07,032
Training	31,860
R & D	10,02,000
Total	**77,88,903**

MoU exchanged for Arka Poorna; Licensee - Mr. Pothineni Raja Naga Gowtham

MoU exchanged for Arka Jackolate and Arka Avocado Powder; Licensee - M/S. Unique Victuals

MoU exchanged for RTS Probiotic Pineapple beverage; Licensee- M/S Makers of Mysuru Pvt. Ltd.

12. Major Institute Research Council (IRC) Recommendations

Chairman: Dr. M.R. Dinesh

Members: All scientists of ICAR-IIHR

Member-Secretary: Dr. T.S. Aghora

The 90th IRC meeting was held from 19 Feb to 11 Jun 2020, under the Chairmanship of Dr. M. R. Dinesh, Director, ICAR-IIHR, Bengaluru. The IRC was held in the virtual mode on 21, 22 Apr and 11 Jun 2020 owing to the COVID pandemic. A total of 24 projects, 154 sub-projects and 31 new projects were reviewed, and the technical programs for 2020-21 were approved.

Major recommendations (project wise)

1. Genetic improvement of fruit crops for improved productivity, quality and resistance to biotic and abiotic stresses

- In mango, the anthracnose resistant genotype is to be used in the breeding programme as one of the parents. The sugar profiling of Arka Udaya is to be published
- In jamun, the year round bearing variety from Tumakuru area is to be observed in 2020 for confirmation. A VTIC proposal is to be submitted for release of Seedling Selection-63
- In papaya, no further advancement of F_{10} progenies of Arka Surya x *V. cauliflora* is required as there is no homozygosity for resistance to PRSV. The F_2 population of Arka Prabhath x *V. cauliflora* and Arka Prabhath x *V. cundinamarcensis* is to be evaluated for PRSV resistance. The stable hermaphrodite of F_2BC_1 population of Arka Prabhath x *V. cauliflora* to be evaluated further for PRSV resistance
- In pomegranate, at least 10000 mutant populations of Bhagwa may be raised and screened at nursery level for exploring the possibility of deriving resistant genotype(s). Progenies found resistant to wilt may be used in the scion breeding programme, in addition to rootstock breeding. The biotic stresses especially, wilt and bacterial nodal blight are pressing national problems limiting pomegranate production in the country, so ICAR-IIHR needs to intensify the work for deriving resistant/ tolerant varieties and/or managing them effectively
- In guava 500 plants each of Arka Kiran, Arka Poorna and Arka Rashmi have to be raised on *P. cattleiannum* and this rootstock can be tried for multiplication through cuttings
- *In situ* evaluation and chemical profiling of selected Rudrakshi type jackfruit may be done and the most promising genotypes from Tripura and Kolar may be collected
- In mango, DNA may be extracted from each segment of the kernel of polyembryony to confirm the origin of the embryos
- In tamarind, a diversity map may be prepared and an effort must be made to get the previously published diversity maps by other institutes elsewhere in India
- Wood apple and Rose apple to receive more focus among the documented underutilized fruit crops for enhancing the strength of germplasm. All the indigenous fruit species of Kodagu may be collected and conserved
- The PA-IIIA avocado clone may be proposed for VTIC identification

2. Development and refinement of production technology of fruit crops

- Work on rooting of cuttings of papaya may be intensified
- Cocopeat and nutrient solutions developed by the Division of NRM should be tested for rooting of these cuttings

3. Genetic improvement of vegetable crops for improved productivity, quality and resistance to biotic and abiotic stress

- In tomato, indeterminate hybrids for open and polyhouse cultivation have to be developed
- The released F1 hybrids of chilli need must be evaluated as scions on selected rootstocks and to be compared on their own roots. The promising Bhut jolokia segment F1 hybrid must be evaluated in NE states for yield, pungency and acceptability. Emphasis should be given for the development of indeterminate coloured capsicum lines
- In brinjal, replicated trials of all the advanced breeding lines in different segments (purple round, manjarigota, bottle brinjal etc.) with suitable checks

(private hybrids) are to be conducted. Bottle brinjal lines with green calyx to be developed

- Watermelon lines developed with high carotenoid content should be evaluated on large scale and put up to VTIC. *Fusarium* resistant rootstock may be identified by GAC for NBPGR registration and commercialization
- Varieties/hybrids of okra in pipeline have to be tested in hotspots for virus resistance
- Heat tolerant lines of garden pea to be evaluated during summer at temperatures higher than 38 ^{o}C and demonstrations of released varieties to be taken up outside the state
- Indeterminate types of cluster bean to be developed
- In onion, purple blotch resistant lines are to be tested by artificial screening; and DNA fingerprinting to be done for all tolerant/resistant advanced breeding lines
- Powdery mildew and leaf miner resistance needs to be addressed in ridge gourd
- In bitter gourd, varieties to be developed with less bitterness
- In pumpkin, multiple desirable traits are to be incorporated in a single line
- Suitable genotypes of radish have to be identified separately for root yield and pod yield and parents to be chosen for hybridisation.
- Molecular characterisation of drumstick germplasm and pyramiding of genes for various traits may be initiated.
- Both male and female plants of Arka Neelanchal Shanthi to be supplied to ICAR-IIHR for multiplication
- Artificial screening of field resistant lines against anthracnose and fruit rot has to be taken up at CHES, Bhubaneswar. Few more crops need to be identified based on QRT recommendation

4. Development and refinement of production technology of vegetable crops

- In water management and rain-fed production trial in vegetable crops, water quality status needs to be mentioned in the respective experiments
- In organic farming trial of vegetable crops, Panchagavya can be added as a treatment
- A bacterial wilt susceptible variety should be tried to study the impact of resistant rootstock
- Chilli scion Arka Haritha may be replaced with TLCV resistant hybrids and compared with commercial hybrids
- Standardisation of grafting procedure for watermelon on identified rootstock to be taken up

5. Development and refinement of efficient seed production and plant propagation technologies in key horticultural crops

- Seed storage information generated and compiled so far should be uploaded onto the ICAR-IIHR seed portal

6. Genetic improvement of ornamental crops for improved productivity, quality and resistance to biotic and abiotic stress

- In tuberose, the work should focus on different segments, viz., concrete, loose flower, big flower and cut flower
- Developing white colour gladiolus varieties should be given preference, as all novel colours are already identified
- Large scale planting material multiplication should be done though seed village concept, RFS, KVK's, TSP and SCSP programs
- Suitability of ICAR-IIHR gerbera varieties for vertical gardens may be studied
- For control of thrips, *Metarhizium anisopliae* technology should be demonstrated
- There is a need to develop chrysanthemum varieties suitable for pot culture and garden display. The priority should be to develop photo-insensitive chrysanthemum varieties
- Large scale demonstrations of China aster should be conducted. Substantial area of floriferous China aster varieties should be visible in the Institute landscape. Pseudo ray floret types in China aster should be identified

7. Development and refinement of production technologies of ornamental crops

- Phenophase based nutrient scheduling including bio-formulations and ICAR-IIHR developed bio-formulations can be taken up in gerbera var. Arka Red for open conditions

8. Genetic improvement of Medicinal Crops

- The varietal selections of kalmegh to be proposed for VTIC should be comprehensively different. Demonstrations should be taken up through KVK and video documentation of existing demonstrations

should be done

9. Production, chemistry and related studies on plants of medicinal and agrochemical importance

- Demonstrations on recommendations should be taken up and field days on Brahmi should be conducted

10. Development of sustainable technologies for post-harvest management, processing and waste utilization

- Hot water treatment for Arka Suprabhath and Arka Udaya may be tried
- The technical bulletin on shelf life extension of fruits and vegetables may be sent to ICAR for circulation among the concerned Departments/ Ministries and State Government departments
- Quarantine HWT should be standardized for Alphonso mango as the present hot water is causing internal breakdown
- Sealability of biopolymer films can be tried by using some edible or other gum materials
- Vacuum frying of okra may be initiated once the vacuum frying machine is procured
- Coloured seedless grapes, black and red carrots and jamun Selection-45 can be tried for preparation of probiotic juices
- Jackfruit selections Siddhu and Shankara should be tried for various products and profiling of the products may be worked out

11. Development of machinery for production and processing of horticultural crops

- Chilli harvester has to be tried
- Vegetable grafting machine should be readied on priority
- Priority should be given for combining Fertreedrill with pruning equipment and guava pruning machine this year

12. Diagnostics and integrated management of viral diseases of tropical horticultural crops

- Screening of tomato and gerbera germplasm against big bud disease to be taken up in the respective breeding projects
- Treatments of cucumber virus management have to be revised in consultation with entomologists
- Sap inoculation techniques needs to be standardized for *Polerovirus* and *Begomovirus* in cucurbits
- Extent of incidence and loss due to the virus diseases to be reported and the extent of reduction in loss due to IDM should be worked out
- The prediction model for Chilli Leaf Vein Mosaic Virus has to be generated. Possibility of developing a dip stick method for quick detection of viruses to be explored.
- Part of the CRISPR/Cas-9 work on papaya will be carried out in new National Fund Project

13. Integrated management of fungal and bacterial diseases of tropical horticultural crops

- The borer management in mango may be taken up in at least two North Indian states
- Screening of tomato for bacterial leaf spot and aster for phytoplasmas will be carried out in breeding projects

14. Genetic improvement and development of production and utilization technology of tropical mushrooms

- Besides developing mushroom products and conducting trainings, there is also need for working on mushroom improvement
- Antioxidant properties of *Macrocyb gigantea* (new strain) has to be estimated and its nutrient profile has to be compared with *Pleurotus* mushroom

15. Integrated Insect pest management in tropical horticultural crops

- More number of mango rootstock varieties need to be evaluated for their resistance to stem borer
- Efficacy of bio-pesticides should be adequately established on at least 2-3 crops before proposing for registration as the process is very expensive
- Neem and pongamia products of ICAR-IIHR should be used as standard check to compare efficacy of new botanical pesticides
- LCV resistant hybrids of chilli need to be tested for leaf curl incidence
- Incidence of tea mosquito bug may be checked on scab affected avocado fruit

16. Integrated Nematode Management in tropical horticultural crops

- The decline in nematode population has to be monitored over time after incorporation of *Mucuna*

17. Understanding the physiological and biochemical mechanism and their application for improving productivity and quality of mandate horticultural crops

- Hot water treatment can be standardized for moringa, curry leaves (before powdering) to decrease the pesticide residue levels
- A basket centrifuge may be used to get the required agitation to check the efficiency of Veggi-Wash
- Uric acid levels to be estimated in the rust resistant lines
- The epicuticular wax profile and lignin content can be correlated with rust resistance mechanisms

18. Soil, nutrient and water management in horticultural crops and cropping systems

- The nutrient solution that has been developed can be tried under both protected and open field conditions
- The nutrient uptake of guava Arka Poorna grafted on *P. catlianum* has to be analyzed. The nutrient requirement of the grafted plants has to be worked out
- Grafting work may be initiated in chilli on chilli root stock and capsicum on chilli

19. Improving knowledge and skill of stakeholders for improving productivity of horticultural crops and impact assessment of adopted technologies

- The concept proposed for effective functioning of FPO's should be communicated to SFAC and Dept. of Horticulture
- A consolidated report of NER demonstration trials to be prepared and uploaded to website and sent to Council

20. Addressing soil health and environmental safety in horticultural crops and cropping systems

- The superiority of the developed consortium over the existing Arka Microbial Consortium and Arka Actino-Plus has to be clearly established. The efficiency of individual isolates used in the consortium can be established
- The formulation has to be tried in wilt sick plots/ cement rings

21. Improving knowledge and skill of stakeholders for improving productivity of horticultural crops and impact assessment of adopted technologies

- Data from NEH and other regions needs to be compared and the report compiled
- Based on the information generated in the project, feedback to improve ICAR-IIHR technologies should be conveyed to innovators
- A segment wise analysis of vegetable varieties should be made.

