Improvement and Management of Horticultural Crops

Mango

National Active Germplasm of mango at CISH, Lucknow, maintained 735 accessions in the field gene bank. Sixty accessions were characterized for fruit characteristics. The GIS tool could be employed for identification of cultivar-specific climatological region and in developing cultivar(s) specific region(s) in the country. Tommy Atkins was found a potential donor for red peel and precocity characters. Microsatellites have been isolated from mango Alphonso using dynabead-based microsatellite enrichment method. Mango Langra, Borsha and Raspuri were differentiated using MID01F-R, MID06F-R, MID10F-R and MID26F-R. The products were separated on Polyacrylamide gel electrophorosis (PAGE) at IIHR, Bangalore.

Drip irrigation in mango orchards increased the fruit yield by 12% and saved fertilizers by 25%. High-density plantation of Arka Anmol (400 plants/ha) raised on Vellaikolumban rootstock gave more fruit yields even with 75% of recommended dose of fertilizers and 50% of evaporation rate. Alphonso mango scion grafted *in situ* on Vellaikolumban and Olour rootstocks at planting density of 1,111 (3 m × 3 m), 400 (5 m ×5 m) and 178 (7.5 m × 7.5 m) trees/ha trees indicated better field establishment at higher planting densities on Olour rootstock as compared to Vellaikolumban.

Lowering the respiration and ripening temperature to 20°C helped in reducing the incidence of spongy tissue formation. Better germination of seeds extracted from spongy tissue affected fruits in field as compared to those from healthy fruits appeared due to physiological shift in seed to enable it to act as a stronger physiological sink for water and other resources from the adjoining mesocarp resulting in development of spongy tissue. Prediction models were developed for trap catch of mango fruit fly (*Bactrocera correcta*) using all weather parameters. Antioxidant potential of Alphonso mango peel and kernels were 20 and 40 times more than pulp and hence kernels can be used as a food additive for enhancing antioxidant property in processed foods.

Use of black polyethylene mulching (100 µ) in September was found beneficial in Chausa and Langra to curtail the loss of paclobutrazol applied for flower induction @ 3.2 ml/m canopy diameter and reduced fruit drop. Application of paclobutrazol also resulted in increase in number (15.2–20.22) and size of stomatal aperture (9.8–14.17 µm) and caused higher accumulation of starch granules as compared to control in leaves of mango Chausa and Dashehari. Fruits of Langra with thinner pedicel (3.79 mm) showed more drop than Dashehari (4.18 mm), Chausa (4.99 mm) and Mallika (5.86 mm).

- The National Active Germplasm of mango was enriched
- Black polyethylene mulching was beneficial in mango
- Eighteen new cultivars and 26 seedling accessions of mango were collected
- The antagonists reduced disease incidence in mango

All the antagonists used as post-application significantly reduced the disease to 7.57–10.76% from 74.35% in the control.The antagonist from karanj (*Pongamia* sp.) leaf based organic pesticides controlled disease better (7.57%). These effective antagonists were identified as species of *Bacillus*, *Pseudomonas* and *Acenetobacter*.

A total of 18 new cultivars and 26 seedling germplasm accessions of mango were collected. Dudhia Malda produced maximum yield with good TSS at different centres. Two clones, T19 and T20, of mango Himsagar were found promising with higher yield and good TSS. Mallika showed superiority over other varieties in yield and TSS. Double hedge row system of planting recorded significantly higher yield. Mango germplasm Misrikhan recorded minimum disease incidence (0.1%), while mango Meghlanatan was found free from malformation during third year. Three sprays of carbendazim (0.1%) starting with the onset of anthracnose disease in mango followed by spraying at 15 days intervals managed the disease effectively.

Guava

Ninety-six accessions including six species of *Psidium* were maintained in the field genebank. Twenty accessions of guava were collected from Allahabad and its surrounding areas, while 68 were characterized for fruit morphology and quality parameters. Pink-fleshed guava, HAPSI-35 and HAPSI-46/ere found suitable for nectar preparation and HAPSI-16 retained vitamin-C for longer period. Interspecific wilt resistant guava rootstock (*P. molle* × *P.*

- Ninety-six accessions of guava were maintained
- Sixty-eight accessions of guava were evaluated
- Guava HAPSI 35 and HAPSI 46 were suitable for nectar production
- Guava HAPSI 16 retained vitamin C for a longer period

guajava) was multiplied successfully through stem cuttings. Allahabad Safeda and Sardar were found superior in fruit yield.Double hedge row system of planting yielded more in guava. Maximum yield and best quality fruits in winter season were obtained by regulating flowering with treatment of 15% urea at 50% bloom stage in April–May followed by its second spray after 10 days.Soil application of *Trichoderma viride* along with FYM around root zone was found most effective in reducing the incidence of guava wilt.