22. Development and application of economic, statistical and ICT tools and strategies for improving and assessing productivity of horticultural crops

- Multi-dimensional scaling approach may be used for grouping of genotypes while performing crop stability analysis
- More crops from AICRP (VC) can be included for stability analysis, carried out based on ICAR-IIHR data with the available methods
- The video modules in the developed app are to be linked to Bagwani app. Information regarding the app to be communicated to DG, ICAR
- Information on licensees who have taken IIHR technologies and commercialized to be added in the app
- Regional language and Hindi apps are to be developed
- The IIHR seed portal is to be linked to these applications
- A Decision Support System (DSS) is to be included with solutions to crop protection aspects

23. Development, refinement and use of biotechnological approaches for horticultural crop improvement and production

- Powdery mildew resistance for capsicum needs to be screened with markers. Molecular markers for fungal diseases like *Cercospora* may be identified
- Since pungency is a polygenic character, QTL analysis may be carried out in conjunction with markers
- Resistant breeding lines identified through molecular markers to be tested and used in breeding program especially for nematode resistance
- Aster yellows (phytoplasma generated) to be studied in China aster. Among the hoppers, the species causing more economical damage must be identified in the selected crops.

13. Presentation of Papers in Conferences, Seminars, Symposia etc.

Indian Science Congress, January 3-7, 2020, UAS, GKVK, Bengaluru

- Laxman RH - Visual imaging technique for assessing response of *Capsicum* species to water stress.

Webinar on "Entrepreneurship Orientation Program on Medicinal and Aromatic Plants", January 8, 2021, ICAR-DMAPR, Boriavi, Gujarat, India.

- Kalaivanan D - Soilless culture of medicinal and aromatic plants.

Indian Horticulture Summit-2020, February, 14-15, 2020, Mahatma Gandhi Chitrakoot Gramodya Vishwavidyalaya, Chitrakoot, MP

- Tripathi PC, Senthilkumar R, Kalaivanan D, Reddy PVR, Anil Kumar Nair, Sathisha J, Rajiv Kumar, Venkattakumar R, Dhananjaya, Vishwanath and Mallikarjuna - Success stories of ICAR- IIHR technologies at famers field in Bhoo-samrudhi districts of Karnataka

VIROCON-2020, February, 18-20, 2020, INSA, New Delhi

- Baskar S, Latha TKS, Karthikeyan G, Sutha M and Patil BL - Variability of pigeonpea sterility mosaic emaravirus in Tamil Nadu state.
- Patil BL - The evolution and emergence of emaraviruses: Pigeonpea sterility mosaic emaraviruses as classic examples.

International Conference on Banana 2020: Innovations in sustainable production and value chain management in banana," February 22-25, 2020, ICAR-National Research Centre for Banana, Tiruchirappalli; Society for Promotion of Horticulture, Bangalore and Alliance Bioversity International-CIAT

- Laxman RH - Phenotyping techniques for assessment of abiotic stress tolerance in banana.
- Megha HS, Rekha A, Laxman RH, Shivashankara KS and Ravishankar KV - Role of banana leaf cuticular wax in drought tolerance: Composition and regulation of its biosynthesis.
- Patil P - Networking for Banana Improvement and Sustainable Production.
- Sangeetha Ganesan, Hari Shankar Singh, Srinivas Petikam and Gobind Ch Acharya - Blast/pitting disease of banana: Current state of Knowledge and management strategies.

International Seminar on "Transboundary pest management", March, 4-5, 2020, TNAU Coimbatore

- Usharani TR, Anjali PC, Sowmya HD and Rajabaskar D - Molecular identification of viruliferous thrips in watermelon- WBNV -pathosystem.

National Webcon on Agricultural Production & support system managing Covid 19 pandemic: Experience sharing & Strategies," May 6-8, 2020, Chandra Shekhar Azad University of Agriculture & Technology, U.P.

- Safeena SA, Shilpashree KG, Tarak Nath Saha, Naveen Kumar P and Prasad KV - Vertical Gardening: An Efficient Strategy to overcome stress during situations like Covid 19 pandemic.
- Tarak Nath Saha, Safeena SA, Naveen Kumar P, Raju DVS, Ganesh B. Kadam, Prashant G. Kawar, Shilpashree and Prasad KV - Essential oils from flower crops.

Webinar on Innovations during COVID 19 period," May 13, 2020, CCS-NIAM, Jaipur and ICAR-IIHR, Bengaluru.

- Gajanana TM - Innovations and good practices for marketing of fruits and vegetables during COVID-19.

National Webinar on Importance of Native Trees and Plants for Landscape Professionals - An Opportunity for Indian Nurserymen," May 23, 2020, Floriculture Today, Media Today Group, New delhi.

- Sumangala HP - Emerging Role of Indigenous Plants Varieties in Nursery Industry and Landscaping.

National Webinar on Harnessing the Potential of Indigenous Ornamentals: Post Covid 19 Pandemic," June 18, 2020, The Horticultural Sciences Division, ICAR, New Delhi and ICAR-DFR, Pune.

- Prasad KV and Safeena SA - Research and development efforts in indigenous ornamentals in India.

International Web-Conference on New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development (NTAEBSID-2020), June 21-22, 2020, Agro Environmental Development Society, Rampur, U.P.

- Kanupriya, Karunakaran G, Pritee Singh and Venugopalan R - Harnessing tamarind diversity for improving rural livelihood.

Webinar on Bioprospection: Synthesis of novel biomolecules and their patents," July 1, 2020, Jyotinivas college, Bengaluru.

- Aswath C - Use of Bio-reactors for Production of Secondary Metabolites.

Webinar on Entrepreneurship Orientation Program on Medicinal & Aromatic Plants" August 24, 2020, ICAR-DMAPR in association with Medi-Hub TBI.

- Smitha GR - Post-harvest management of High Value Medicinal and Aromatic Plants.

Webinar on Building a Sustainable, Asian Knowledge Commons for Open Science Era," September 9-16, 2020, Seoul, South Korea.

- Gutam S - Open Access in India.

International Web Conference on Food Security through sustainable agriculture (FSSA)," September 21-22, 2020, Shri Vaishnav Institute of Agriculture, Indore, Madhya Pradesh

- Kanupriya, Karunakaran G, Pritee Singh and Venugopalan R - Tamarind for improving rural livelihood security through sustainable integrated farming.

- Pritee Singh and Karunakaran G- Jackfruit for nutritional security and livelihood of rural communities of India.

4th Annual Agri-Biotech India Summit, September 22-23, 2020, Inventicon Business Intelligence, Hyderabad,

- Patil BL - Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas9 system for Indian agribiotech.

Webinar on "Common Medicinal Plants for Immunity Boosting," September 25, 2020, Business Entrepreneurship and Start-up Support through Technology- Horticulture (BESST -HORT), A TBI of ICAR-IIHR, Hesaraghatta.

- Smitha GR - Harvest and Post-harvest management of Medicinal Plants for improving quality.

International Web Conference on Perspective on Agricultural and Applied Sciences in COVID-19 Scenario (PAAS-2020)," October 4-6, 2020, Agricultural & Environmental Technology Development Society (AETDS), U.S. Nagar, Uttarakhand

- Arivalagan M, Karunakaran G, Tapas K Roy, Satisha GC and Shivashankara KS - Biochemical and Nutritional Characterization of Dragon Fruit (*Hylocerous* species).

Virtual International Conference on Advances in Food and Agricultural Science and Technology (VICAFAST-2020)", October 31, 2020, Chemical Science Review and Letters, Salem, Tamil Nadu.

- Safeena SA, Shilpashree KG, Tarak Nath Saha, Naveen Kumar P and Prasad KV- Evaluation of Heliconia - A Speciality ornamental under agro climatic conditions of Maharashtra.

International E-Conference on Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity," November, 24-27, 2020, University of Horticultural Sciences, Bagalkot and College of Horticulture, Bengaluru

- Arivalagan M, Santhosh N and Tejaswini - Marigold germplasm - a potential source for natural polyphenolic compounds and carotenoids with antioxidant potential.

- Bhat NV, Vageeshbabu S. Hanur and Dinesh M - TILLING based molecular mutagenesis for crop improvement of papaya (*Carica papaya* L. cv. ArkaPrabhath).

- Jayashree MJ, Vageeshbabu S. Hanur, Vasugi C. and Manamohan M - Molecular genetic improvement of productivity traits in papaya cv. ArkaPrabhath by TILLING.

- Deepika V and Vageeshbabu S. Hanur - Applications of apomixis and tissue culture technique for development of double haploid lines in papaya (*Carica papaya* L.).

- Mallick B, Meenu Kumari, Pradhan SK, Parmeswaran C, Acharya GC and Naresh P -

Genome wide analysis and characterization of Heat Shock Transcription Factors (*Hsfs*) in common bean (*Phaseolus vulgaris* L.).

- Naveen Kumar VM, Nandeesha P and Vasugi C - *In vitro* hybrid embryo rescue from intergeneric crosses in papaya for papaya ring spot virus resistance.
- Patil BL - miRNA-Induced Gene Silencing (MIGS): for control of multiple pests and pathogens.
- Smitha S and Vageeshbabu S. Hanur - TILLING based molecular mutagenesis and speed breeding in papaya cv. ArkaPrabhath for enhancing the fruit quality and yield traits. Vageeshbabu S. Hanur - Accelerated breeding by TILLING: A Non-GE Dexterity in Biotechnology.

National Webinar on "Urban and Peri-urban Horticulture for Health and Nutrition," November 25, 2020, ICAR-Central Island Agricultural Research Institute, Port Blair.

- Smitha GR - Health and nutritional security through urban and peri-urban horticulture.

Webinar on "Entrepreneurship Orientation Program on Medicinal and Aromatic Plants," December 7, 2020, ICAR-DMAPR, Anand, Gujarat, India.

- Kalaivanan D - Potential of soilless culture/ hydroponic for enterprise development in horticulture vis-à-vis medicinal and aromatic plants.

National Seminar on "Climate Smart agriculture for Enhancing Farm Profitability", January 28-29, 2020, Indian Society of Agronomy, Odisha Chapter and Department of Agronomy, College of Agriculture, OUAT, Bhubaneswar at OUAT, Bhubaneswar.

- Sangeetha Ganesan and Gobind Ch Acharya - Potential Plant Disease Management Strategies under a Changing Climate with an Emphasis on Fruit Crops.

Webinar Series by National Facilitators of CCS NIAM, Jaipur, Rajasthan April 30 to May 23, 2020.

- Jayaraghavendra Rao VK - Unconventional Strategies for reaching Customers during Lockdown Period.
- Innovations and Good practices in marketing of fruits and vegetables.

Webinar on "Strategies to combat recent challenges in Floriculture industry," July 18, 2020, Annamai University, Tamil Nadu.

- Aswath C - Problems and Prospects of Floriculture in India.

14. News and Events

National Horticulture Fair 2020

ICAR-IIHR, Bengaluru, organized a four-day National Horticulture Fair (NHF 2020) from February 5-8, 2020. The theme of the fair was Horticulture: Making Farming an Enterprise. The fair was organized in collaboration with the Society for Promotion of Horticulture, Bengaluru; Department of Horticulture, Government of Karnataka, and Karnataka State Department of Agriculture. It was inaugurated by Dr. Trilochan Mohapatra, Secretary DARE and Director General (DG), ICAR, in the presence of farmers, entrepreneurs, officials of ICAR Institutes, State Agricultural Universities (SAUs), Development Departments, representatives of private industry and the press.

The fair attracted large numbers of farmers for on-farm demonstration of several improved, and disease/ pest resistant varieties of vegetables, fruits, flowers and medicinal crops developed by the Institute. Promising processing tomato cultivars, Arka Apeksha and Arka Vishesh, rust resistant pole type French bean variety, Arka Sukomal and gummy stem blight resistant bottle gourd hybrid, IIHR BGH-10, and technologies for the management of pinworm, *Tuta absoluta*, diamond black moth and aphids in cabbage using neem powder pellets, and integrated disease management in chilli were the new technologies demonstrated.

Demonstration on Mango-based Integrated Farming Systems, Mixed Cropping System, vegetable grafting technology in chilli and tomato, and organic and soilless cultivation of vegetables were the special features of the fair. The polyhouse with cultivation of high value vegetables and ornamental crops was another highlight. Special focus was given on the needs of peri-urban horticulture through daily workshops on terrace gardening organized by the Society for Promotion of Horticulture, ICAR-IIHR, Bengaluru. The two solar-powered tricycles, one for vegetables to reduce post-harvest losses and other for fresh mushroom harvesting, were inaugurated during the fair.

Scientists of ICAR-IIHR through interactions helped provide solutions to farmers in horticulture related problems, information on production technologies, plant protection measures, mushroom cultivation technologies and value addition of horticultural produce. For online sales of vegetable and flower seeds of ICAR-IIHR developed varieties, a web application, 'ICAR-IIHR Seed Portal' was launched during the fair. A trilingual mobile app 'Arka Bagwani' in English, Hindi and Kannada, providing information on varieties and technologies developed by the Institute, success stories, and availability of seeds and planting material, and a technical bulletin containing information about various schemes of the Government of India were also released.

Several ICAR Institutes, development departments, public and private sector organizations and industries set up 268 stalls for exhibition. A highlight of the fair was felicitation of eight farmers from Karnataka, Tamil Nadu, Andhra Pradesh, Mizoram and Odisha by the DG, ICAR, for their contributions in the field of horticulture and popularising the varieties/ technologies of ICAR-IIHR. Prizes for the best exhibitors in the Fair were distributed by Dr. W.S. Dhillon, ADG (Horticultural Sciences), ICAR, New Delhi. Shri. S.R. Vishwanath, MLA, Yelahanka Constituency, participated in the valedictory function and appreciated the arrangements made for the benefit of farmers.

NHF-2020 was a grand success with more than 70,000 farmers and other stakeholders representing 26 states attending it. An impact analysis on NHF-2020 revealed that the technical demonstrations were a great success in motivating and creating awareness among farmers for horti-entrepreneurship, nursery management, biopesticides and PHT products. The fair gave an opportunity to all the stakeholders connected with horticulture to appreciate the technologies developed by the institute.

National Horticultural Fair 2020

VII Group Discussion of ICAR-All India Coordinated Research Project on Fruits

The seventh Group Discussion of the ICAR-All India Coordinated Research Project on Fruits was organised at Punjab Agricultural University (PAU), Ludhiana, from 16-19 January 2020, in which more than 200 delegates from 50 participating centres across the country participated in the deliberations. The Chief Guest was Dr. W.S. Dhillon, Assistant Director General (Hort. Sci.-II), ICAR, New Delhi, and Padma Shri Dr. B.S. Dhillon, Honourable Vice Chancellor, Punjab Agricultural University, Ludhiana, presided over the function. Directors of ICAR Institutes and officials from ICAR headquarters attended the group discussions and participated in the deliberations. A monograph entitled "Litchi insect pests and smart management options", and two CD-ROMs: 'Key characters of varieties/ hybrids under MLTs' and 'Monograph on mango pollinators' were released, as also a postal stamp of 7th Group Discussion of ICAR-AICRP on Fruits during the event.

VII group discussion of AICRP on fruits

Entrepreneurship Development Program

Entrepreneurship Development Program on the theme "Attracting Youth Towards Hortipreneurship" was conducted at KVK, Gonikoppal, in association with Business, Entrepreneurship and Start-up through Technology in Horticulture (BESST-HORT), the technology business incubator of ICAR-IIHR, Bengaluru, on 18 January, 2020. The program was attended by 47 participants.

Entrepreneurship Development Program

Training Program to Promote PHT and Mushroom Cultivation

A sponsored training on Post-Harvest Technology in Horticultural Crops and Oyster Mushroom Cultivation was conducted on 18 January 2020 at Kaidala village, Tumakuru, in collaboration with Department of Horticulture, Tumakuru, for entrepreneurship development, income generation and nutrition security. This training program was attended by 50 farm women from Kaidala village. Smt. Radha R. Banakar, SMS (Home Science), gave a lecture on importance of processing, value addition and preservation techniques in horticultural crops and oyster mushroom cultivation as an income generation activity.

Training program on PHT and mushroom cultivation

Graduation of Diploma in Agricultural Extension Services for Input Dealers (DAESI)

The Graduation Day of Diploma in Agricultural Extension Services for Input Dealers (DAESI) was conducted at ICAR-KVK, Gonikoppal, Kodagu, on 21 January 2020. This is a flagship program of the Government of India to train agricultural input dealers to impart scientific recommendations to farmers. Forty input dealers were trained in this program. The top ranks were obtained by the following candidates in the program: Mr. Nanada Kumar, M.R. Astra Processor, Somwarpet, (I Rank), Mr. Somanna P.A, Kushalnagar, (II Rank) and Smt. Sandhya, V., Coorg Agro Centre, Kundanahally, (III Rank). This one year Diploma Course was coordinated by Mr. Veerendra Kumar, K.V, Subject Matter Specialist (Plant Protection).

Graduation Day of DAESI

Kisan Mela

A two-day district level Kisan Mela was conducted at KVK, Gonikoppal (Athur farm), in collaboration with the Agricultural Technology Management Agency (ATMA) from 11-12 March, 2020. More than 20 exhibition stalls of government and private agencies and FPOs were arranged for the benefit of the farmers. More than 1000 farmers visited the Mela and interacted with the scientists, specialists and officials.

Kisan mela at KVK Gonikoppal

Functioning of Agri Input Outlet during Lockdown

KVK in association with Puthari FPO (stationed at KVK campus) helped farmers in Kodagu and Mysuru districts during lockdown, by procuring their produce, which was otherwise being sold at throwaway prices. The Agri input outlet was opened at KVK by the Puthari FPO, functioning in compliance with the district administration directions. Awareness about the importance of social distancing was also created among farmers. The FPO priced all its produce 30% below the market price, providing a great relief to farmers. The outlet was open from 7 am to 12 noon, thrice a week (Monday, Wednesday and Friday) from 7th-18th April 2020.

Farm Fresh Avocado Sale during COVID-19 Pandemic

ICAR-KVK, Gonikoppal, facilitated the collection of about one ton of avocado from distressed farmers, graded it and later coordinated its sale at apartments in Bengaluru on 10 May 2020. Shri. K.N. Jagadeesh of KVK, Hirehalli, Shri. Kiran from Bengaluru, and Dr. G. Pillai, facilitated the sales in different apartments, following the COVID-19 protocols. Farmers realized Rs.60 to 70 per kg through such marketing, which was roughly 100 to 140% more than the offered market gate price of Rs.25 to 30 per kg.

Live Streaming of KVK Initiatives during the Pandemic on Facebook

ICAR-KVK, Gonikoppal, Kodagu, participated in a Facebook live program conducted by Agriculture World and Krishi Jagaran, on the topic 'KVK Kodagu initiatives in Supporting farmers through district level intervention during COVID times', on 16 May 2020. In the program, Head, KVK, highlighted the efforts made towards procurement of vegetables and fruits directly from farmers, opening a temporary vegetable sale point at KVK, running of agricultural inputs sales centre operated by Puthari FPO, and the avocado sale to apartments in Bangalore. Similarly, numerous weather-based advisories to farmers were also enumerated.

Distribution of Food-Kits and Other Inputs

ICAR-KVK, Hirehalli, Tumakuru, was involved in the distribution of food-kits and other inputs (seeds, manures) to low-income, SC farmers and migrant workers in Tumakuru, arranged by the Aviskar NGO, Tumakuru. The program was organized on 15 and 26 May, 2020, at Aregujjanahalli and Thimmanaikanahalli village of Tumakuru respectively. About 90 farm women from SC community participated in the programs. Mr. Anand of Aviskar Foundation highlighted the precautionary

measures to be taken to prevent COVID-19. Dr. N. Loganandhan, Head, KVK, explained about the various supports extended during the pandemic period, especially to the farming community. The program was supported by Sri. Marikamaba, FPO of Tumakuru.

Distribution of food-kits to farm women

Awareness cum Training Program on Immunity Boosting Aspects of Spirulina Algae

ICAR-KVK, Hirehalli, Tumakuru, in collaboration with Spirulina Foundation, Tumakuru, organized a one-day Awareness cum Training Program on immunity boosting aspects of Spirulina algae on 27 May 2020, to deal with the present Covid-19 challenges and also to introduce the income generating avenues to members of the Women SHG. About 15 women from Sri. Lakshmi SHG of Kesaramadu Gram Panchayat, Tumakuru, participated in the program. Mr. R.V. Mahesh from Spirulina Foundation, Tumakuru, was the resource person who covered the nutritional values of algae, methods of food production, business model, and training at CFTRI, Mysore, etc. The methods of producing Spirulina algae and preparation of Chikki sweets incorporating the algae, were subject matters during the training.

Training program on Spirulina algae

Online Training Program on Prospects in Dragon Fruit Cultivation

ICAR-KVK, Hirehalli, conducted an online training program on 'Prospects in Dragon Fruit Cultivation' using online platform, for 208 participants from several states, on 1 June 2020.The expert for the program was Dr. G. Karunakaran, Principal Scientist, ICAR-IIHR, Bengaluru. The program was organised in collaboration with ICAR-IIHR, Bengaluru, and ICAR-ATARI, Bengaluru.

Training program on dragon fruit cultivation

Minimal Processing in Jackfruit

Trials on minimal processing in jackfruit were conducted at ICAR-IIHR, Bengaluru, on 2 June 2020. Dr. C.K. Narayana, Principal Scientist, shared his experience in value addition of jackfruit, namely, Instant Jackfruit Juice, Biscuits and Chocolates with Mr. Mahesh, N.M., President of FPO, Grama Chethana, Tumakuru, Mr. Hemanath, progressive farmer from Tumakuru and Mr. Sameer Patil and his team.

Minimal processing in jackfruit trials

World Environment Day

A Webinar on "Conserve & Celebrate Biodiversity" was organized at ICAR-IIHR, to celebrate World Environment Day on 5 June 2020, and attended by more than 425 participants – staff of ICAR-IIHR and ICAR Institutes, students from different Universities and othera. Dr. G.R. Smitha, Nodal Officer of Sports

& Staff Welfare Committee welcomed the gathering, Dr. P.E. Rajashekharan, Principal Scientist, Division of Floriculture & Medicinal Crops, spoke on the "Importance of Conservation and Biodiversity - the Backbone of Agriculture", and Dr. R. Ramanatha Rao, Co-Founder, GRSV Global Research for Development Support Ventures lectured on "Tree Fruit Diversity - India's Goldmine". Dr. A. Ganeshamurthy, Former Principal Scientist and Head, Division of Soil Science & Agricultural Chemistry, ICAR-IIHR, Bengaluru, deliberated on "Soil Diversity & Carbon Sequestration". Dr. V.V. Belavadi, Emeritus Scientist, Department of Entomology, University of Agricultural Sciences, GKVK, Bengaluru, highlighted the role of pollinators in agriculture for increasing productivity, ecological services, food and nutritional security. Dr. S. Ganeshan, Former Principal Scientist & Head, Division of PGR, ICAR-IIHR, Bengaluru, stressed the need and future prospects of cryopreservation. Dr. M.R. Dinesh, Director, ICAR-IIHR explained ICAR-IIHR's role in collection and conservation of horticultural crops and native germplasm.

World Environment Day

International Day of Yoga

International Day of Yoga (IDY) was observed at ICAR-IIHR on 21 June by mass performance of the Common Yoga Protocol (CYP). Due to COVID-19 pandemic, this year IDY was observed as YOGA@HOME; YOGA with FAMILY for 45 minutes from 7.00 AM, on 21st June 2020, and attended by 150 staff and 410 family members. At ICAR-IIHR, awareness was created among staff and their family members through emails, WhatsApp messages, banners etc. 'My Life, My Yoga' Video Blogging Contest was launched by the Hon'ble PM on 31 May 2020

XV Parthenium Awareness Week

XV Parthenium awareness week was observed from 16-22 August 2020, at ICAR-IIHR, Bengaluru, and its regional stations. The staff of various divisions participated in two hours of *shramdhaan* in their respective blocks for uprooting parthenium weed. On 21 August 2020 a web meeting was held under the chairmanship of Dr. M.R. Dinesh, Director, ICAR-IIHR, on the topic 'Parthenium Awareness cum Eradication programme at ICAR-IIHR'. In CHES, Chettalli, XV Parthenium Awareness Week was observed from 17-21 August 2020

Parthenium awareness week in CHES, Chettalli

54th Foundation Day of ICAR-IIHR

ICAR-IIHR organized its 54th Institute Foundation Day on 11 September 2020, by following COVID-19 standard operating procedures, by webcasting through YouTube. In his inaugural address Dr. Anand Kumar

Singh, Deputy Director General (Hort. Sci.), ICAR, New Delhi, appreciated ICAR-IIHR's contribution through improved varieties and technologies, transfer of technology and economic gains accrued thereof, and also advised on future line of work like value addition, transfer of technology through reliable package of practices to farmers to cater to export and trade demands in horticultural sector. In his introductory remarks Dr. M.R. Dinesh, Director, ICAR-IIHR, explained the activities and events organized, release of improved varieties and technologies like immunity boosting biofortified drinks, Arka Herbiwash for removal of pesticide residues and launch of ICAR-IIHR seed portal and its linking with SBI YONO Krishi App. Dr. K.S. Shashidhar, Former Additional Principal Chief Conservator of Forest and Chief Wildlife Warden, Nagaland Forest Department, delivered the foundation day lecture on 'Conservation of Orchids and its Cultivation in Home Gardens of Bengaluru'. In his address, the Chief guest Dr. K.M. Indiresh, Vice Chancellor, University of Horticulture Sciences, Bagalkot, appreciated the varieties and technologies released by the Institute.

As a part of the event, 31 frontline Covid warriors - police officers from Bengaluru North, medical officer and staff of Primary Health Center, Ivarakandapura, and ICAR-IIHR Staff were felicitated by the Chief Guest and Director. Other awards distributed were: Best Farmer awards to Mr. Manjunath, Doddamanchi village, Krishnagiri District, Tamil Nadu, Dr. P.V. Srinivas, Chickballapur, and Mr. N. Hanumantharaju, Bengaluru; Best Staff awards to Mr. N. Jayaramaiah and Mr. D.N. Jagadeesh Kumar in Technical, Mr. Syed Rabbani in Administration and Mr. Venkataramanappa D., Mrs. H.L. Lalitha, Mr. Anjanappa K. and Mr. Siddappa V. in Skilled Support Staff Categories; Dr. S. Sriram, Principal Scientist, Division of Plant Protection was awarded Best Teacher Award. In his virtual address Dr. Vikramadithya Pandey, Assistant Director General I/C - Hort. I, ICAR, New Delhi, congratulated the staff and conveyed his wishes for future endeavors. Dr. G.R. Smitha, Nodal Officer, Sports and Staff Welfare Committee proposed vote of thanks.

Felicitation of Covid warrior

Felicitation of Covid warrior

Distribution of Solar Based Arka Tricycle

The Arka solar powered tricycle for vending fruits and vegetables were distributed to selected beneficiaries on 9th September 2020 under the Scheduled Caste Sub Plan (SCSP) Scheme of Government of India. The program was inaugurated by |Sri. B.S. Yediyurappa, Honourable Chief Minister, Government of Karnataka. Sri. S.R. Vishwanath, MLA and Special Secretary to Chief Minister, Government of Karnataka and Dr. M.R. Dinesh, Director, ICAR-IIHR, Bengaluru, graced this occasion at the CM's Official Residence, Bengaluru. The Chief Minister stated that these eco-friendly vehicles would be a boon to street vendors and farmers to increase their socio-economic status, and congratulated the scientists of ICAR-IIHR, Bengaluru, for the innovation. The beneficiaries Mr. Manjunatha, B., Ivarakandapura, Bengaluru; Mr. Patalappa, Addiganahalli, Bengaluru; Mr. Manjunath, Hessaraghatta, Bengaluru; Mr. Ravi Nayak, Singanayakanahalli, Bengaluru; and Mr. Surendra, Dandinashivara, Tumakuru, expressed their gratitude to ICAR-IIHR and the SCSP Scheme of Government of India for making this technology accessible.

Distribution of Solar Based Arka Tricycle to beneficieries by Sri. B.S. Yediyurappa, Honourable Chief Minister, Government of Karnataka"

Poshan Maah Abhiyaan Programme

ICAR-KVK, Kodagu, celebrated Poshan Maah Abhiyaan program on 17 September, 2020. The event was inaugurated by Hon. Member of Legislative Assembly, Virajpet taluk, Shri. K.G. Bopaiah. He emphasized on the role of anganwadi teachers in promoting nutrition among children and also to collaborate with KVK in establishing more nutrition gardens in anganwadi centres.

Seed kits were distributed to all the participants which was followed by a technical sessions on preparation and maintenance of kitchen garden. A quiz programme on nutrition was also conducted. About 68 participants attended the event which included Anganwadi teachers, farm women and KVK Staff.

150th Birth Anniversary of Mahatma Gandhi

To celebrate the 150th birth anniversary of Mahatma Gandhi, Dr. Wooday P. Krishna, President of Karnataka Gandhi Smarak Nidhi, Gandhi Bhavan, Bengaluru, gave a talk on Gandhian Philosophy on 28 September 2020, through online mode. A drawing competition was conducted for the children of ICAR-IIHR staff on 29 September 2020, and an essay competition for the staff and students of ICAR-IIHR on 'Gandhian Philosophy', on 30 September 2020. Arka Tricycle Fruits and Vegetable Vending Van, designed and developed at ICAR-IIHR, was distributed to two Scheduled caste beneficiaries via implementation of centrally funded projects like SC/ ST plans, tribal sub plans, NEH region programs etc., The two beneficiaries are Mr. Karna from Sira taluk, Tumkur district and Mr. Vijaykumar, N., from Ivarakandapura village, Bangalore, both fruits and vegetables vendors.

Distribution of Arka Tricycle Fruits and Vegetable Vending Van to beneficiaries

Swachch Bharat Activity

On 30 September 2020, Swachch Bharat activities like weeding out parthenium, collection and disposal of plastic and other difficult to decompose material was arranged in ICAR-KVK, Hirehalli campus as part of the Gandhi Jayanthi Celebrations.

Swachch Bharat at ICAR-KVK, Hirehalli

Tree Planting to Celebrate Gandhi Jayanthi

A tree planting program was arranged as part of Gandhi Jayanthi Celebrations at ICAR-KVK, Hirehalli, on 1 October 2020. Mr. Sarath, Mr. Santhosh, Mr. Brook and Mr. Swami from NGOs like Signa and Cauvery Calling team were the chief guests. Mango and guava samplings were planted by the guests and all the staff and workers of KVK. The chief guests reiterated the importance of trees in developing the ecological system of the districts, state and the country. They also appreciated the efforts of KVK in following the path of Gandhiji.

Tree planting at ICAR-KVK, Hirehalli

National Webinar on 'ATMA NIRBHAR-KRISHI'

A National level webinar was organized on 'ATMA NIRBHAR-KRISHI – Fruits', in collaboration with GOI Field outreach bureau (Ministry of I & B), Mysuru, on 8 October 2020. Dr. M.R. Dinesh, Director, ICAR-IIHR spoke on Fruit crops and opportunities for the ATMA NIRBHAR KRISHI. Dr. B. Narayanaswamy, Principal Scientist, IIHR, & Dr. T.C. Poornima, Deputy Director, Ministry of I&B were the panelists and coordinated the program.

National Webinar on 'ATMA NIRBHAR-KRISHI'

Sale Counter at Sanjay Nagar, Bengaluru

ICAR-IIHR has opened a sale counter at Sanjay Nagar, Bengaluru, on 26 October 2020, to provide agricultural inputs such as quality seed and planting material, bio

fertilizers, bio pesticides and micro nutrients. The sales counter was setup to cater to the needs of health-conscious urban Bengaluru citizens who are taking up back yard/ roof top gardening seriously to grow fresh and safe pesticide free vegetables.

ICAR-IIHR sale counter at Sanjay Nagar, Bengaluru

Vigilance awareness week

Vigilance Awareness Week was observed at CHES (ICAR-IIHR), Bhubaneswar, from 27 Oct to 2 Nov 2020 on the theme of *"SATARK BHARAT: SAMRIDDH BHARAT"* (Vigilant India: Prosperous India)". Dr. G.C. Acharya, Head I/C administered the Integrity Oath pledge to the staff on 27 Oct at 11.00 AM. A debate program was also organized during the Vigilance Awareness Week. Scientific, technical and administrative staff of the station expressed their views on importance of transparency and accountability in making the system corruption-free. Videos on 'Integrity and Transparency in Life' was screened in the valedictory function.

Foundation Day of CHES, Bhubaneswar

CHES (ICAR-IIHR) Bhubaneswar celebrated its 28th Foundation Day on 6 Nov 2020. In his Foundation Day address, Director, ICAR-IIHR, appreciated the contribution of CHES (ICAR-IIHR), Bhubaneswar, in developing varieties of fruits and vegetables, production and protection technologies and the farm machineries developed, and ensuring effective transfer of technologies among the farming community including tribal farmers. On this occasion successful farmers Sri. K.C. Mohapatra, Rayagada and Sri. Bamadeb Swain, Cuttack, were felicitated for adoption and promotion of ICAR-IIHR technologies. The video on success story of Tribal Sub Plan interventions in Rayagada was played. Chief Guest of the function was Dr. Gourahari Naik, former Head and Guest of honor was Mr. Banshidhar Mohapatra, former AFAO.

Foundation day celebration at CHES, Bhubaneswar

Rural Mart

A Rural mart was inaugurated at KVK Campus on 11 November 2020, and is now operated by Puthari PFCL, connecting producers and consumer without the involvement of middle men, thereby guaranteeing a better price realization for farmers. Now with more than 1000 farmer members Puthari is one of the largest FPO in plantation sector and is hoping to achieve greater heights with KVK and NABARD support. The chief guest Mr. Niraj Kumar Varma, Chief General Manager of NABARD regional office, Bangalore, appreciated the efforts of Puthari for envisaging this project for the benefit of farmers of Kodagu. Mr. Manohar Reddy, Manager, Mr. P.V. Sreenivasa, DDM and Mr. M.C. Nanaiah retired DDM, NABARD of Kodagu, Puthari Board of Directors and stakeholders, and KVK staff participated in the event.

Distribution of Solar Based Arka Tricycle

Solar Based Arka Tricycle, developed by ICAR-IIHR, Bengaluru, was distributed to Mr. Surendra, a vegetable vendor, on 19th November 2020, as part of the SCSP program. Dr.K.S. Shivashankar, Director In-charge, ICAR-IIHR; Shri. Shivaprasad, Member-IMC, IIHR; Dr. H.S. Oberoi, Head, Division of Post-Harvest Technology & Agricultural Engineering (PHT&AE), Dr. G. Senthilkumaran, Principal Scientist, Division of PHT&AE, ICAR-IIHR and Dr. Logananthan, Head, KVK- Hirehalli participated in the event. Dr. Senthil Kumaran, the innovator, explained about the various superior features in this tricycle compared to the regular vegetable push carts.

Distribution of Solar Based Arka Tricycle

Blood Donation Camp

Covid-19 has resulted in decrease in voluntary blood donations and an alarming shortage of blood. Hence, Dr. G.R. Smitha, Nodal Officer, Sports and Staff Welfare Committee with the co-ordination of Dr. C. Aswath, Head (I/c), Division of Flowers and Medicinal Crops, and support of Dr. M.R. Dinesh, Director, ICAR-IIHR, organized a Blood Donation Camp at the Institute on 28-11-2020. The camp was organized by a team from Bengaluru Medical Services Trust in accordance with the regulations issued by the Government and CDC, following COVID-19 guidelines. Staff and students of the Institute donated 71 units of blood.

Blood Donation Camp

Awareness Program on Gherkin Cultivation

An awareness program on gherkin cultivation for 20 farmers of FPOs was organized by NABARAD, Tumakuru, on 3 December 2020, at DCC Bank premises. The farmers were briefed on the business opportunities in gherkin cultivation and market demand. Dr. Loganandhan briefed about the support extended by KVK for gherkin cultivation, like application of organic manure, organic pesticides, etc.

Awareness program on gherkin cultivation

51st SAC Meeting

ICAR-KVK conducted the 51st SAC meeting on 4 December 2020 at KVK Gonikoppal, online. Dr. V. Venkatasubramanian, Director, ATARI, and Dr. K.C. Shashidhar, Director of Extension, UAHS, Shivamogga, participated in the meeting. Around 28 officials and farmers participated in the meeting. Dr. M.R. Dinesh, Director and Chairman of SAC, emphasised on the role of KVKs in promoting different ICAR technologies and documentation of their impact. Shri. Thimmaiah, a progressive farmer from Kodagu district who received the Jajivan Ram Puraskar award of 2019 was felicitated by bestowing the award certificate and citation in the function. An extension folder on scientific calf management was also released.

Linking Biodiversity to Livelihood Security-Jackfruit

ICAR-IIHR has identified two elite jack fruit varieties with attractive coppery red colored flakes, and honored the farmers for conserving these varieties as 'Custodians of Genetic Diversity'. Of the revenue generated, 75% is the share of the jackfruit farmer (licensor) and 25% the Institute's. Mr. S.S. Paramesha and Mr. Shankariah from Tumakuru, are the custodians of Siddu and Shankara jack varieties respectively; they are also trained in mass propagation techniques. Hon'ble Shri. Parshottam Rupala, Minister of State for Agriculture & Farmers Welfare, Government of India, in the Annual Conference of Vice Chancellors of Agricultural Universities and Directors of ICAR Institutes, on 5th December 2020, at Krishi

Bhavan, New Delhi, distributed cheques worth Rs. 5 Lakhs each to Mr. S.S. Paramesha, and Mr. Shankaraiah, as a recognition. Shri. Kailash Choudhary, Hon'ble Union Minister of State for Agriculture and Farmers Welfare, was also present. Dr. Trilochan Mohapatra, Secretary, Department of Agricultural Research and Education & Director General, ICAR, explained the importance of linking biodiversity to livelihood security of the farmers.

Distribution of cheques to custodians of jack fruit varieties

World Soil Day Celebration

World Soil Day was celebrated at ICAR-IIHR, Bangalore, on 5th December 2020. Dr. K.H. Vinaya Kumar, IFS (Rtd), Former CCF Forest Resource management and Director, EMPRI, EMPRI Fellow-Environment, Bengaluru, spoke on soil health and soil related issues. KVK, Hirehalli, organized World Soil Day at Shivanagere village, Madhugiri taluk, where 50 farmers participated, and 250 Soil Health Cards were distributed to farmers.

World soil day celebration

Swachhta Pakhwada 2020

ICAR-IIHR, Bengaluru, organised Swachhta Pakhwada 2020 during 16-31 December 2020, to reiterate the importance of COVID appropriate behaviours; it included activities like Swachhta pledge, display of banners, cleanliness drive, workshops and awareness programs for waste to wealth, water recycling for agriculture, tree planting etc.

Swachhta Pakhwada at ICAR-IIHR, Bengaluru

Swachhta Pakhwada 2020 was organized at CHES, Chettalli, from 16-31 December 2020, with the implementation of sanitation and cleanliness drive in the office premises, community areas, staff canteen and guest houses, residential areas and farm and nursery areas. Awareness lectures and demonstrations were conducted on safe disposal of waste, polythene free environment, waste recycling, composting, etc.

CHES, Bhubaneswar, organized various activities during the *Swachhta Pakhwada from 16-3* *Dec 200* Dr. G.C. Acharya, Principal Scientist & Head (I/C) administered the pledge of Swachh Bharat to all the staff members on 16 December. A cleanliness drive in and around CHES campus was undertaken to maintain cleanliness and keep the area plastic free. The various programs organized include: Celebration of Kisan Diwas, Urban cleanliness program in nearby village areas, awareness rally and plantation, debate competition, guest lecture on global waste problem by Sri. Narasingh Panigrahi, Director, Siddha Development Research Consultancy Pvt. Ltd.

Awareness Camp on Waste to Wealth, Bidadi

The awareness camp on waste to wealth was conducted for about 100 farmers on 22nd December 2020, by the Division of Social Science and Training. Dr. M.R. Dinesh, Director, briefed about the hortipreneurial opportunities of the 300 odd technologies at ICAR-IIHR with potential for commercialization under the licensing process, and highlighted the Arka Decomposer and Arka Microbial Consortium technologies which shortened composting time and facilitated better biodegradation. In his Presidential remarks Dr. Arunachalam, Trust campus, Bidadi, advised farmers and youth to take up entrepreneurial activities with a scientific temper. Three technical sessions were conducted on Arka Fermented Cocopeat, Composting of farm residues and domestic wet waste, and Vermicomposting, by ICAR-IIHR resource personnel.

Kisan Diwas 2020

ICAR-IIHR, Bengaluru, celebrated Kisan Diwas 2020 on 23 December, 2020, by felicitating three farmers who have adopted ICAR-IIHR technologies. The chief guest Dr. K. Narayana Gowda, Ex-VC, UAS Bengaluru, appreciated the Institute for reaching its technologies to various stake holders including farmers. ICAR-IIHR distributed awards to farmers including Sri. Chikka Thimmareddy, who has planted and nurtured more than 2000 trees in Adde Viswanathapura village, Yelahanka taluk; Mr. Srinivasa Reddy from M.R. Palli, Pavagada taluk, Tumkur district, who has adopted Arka Microbial technology to produce disease free clean pomegranates; and Mr. Harish, B.M., from Madappanahalli village, Bangalore North, who has used Arka Neem seed pellet technology in cauliflower for producing residue free product. Soil Health cards and Plant Health cards were distributed to farmers from MGMG villages.

Kisan Diwas at ICAR-IIHR, Bengaluru

CHES, Chettalli celebrated Kisan Diwas on 23rd December 2020, at 7th Hoskote village, Suntikoppa Hobli, Kodagu district, in collaboration with Karnataka State Department of Agriculture (KSDA), Suntikoppa. The importance of soil testing and soil health card, and how to submit the soil samples to district soil testing laboratory and details to be furnished along with the samples, different government schemes for the benefit of the farmers, the major pests and diseases of Coorg mandarin, coffee, pepper and avocado and their control and management measures were discussed. About 30 farmers from the nearby villages had participated in the program.

Celebration of Kisan Diwas at CHES Chettalli

ICAR-KVK, Gonikoppal organized Kisan Diwas on 23 December 2020 in collaboration with ATMA, Department of Agriculture, Virajpet taluk. The program was inaugurated by Shri. P. Srinivas, District Development Manager, NABARD, Kodagu District. In his inaugural address he appreciated the efforts of the KVK team in imparting knowledge among the farming community and support for organizing entrepreneurship programs for farmers, farmers associations and SHG groups. Smt. Ahraf Unnisa, mushroom entrepreneur, New Farm Fresh mushrooms and Shri. Balakrishna, KVK Skill Development program trainee who is successfully practicing coffee and Arecanut nursery at Kushalnagar were felicitated. Shri. Somengada Thimmaiah, Krishi Panditha and Jag Jeevan Ram Awardee shared his innovative farm experiences viz. bamboo farming, fish farming, paddy mechanization to the participants.

Celebration of Famers Day cum Kisan Ghosti

Famers day cum Kisan Ghosti was celebrated on 23 December 2020, at KVK, Hirehalli. Sri. Papanna, President, Tumkur district Krushikasamaj inaugurated the program and stressed the need for implementing recent innovations in agriculture. Dr. Rajasulochanan, JDA, in her presidential remarks urged farmers to make use of facilities available in the department. Shri. Anandkumar, Avishkar NGO and Ravish, progressive farmers were resource persons. Shri. Umesh, DDA and Smt. Anusuya Kale gowda from Krushikasamaja were also present. Around 150 farmers participated in the program.

Farmers Day cum Kisan Ghosti

National Mushroom day celebration

Mushroom lab, ICAR-IIHR celebrated National Mushroom day on 23 December 2020, at the Peoples Trust NGO, Sriramanahalli, Rajankunte, Bengaluru. Two products were standardized for the participants - 46 children and women of the nearby villages. The immune enhancing properties of mushrooms and well-known Indian herbs and spices like Ashwagandha, Giloy, black pepper, dry ginger was combined to formulate a mushroom herbal soup. Another nutritional drink combining the goodness of

an indigenous mushroom from North east with high protein content and milk suitable for children was formulated. The two beverages were given to the women and children for sensory evaluation and was well accepted.

Mushroom and herbs based herbal soup

PM-Kisan Samman Nidhi programme

The webcasting of PM-Kisan Samman Nidhi program was organized at ICAR-IIHR Bengaluru, and its constituent units at Chettalli, Gonikoppal, Hirehalli and Bhubaneswar on 25th December 2020, for viewing the speech of Hon'ble Prime Minister, by 413 farmers, students, and staff.

Webcasting PM-Kisan Samman Nidhi program

Graduation Day of Diploma in Agricultural Extension Services for Input Dealers

The Graduation Day of Diploma in Agricultural Extension Services for Input Dealers (DAESI) was conducted at ICAR-Krishi Vigyan Kendra, Hirehalli, Tumakuru, on 28 December 2020. The final Diploma certificates were issued from the National Institute for Agricultural Extension Management (MANAGE), Hyderabad. Dr. Pennaboliswamy, State Nodal officer, DAESI-SAMETI, UAS, Bengaluru and Dr. Umesh, Deputy Director of Agriculture, Department of Agriculture, Tumakuru, were the Guests of Honour. These input dealers can now act as krishi information centres, instead of merely functioning as agriculture input shops in the rural areas. The one-year Diploma course was coordinated by Mr. Jagadish, K.N., Subject Matter Specialist (Agricultural Extension) as Coordinator and Mr. Umesh Chandra Banarjee as Facilitator.

Graduation Day of DAESI

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15. North East Service, Tribal Sub-Plan & Women Empowerment

15.1. Technology Demonstration in North East States

States Covered	KVK/ District covered	No. of crops covered	No. of varieties & technologies of ICAR-IIHR demonstrated	Area covered (Acre)	No. of demonstrations
Assam	12	15	36	101.35	335
Mizoram	8	11	29	51.56	149
Nagaland	5	04	6	26.00	83
Meghalaya	3	12	21	28.60	106
Tripura	6	08	17	19.75	80
Sikkim	4	14	20	61.98	227
Arunachal Pradesh	3	11	19	59.04	180
Total	**41**	**75**	**148**	**348.28**	**1160**

15.2. On-farm trials under Tribal Sub Plan (TSP) Program:

Demonstration title	No. of farmers covered	Area (Acre)	Package demonstrated	Inputs distributed
Okra - Arka Nikita	4	3	Improved variety and precision farming in Okra - Arka Nikita	Seeds of ICAR-IIHR variety- Arka Nikita
Onion - Arka Kalyan	25	34	Improved variety and precision farming in onion – Arka Kalyan	Neem soap, vegetable special and AMC liquid
Tuberose - Arka Prajwal	4	1.5	Precision farming in Tuberose	Bulbs of ICAR-IIHR variety- Arka Prajwal

15.3. Programs conducted

HRD Program for TSP beneficiaries: HRD programme for tribal beneficiaries was held at Pavagada, Tumakuru district on 17 Jan, 2020. To implement ICAR-IIHR technologies through tribal beneficiaries, an awareness programme was organized to educate them on livelihood security through IIHR technologies. Mr. Shivaprasad, member of RMC, ICAR-IIHR inaugurated the awareness program and lauded the efforts of IIHR for its initiatives in dissemination. Dr. B Narayanaswamy, PS & Nodal Officer of TSP, handled the class on farmers' friendly IIHR technologies to increase their income. There were 190 tribal farmers attended the program.

HRD program for TSP beneficiaries

Launching of Tribal Sub-Project in Chamarajanagar District

Launching of Tribal Sub-Project was organized at Konanakere village of Kollegala taluk of Chamarajanagar district, on 12 Feb, 2020. There were 320 tribal farmers from 16 villages (different Podus) selected based on survey, to uplift their livelihood security through ICAR-IIHR technologies. The event was organized by ICAR-IIHR in collaboration with the Soliga Abhivridhi Sangha which was promoted by VGKK, BR Hills. Around eight varieties of different fruit crops viz., jamun, mango, guava, custard apple, papaya and 12 varieties of different vegetables viz., chilli, tomato, bhendi, brinjal, amaranthus, French bean, dolichos, pumkin and curry leaf were distributed to benefit 180 TSP beneficiaries.

A view of the TSP participants at Konanakere

Tribal Sub-Plan project in Pavagada, Tumakuru district

ICAR-IIHR extended its Tribal Sub-Plan (TSP) project to Tumakuru district. It was launched at Devalakere village of Pavagada taluk on 26 Feb, 2020. About 360 tribal farmers and others from 18 villages were selected based on the preliminary survey. The tribal beneficiaries were provided with nine varieties of different fruit crops viz., mango, guava, jamun, custard apple and 12 varieties of different vegetables viz., chilli, tomato, bhendi, brinjal, amaranthus, drumstick, French bean, dolichos, pumpkin and curry leaf, for 120 acres. The importance of TSP project and its extension to Tumakuru district, package of practices of important crops for higher returns, were highlighted during the program.

Beneficiaries of Tribal Sub-Plan (TSP) project in Tumakuru district

Installation of Seed Vending Machine

Sri. G.S. Basavaraju, Honourable Member of Parliament (MP), Tumakuru, Karnataka, inaugurated the Seed Vending Machine at ICAR-IIHR Sub-Centre, Hirehalli, Tumakuru district, on 3 Nov, 2020, under the Tribal Sub Plan (TSP) program, for the benefit of tribal and other vegetable farmers of Tumakuru district, which is one of the selected districts for implementation of TSP program.

A view of seed vending machine and its inauguration

International women's day celebration at KVK, Gonikoppal

In association with Department of Women and Child Development, Government of Karnataka and Gram panchayath, Gonikoppal, Krishi Vigyan Kendra (IIHR), Gonikoppal celebrated International Women's Day at KVK, Gonikoppal on 8th March 2020 Dr.Saju George, Head, Krishi Vigyan Kendra, spoke on the event and stressed upon the facilities available at KVK for empowerment of the Women. Mr.Shrinivas , Panchyath Development Officer (PDO), Gonikoppal, stressed on the role of women for the overall socioeconomic improvement of the community and also promised on the behalf of Panchayth to respond the various problems which are being faced by the women especially. The programme had witnessed more than 50 women and all the staff of the KVK. Later during the programme training programme was arranged on the importance of Nutrition/Kitchen garden on human nutrition and also Demonstration was arranged on Oyster mushroom cultivation. At the end of the programme, various competitions were arranged for participated women and totally 8 prizes were distributed for the Winners of the women members.

Celebration of Mahila Kisan Diwas

Mahila Kisan Diwas was celebrated at KVK-Hirehalli, Tumakuru, on 15 Oct, 2020, in collaboration with ATMA, Department of Agriculture Tumakuru, with the participation of about 35 women from SHG groups. Mrs. Keerthi Prabha, DDM, NABARD, Tumakuru, Mrs. Chandrakala, PDO, Hirehalli, Shri. Ashwath Narayan, ADA, Department of Agriculture, Tumakuru, and Dr. Loganandhan. N., Principal Scientist and Head, KVK, Hirehalli, highlighted the activities related to women empowerment. Food competition was conducted and prizes distributed to the winners.

16. Official Language Implementation

The Official language implementation section of the Institute carried out the following activities for the effective implementation of Official Language Policy of Government of India during January to December 2020.

16.1. Main Station, ICAR-IIHR, Hesaraghatta, Bengaluru

Quarterly Meetings of Official Language Implementation Committee

- During 2020 four quarterly meetings of Official Language Implementation Committee of the Institute were convened on 12.03.2020, 23.05.2020, 18.08.2020 and 10.12.2020 during January-March 2020, April-June 2020, July-September 2020, and October-December 2020, respectively.

Hindi Workshops

The Institute organised the following Hindi Workshops during 2020:

- A table workshop on "Working easily in Hindi on Computer" was conducted on 17.02.2020 for the staff members of Administrative Section.
- A Hindi workshop on "Information Technology and Presentation in Hindi" was conducted on 05.08.2020 for the PG students of ICAR-IIHR.

Hindi Week Celebration

ICAR-IIHR, Hesaraghatta, Bengaluru, observed Hindi Week during September, 14-21, 2020. Hindi Terminology and Noting and Hindi Essay competitions were conducted for the benefit of the staff members of the Institute. Shri. Ashok Kumar Billure, Retd. Joint Director (OL), ISRO, Bengaluru, inaugurated the Hindi Week on September 14, 2020, and it concluded on September 21, 2020.

Inaugural function of Hindi Week at ICAR-IIHR

Valedictory function of Hindi Week at ICAR-IIHR

Hindi Publications: Annual Official Language magazine '*Bagwani*', 'Annual Report (Hindi) 2019' were some publications that were brought out in Hindi.

Hindi Incentive Scheme: Hindi incentive scheme was implemented at the Institute for working in Hindi originally and during the year, out of the total 10 participants 2 secured first, 3 secured second and 5 secured third prizes. The prizes and certificates for the participants were distributed during the valedictory function of Hindi Week Celebration.

16.2. CHES, Bhubaneswar

Hindi week celebration

Central Horticultural Experiment Station (ICAR-IIHR), Bhubaneswar, celebrated 'Hindi Week' from 14 – 21 September, 2020 to promote Hindi language in office activities and communication. During the celebration of Hindi Week; various competitions like reading, extempore, debate, essay, singing competitions in Hindi were organized for all the staff. The program was co-ordinated by Dr. Meenu Kumari (Scientist & Chairperson, Hindi language and Official Implementation Committee, CHES) with the active support of Dr. K. Kishore (Principal Scientist & Member), Mrs. Rina Pattnaik (AFAO & Member) and Mrs. S. Pradhan (PA & Member Secretary).

16.3. KVK Gonikoppal

ICAR-KVK, Gonikoppal, organised Hindi week from 08-14 September, 2020. During this week, Hindi word dictation, word meaning writing and Hindi speech competitions were organised. All the staff took active participation in these competitions and the winners got prizes too.

On 14.09.2020 Hindi day was celebrated. Dr. Saju George, Head, KVK, Gonikoppal, gave speech on importance of Hindi day celebration and appealed to the gathering to learn and use Hindi language where ever possible in their daily office work. About 25 staff and farmers were present in the program. Dr. Suresh, S.C., SMS (Livestock) coordinated and organised the Hindi week program.

17. Distinguished Visitors

ICAR-IIHR, Bengaluru

- Dr. Prem Kumar, Agriculture, Animal & Fisheries Resources Minister, Govt. of Bihar.
- Sri. V. Gopala Gowda, Hon'ble Supreme Court Judge (Former)
- Dr. K. Narayana Gowda, Former Vice Chancellor of UAS,GKVK, Bengaluru
- Shri. S. Suresh Kumar, Hon'ble Minister for Education & Sakala, Government of Karnataka
- Shri. Vishweshwar Hegde Kageri, Hon'ble Assembly Speaker, Government of Karnataka.
- Shri. G.V.L. Narasimha Rao, Hon'ble Member of Parliament and Chairman of Task Force on Chilli

CHES, Bhubaneswer

- Dr. M. P. Singh, Director, ICAR-IIPR, Kanpur

ICAR-KVK Gonikoppal

- Dr. Pennabaliswamy, State Nodal officer, DAESI-SAMETI, UAS, Bengaluru
- Dr. V. Venkatasubramanian, Director ICAR-ATARI, Bengaluru
- Dr. K.C. Shashidhar, Director of Extension, UAHS, Shivamogga

ICAR-KVK, Hirehalli

- Sri. B.C. Nagesh, Hon'ble MLA, Tiptur
- Sri. B. Suresh Gowda, Hon'ble Ex-MLA
- Dr. V. Venkatasubramanian, Director, ICAR – ATARI, Bengaluru

18. Personnel

DIRECTOR

Dinesh, M. R. Ph.D.

SCIENTIFIC STAFF

IIHR, Hesaraghatta, Bengaluru, Karnataka

Division of Fruit Crops

Reju M. Kurian, Ph.D.
Principal Scientist (Horticulture)
I/c Head

Tripathi, P.C. Ph.D.
Principal Scientist (Horticulture)

Manjunath, B.L. Ph.D.
Principal Scientist (Agronomy)

Anuradha Sane, Ph.D.
Principal Scientist (Horticulture)

Sujatha, S. Ph.D.
Principal Scientist (Agronomy)

Sakthivel, T. Ph.D.
Principal Scientist (Horticulture)

Satisha, J. Ph.D
Principal Scientist (Horticulture)

Sankaran, M. Ph.D
Principal Scientist (Horticulture)

Vasugi, C. Ph.D.
Principal Scientist (Horticulture)

Karunakaran, **G.** Ph.D
Principal Scientist (Horticulture)

Anjani Kumar Jha,
Principal Scientist (Horticulture)

Kanupriya, C. Ph.D.
Scientist (Horticulture.)

Linta Vincent, Ph.D.
Scientist (Fruit Sci.)

Anushma P.L. M.Sc.
Scientist (Fruit Sci.)

Sreenivasa Murthy, B.N. Ph.D.
Principal Scientist (Horticulture)
On deputation wef 28.05.17

Division of Vegetable Crops

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Yogeesha, H.S. Ph.D.
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Aghora, T.S. Ph.D.
Principal Scientist (Horticulture)

Pitchaimuthu, M. Ph.D.
Principal Scientist (Horticulture)

Varalakshmi, B. Ph.D.
Principal Scientist (Horticulture)

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Singh, T.H. Ph.D.
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Anil Kumar Nair, Ph.D.
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Dhananjaya, M.V. Ph.D.
Principal Scientist (Plant Breeding)

Prasanna, H.C. Ph.D.
Principlal Scientist (Plant Breeding)

Padmini, K. Ph.D.
Principal Scientist (Horticulture)

Sreenivasa Rao, E. Ph.D.
Principal Scientist (Horticulture)

Thangam, M. Ph.D.
Principlal Scientist (Veg.Science)

Raja Shankar, Ph.D.
Principal Scientist (Veg. Science)

Bharathi, **L.K.** Ph.D
Principlal Scientist (Veg. Science)

Smaranika Mishra, Ph.D.
Scientist (Veg.Science)

Raghu, B.R. Ph.D.
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I/c Head

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Rajasekharan, P.E. Ph.D.
Principal Scientist (Economic Botany)

Sujatha A. Nair, Ph.D.
Principal Scientist (Horticulture)

Hima Bindu, K. Ph.D.
Principal Scientist (Plant Breeding)

Safeena, S.A. Ph.D.
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Rajiv Kumar, Ph.D.
Principal Scientist (Horticulture)

Sumangala, H.P. Ph.D.
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Smitha, G.R. Ph.D.
Senior Scientist (Horticulture-Floriculture)

Usha Bharathi, T. Ph.D.
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Rohini, M.R. M.Sc.
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Sudhakara Rao, D.V. Ph.D.
Principal Scientist (Horticulture)

Tiwari, R.B. Ph.D.
Principal Scientist (Horticulture)

Senthil Kumaran, G. Ph.D
Principal Scientist (FM&P)

Harinder Singh Oberoi, Ph.D.
Principal Scientist (Microbiology)
Deputation to FSSAI

Carolina Rathina Kumari, Ph.D.
Principal Scientist (FM&P)

Bhuvaneshwari, S. Ph.D.
Principal Scientist (AS&PE)

Ranjitha, K. Ph.D.
Senior Scientist (Microbiology-Agricultural Science)

Pushpa Chethan Kumar, M.Sc.
Scientist (Food & Nutri.)

Vijay Rakesh Reddy, S. Ph.D.
Scientist (Fruit Science)

Division of Crop Protection

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Principal Scientist (Plant Pathology)
I/c Head

Meera Pandey, Ph.D.
Principal Scientist (Plant Pathology)

Shivaram Bhat, P. Ph.D.
Principal Scientist (Agricultural Entomology)

Venkata Rami Reddy, P. Ph.D.
Principal Scientist (Agricultural Entomology)

Sridhar, V. Ph.D.
Principal Scientist (Agricultural Entomology)

Sriram, S. Ph.D
Principal Scientist (Plant Pathology)

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Suresh Angadi
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TO (Refri.)

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Manjula, A.C.
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Suma Srinivas
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Anuradha, L.
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Jagadeesan, A.K.
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Administration

Mohan, C.M.
Assistant Administrative Officer

19. Varieties & Technologies Released During 2020

Arka Shyama: Water melon

- It is an icebox segment watermelon variety, with dark red coloured, crispy, sweet (TSS-12%) pulp, oblong fruit shape, 3-4 kg weight, dark greenish black rind, and early harvest (65-70 days) The yield potential is 62.8 t ha^{-1}

Arka Supreme: Avocado

- It is a regular bearing, high yielding genotype with spreading growth habit
- Fruits are oblong, TSS 7.8 ^{0}Brix, fat content 20%
- The flowering behaviour of this variety is of Type "A" category
- A fully grown tree yields 370-400 kg fruits, of 367-428 g average fruit weight

Arka Chandra: Pummelo

- It is a clonal variant of pummelo Accession-18. The tree is medium size (2-3 m), spreading branches, and bears fruits in two seasons in a year
- The fruit weight is 0.8-1.0 kg, spheroid in shape, and has creamy white pulp (White group 155 A), TSS 11-12 °B, acidity 0.89%, and sweet to taste with low level of the bitter principle naringenin (344.75 ng ml^{-1}), and thus suitable for fresh consumption
- It yields an average of 35-40 fruits per plant per season after 4 years after planting; yielding an average of 180-200 kg per plant per year in 10-year-old trees

Arka Anantha: Pummelo

- It is a clonal variant of pummelo accession-25.The tree is medium sized (2-3 m), with drooping branches, and bears fruits in two seasons a year
- The fruit weight ranges from 0.9-1.2 kg, oblique fruit shape, and has pink pulp, TSS 11-12°B, acidity 1.2 %, sweet in taste with low levels of naringenin (160.60 ng ml^{-1}), and suitable for fresh consumption
- It yields an average of 80-90 fruits per plant per season after 4 years after planting; yielding an average of 200-250 kg per plant per year in 10-year-old trees

Arka Tejasvi (H 41): Chilli F1 hybrid resistant to ChLCV

- Suitable for dry small (Teja) segment, plants are medium tall & spreading, fruits are pendent, 7-8 x 1-1.1 cm, firm, highly pungent (90-95000 SHU), green and turns deep red (90-100 ASTA) on maturity, medium wrinkled and resistant to powdery mildew and ChLCV
- The yield potential is 30-35 q dry chilli $acre^{-1}$

Arka Yashasvi (H 8): Chilli F1 hybrid resistant to ChLCV

- Suitable for dry medium segment, plants tall & spreading, fruits pendent, 9-10 x 1.2-1.4 cm, firm, medium pungent (40-50000 SHU), green and turns deep red on maturity (90-100 ASTA), medium wrinkled and tolerant to powdery mildew, RKN (root knot nematodes) and resistant to ChLCV
- The yield potential 30-35 q dry chilli yield $acre^{-1}$

Arka Saanvi (H 19): Chilli F1 hybrid resistant to ChLCV

- Suitable for dual small (green & dry) segment, plants medium tall & spreading, fruits pendent, 7-8 x 1-1.2 cm, firm, medium pungent (50-60,000 SHU), green and turns red (80-90 ASTA) on maturity, medium wrinkled and resistant to ChLCV
- The yield potential 30-35 q dry chilli yield acre^{-1} (or) 100 q green chilli yield acre^{-1}


Arka Tanvi (H 45): Chilli F1 hybrid resistant to ChLCV

- Suitable for dual medium segment, plants tall & spreading, fruits pendent, 9-10 x 1-1.1 cm, firm, medium pungent (60-65,000 SHU), green and turns deep red (90-100 ASTA) on maturity, dry fruits wrinkled and tolerant to powdery mildew, RKN (root knot nematodes) and resistant to ChLCV
- The yield potential is 30-35 q dry chilli yield acre^{-1} (or) 100 q green chilli yield acre^{-1}


Arka Gagan (H 30): Chilli F1 hybrid resistant to ChLCV

- Suitable for green upright segment, plants medium tall & spreading, fruits pendent, 7.5-8.5 x 1-1.1 cm, firm, highly pungent (1-1.2 lakh SHU), green, medium wrinkled and tolerant to root wilt, RKN (root knot nematodes) and resistant to ChLCV
- Yield potential is 100 q green chilli acre^{-1}


Arka Ganga: GSB resistant bottle gourd hybrid

- Early flowering and female flower at 12th node
- Takes 47 days for first female flower appearance and 56 days for first picking of fruits
- Green, oblong/ oval, tender fruits
- Resistant to Gummy stem blight, field reaction 3.18- 9.44 PDI, artificial challenging 8.89 PDI
- Good shelf life with less weight loss, firmness and colour retention up to 10 days of storage under RT
- Yield: 60 t ha^{-1}

Arka Shreyas: GSB resistant bottle gourd variety

- Female flower appears at 15th node
- Takes 48 days for first female flower appearance and 60 days for first picking of fruits
- Green, club shaped, tender fruits
- Resistant to Gummy stem blight, field reaction 7.33- 20.00 PDI, artificial challenging 10.00 PDI
- Good shelf life with less weight loss, firmness and colour retention up to 10 days of storage under RT
- Yields 48 t ha^{-1}

Arka Nutan: GSB resistant bottle gourd variety

- Early flowering and female flower at 9th node
- Takes 45 days for first female flower appearance and 56 days for first picking of fruits
- Green, cylindrical, tender fruits
- Resistant to Gummy stem blight, field reaction 3.34- 8.89 PDI, artificial challenging 9.45 PDI
- Yields 46 t ha^{-1}

Arka Bharath: Teasel gourd variety

- Vigorous growing, vine grows up to 6 m tall and robust
- Fruits are attractive, dark green, long, oval with soft seed and high-quality edible pulp for culinary purpose

- Individual fruits weigh 110 g
- Fruit yield potential is 10 t ha^{-1}

Arka Shubha (MOH 1-2): Marigold hybrid

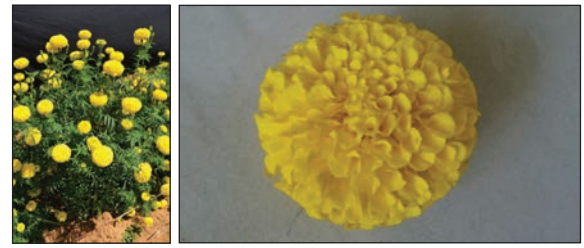
- Arka Shubha is a F_1 hybrid of African marigold identified for its rich carotenoid content (3.25 g per 100 g DW)
- Flowers are orange in colour (RHS colour Orange group N25 C) with shelf life of 5-6 days
- Plants are spreading type
- Yield potential is 12-14 tons $acre^{-1}$

Arka Vibha (MOH 5-3): Marigold hybrid

- Arka Vibha is a F1 hybrid of African marigold identified for its attractive flower shape and keeping quality (shelf life of 8-9 days)
- Flowers are highly compact and attractive orange colour (RHS colour Orange group N25 C)
- Yield potential is 10-12 tons $acre^{-1}$

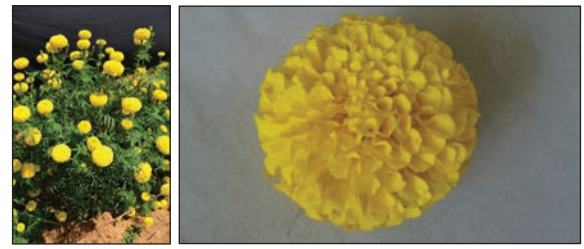
Arka Abhi (MYH 2-1): Marigold hybrid

- Arka Abhi is F_1 hybrid of African marigold identified for its attractive radiant lemon-yellow colour (RHS Yellow group 5 A)
- Flowers are large (7-8 cm) with good shelf life (6-8 days)
- Yield potential is 10-11 tons $acre^{-1}$



Arka Bhanu (MYH 1-4): Marigold hybrid

- Arka Bhanu is a F_1 hybrid of marigold identified for its attractive flower shape and golden yellow colour (RHS Yellow group 12 B)
- Flowers are compact with a shelf life of 7-8 days
- Yield potential is 10-11 tons $acre^{-1}$



Arka Red: Gerbera variety

- The flowers are bright red in colour, double in nature, and best suited for growing outside anytime of the year, for both beds and cut flower
- It yields 360 flowers m^{-2} per year

Arka Herbiwash

- This is an herbal and eco-friendly formulation of dried and powdered plant parts, containing no synthetic chemicals or adjuvants, used to wash fruits and vegetables.
- Up to 80-100% of surface pesticide residues are removed by this product, compared to 30% or more by washing in running water
- Arka Herbiwash also removes surface microbes e.g., bacteria, yeasts and moulds, and up to 90 to 99% of food borne pathogens such as *E. Coli*, *Staphylococcus*
- It is recommended to wash fruits and vegetables in water containing Arka Herbiwash with moderate agitation and/or scrubbing

Arka Sasya Poshak Ras: Liquid nutrient formulation

- The liquid nutrient formulation (comprising of solutions A & B) is a unique balanced blend of the macro (N, P, K, Ca, Mg and S) and micro nutrients (Fe, Mn, Cu, Zn, B and Mo)
- This formulation is suitable for commonly grown vegetables - tomato, chilli, cabbage, zucchini, cucumber, ridge gourd, French bean, peas, cow pea, dolichos etc., and leafy vegetables - amaranthus, coriander, palak etc.
- It is highly suited for cocopeat based cultivation and balcony, terrace gardening, in open or polyhouse conditions

Arka Viral Kit

- The kit is based on Loop-Mediated Isothermal Amplification (LAMP) to diagnose Tomato Leaf Curl Bangalore virus (ToLCBV)
- It is superior in specificity, sensitivity, and rapidity to other molecular techniques like PCR, RT-PCR, and real-time PCR
- It is user friendly, as the testing can be done in a water bath or dry bath; and cost-effective compared to other PCR based diagnostic kits

Arka Cucurlure

- A novel kairomone blend for effective trapping of male melon flies, *Zeugodacus cucurb tae*
- The technology is based on a combinative plant volatile from cucurbitaceous fruits and cue lure
- The lure attracts a larger number of males (~50%), over the conventional cue lure trap

Arka Iron Fortified Mushroom

- The content of iron in fortified elm oyster mushroom (*Hypsizygus ulmarius*) was increased by 338.15 ppm, from 135.60 ppm in non-fortified mushrooms, an increase of 149.37%
- The bioavailability of iron from these fortified mushrooms is 21.68%, significantly higher than the iron bioavailability from plant sources (5-8%) or from inorganic iron supplements (10-12%)

Arka Probio Ready-to-Serve Pineapple Juice

- This probiotic pineapple beverage was prepared using 70% pulp and prebiotics; no other preservatives were added to the beverage
- The beverage has a good mouth feel, texture and body
- It has a shelf life of two months at 5 ^{o}C storage

Ready-to-Serve (RTS) Probiotic Mango Beverage

- This probiotic beverage has been prepared from mango pulp, sugar and water, and does not contain any preservatives or other chemicals
- Shelf life of the product is more than three months under refrigerated conditions
- RTS probiotic mango beverage has the potential to be classified as a health drink

Probiotic Pomegranate Juice

- Probiotic pomegranate juice has been prepared using pomegranate arils and soy milk, and does not contain any preservative or other chemicals
- Shelf life of the product is more than three months under refrigerated conditions
- Probiotic Pomegranate juice has the potential to be classified as a health drink

Arka Haagalarasa: Ready-to-Serve (RTS) Bitter Gourd Juice

- This RTS juice is less bitter than bitter gourd fruit and beneficial for diabetic patients
- The product does not contain preservatives and can be stored more than 6 months at ambient temperature

Arka Avocado Chutney

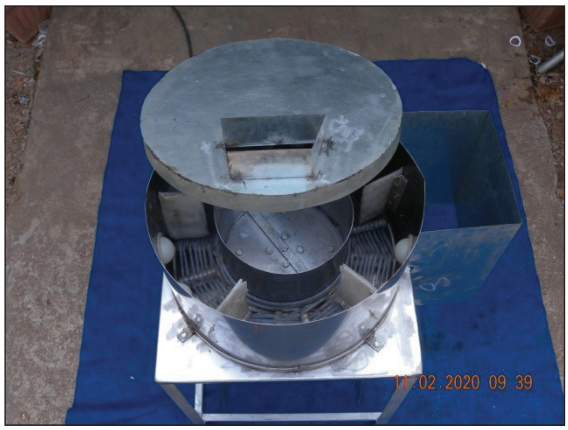
- The product is prepared from avocado fruit pulp and spices, and contains no preservatives or synthetic additives

Arka Avocado Bread Spread

- The product is prepared from avocado pulp, sugar and cocoa powder, and can be consumed as fruit jam or jelly
- The product has a shelf life of s*ix* months at ambient temperatures

Power Operated Pomegranate Aril Extractor

- Dimensions: 840 x 1220 x 550 mm (L x H x W)
- Material: Stainless steel sections, silicone material, belt and pulley
- Power: 0.75 kW, three phase geared motor (115 rpm output)
- Peripheral speed of fruit carrier plate: 158.88 m min^{-1}
- Capacity: 80 kg h^{-1}



Solar Power Operated Tricycle Cart for Fresh Fruits and Vegetables Vending

- This is useful to transport produce from the distribution centre to the consumer's doorstep, and also to keep the produce fresh for 36-48 h
- It also reduces post-harvest losses by10-15%

Solar Power Operated Tricycle Cart for Ready to Harvest Fresh Mushroom Vending

- The technology helps to sell ready to harvest fresh mushrooms bags produced using the previously developed low-cost Solar Power Integrated Outdoor Mushroom Growing Unit

- Customers can pick and choose fresh mushrooms from the bags, at their door step; the unsold bags can be kept in the chamber for sale next day, maintaining freshness and reducing spoilage loss

* * * *

20. Meterological Data

1. ICAR-IIHR, Bengaluru

Month	Temperature (°C)		Relative Humidity (%)		U.S.W.B. Class 'A' Pan Evaporation (mm)	Mean wind speed (km/h)	Rainfall (mm)
	Max.	Min.	07.30 hrs.	14.00 hrs.			
January	30.2	14.2	84.4	46.6	4.4	4.0	0.00
February	31.5	15.6	77.1	38.8	5.7	4.0	0.00
March	33.7	18.2	73.1	38.0	6.8	4.5	6.5
April	34.4	19.4	75.6	43.7	6.8	4.5	104.0
May	34.5	21.3	81.8	50.5	6.1	4.2	74.3
June	31.2	20.8	95.0	74.5	4.5	6.9	85.0
July	29.2	20.4	93.4	75.1	3.9	4.4	224.0
August	28.0	20.2	89.6	72.8	3.4	6.4	95.5
September	28.3	20.0	90.9	77.5	3.4	4.9	298.0
October	27.9	19.2	89.2	68.2	3.0	3.9	151.5
November	27.5	17.4	87.3	63.2	3.1	4.3	19.2
December	26.8	15.4	90.0	60.0	3.1	4.8	13.9

2. CHES, Bhubaneswar

Month	Temperature (°C)		Rainfall (mm)	Relative Humidity %		BSH	Evaporation
	Max	Min		07.00 hrs	14.00 hrs	hrs	(mm)
January	27.9	16.1	12.7	94	51	5.8	3.5
February	28.5	16.2	94.2	91	48	5.2	3.5
March	34.2	22.1	56.5	95	50	7.5	5.1
April	36.9	24.7	107.9	93	50	7.7	6.4
May	36.0	25.9	157.1	89	60	7.8	6.6
June	34.9	26.7	95.3	93	68	4.9	5.6
July	34.4	26.5	158.9	93	68	5.5	3.7
August	32.7	26.0	585.4	95	75	3.5	2.9
September	34.1	26.2	211.7	95	70	5.9	3.3
October	31.9	24.4	247.6	95	76	4.7	3.1
November	31.4	19.6	5.6	90	53	6.5	3.5

3. CHES, Chettalli

Month	Temperature (°C)		Humidity (%)		Mean wind speed (km/h)	Rainfall (mm)
	Max.	Min.	Min.	Max.		
January	31.3	15.9	35.2	96.5	6.7	1
February	31.7	15.9	35.2	96.6	7.2	1
March	32.9	17.4	38.8	96.6	6.6	9
April	32.0	18.3	47.9	99.1	6.0	68
May	30.6	19.5	62.5	99.7	5.7	100
June	25.9	18.7	80.8	99.8	5.2	177
July	25.1	18.4	85.0	99.9	4.4	286
August	24.5	18.2	87.5	99.9	5.5	627
September	24.9	18.0	85.5	100.0	4.7	302
October	26.7	17.0	72.5	99.7	4.4	174
November	26.7	17.0	70.2	99.0	6.7	28
December	26.5	15.4	64.8	99.2	6.6	12

EVENTS OF ICAR-IIHR DURING 2020

Inauguration of dining facility at ICAR-IIHR canteen

DUS Test Monitoring of Bitter gourd at ICAR-IIHR

Training cum interaction meet on Spine gourd at KVK, Gonikoppal

Training on vegetable cultivation at CHES, Bhubaneswar

Avocado sales during lockdown at KVK, Gonikkoppal

Mahila Diwas at KVK, Gonikoppal

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