Papaya

Application of 75% of recommended dose of fertilizer of 50 g each of N and K_2O/plant/year) at Coimbatore recorded higher yield (33.6 fruits/tree with 1.09 kg fruit weight in CO_2. Out of five lakh derived compounds (A, B, C, D and F) tested under *in vitro* condition for their toxic potential against egg hatching and juvenile mortality of root-knot nematode and various life stages of reniform nematode, two important pest of papaya, revealed a varying degree of toxic potential which was found to be dependent on the concentration and exposure time. Only four compounds, A, B, C and D could cause 87–100% juvenile mortality of root-knot nematode at 5,000 ppm after 264 hours of exposure. On the other hand, compound A could bring 100% mortality of reniform nematode during the same exposure period. Application of farmyard manure enriched with biopesticides, *Pseudomonas fluorescens* (10^8 cfu/g), *Pochonia chlamydosporia* (10^6 cfu/g) and *Bacillus subtilis* (10^6 cfu/g) @ of 2 kg/tree (5 years old) at six monthly intervals reduced root population of *R. reniformis* and *M. incognita* effectively (64 and 66%, respectively). Combined application of neem cake (250 g) + carbofuran (1g ai) + *Pseudomonas fluorescens* (4 g) gave highest fruit yield and maximum reduction of nematode population in papaya CO_2.

Litchi

Four new accessions of litchi were added. A total of 52 accessions have been maintained in the field gene bank at NRC for Litchi, Muzaffarpur (Bihar). The 15–20 years old orchards gave 24–36% higher yield. Rejuvation of old senile orchards was demonstrated at farmers' fields. Seedling SG-JAL-1 recorded maximum yield (62.0 kg/tree) at Mohanpur under AICRP on Subtropical Fruits.

Grape

The grape germplasm collection at NRC for Grape, Pune, was enriched by introducing eight exotic accessions from Uzbekistan, thus bringing the cumulative collection to a total of 401 accessions. Fifty-four accessions were characterized for their berry and bunch characters. Bunch weight and number of berries/bunch showed a large variability. A total of 91 accessions were characterized and grouped based on their reproductive phenological stages. The early-ripening varieties clustered in one group, whereas slow-and-late-ripening ones were grouped together. A few grape varieties were characterized based on their phenolic composition and antioxidant activity. A software has been developed to create an electronic database containing characterization data of grape germplasm available in India.

Twenty-one rootstocks were analysed with AFLP and SSR primers. Two clones of rootstock, viz. Dogridge A and Dogridge B, were distinguished. Dogridge B was grouped with *Vitis champinii*, while Dogridge A with 110R (a hybrid of *V. rupestris* and *V. berlendieri*) with 80% similarity.Several accessions resistant to thrips (*Ripiphorothrips cruentatus* and *Sertothrips dorsalis*) and downy mildew were identified through field screening. Eight AFLP and 5 SSR markers showing promising association with resistance/susceptibility to disease have been identified.

Flame Seedless grape gave more yield, when grafted on Dogridge rootstock compared to own root or St. George rootstock. A load of 45–50 bunches/vine was found to be optimum for obtaining good quality grapes in grafted Thompson Seedless. Berry quality parameters like length, diameter and weight were obtained in Thompson Seedless on Dogridge. In Tas-A-Ganesh, 35% cluster clipping with berry thinning and retention of 35 shoots and bunches/vine resulted in better yield with good quality. In Sharad Seedless, berry diameter, and berry and bunch weight were recorded more in bunches on straight canes compared to those on subcanes. The yield was highest in vines grafted on rootstock B2/56 and also found to have better salt exclusion as indicated by lower sodium content in petiole of Thompson Seedless. Black leaf disorder observed in many vineyards were attributed to low potassium content or excess sodium. Tas-A-Ganesh grafted on rootstock showed better water-use efficiency compared to own-rooted vines. Similarly, use of mulch improved water-use efficiency in grape. Subsurface irrigation resulted in 25% saving of irrigation water. Application of hydrogen cyanamide through spray resulted in budbreak, which was at par with swabbing. In grape Sharad Seedless, GA_3 and 6-BA improved weight of berries, diameter and length of berries; TSS and acidity of juice significantly at Bangalore. Bangalore Blue grape peel contained more phenols, flavonoids and antioxidant activity than pulp.Therefore, juice should be extracted with peels and seeds to get more antioxidants.

- Four new accessions of litchi were added
- Rejuvenation of old litchi orchards was demonstrated to farmers
- Twenty-one rootstocks were analysed with AFLP and SSR primers
- Grape germplasm was enriched with exotic accessions.
- Banana Udhayam has been released
- Sigatoka leaf spot in banana was controlled effectively.
- A wild banana species has been identified.

Release of predator *Cryptolaemus mountrouzieri* @ 10/vine 75 and 85 days after pruning resulted in 80% reduction in bunch damage of grapes by mealy bug (*Maconellicocus hirsutus*). Forecasting-based disease management of downy mildew and powdery mildew saved in number of spray, helped in giving timely application of fungicides. Several environment-friendly substances, viz. Chitosan (0.1%), fermented *gomutra* (10%) and milk (10%) were found promising in controlling powdery mildew especially under low disease risk situation. Several fungal and bacterial endophytes were isolated from Tas-A-Ganesh and 2A clone of Thompson Seedless for testing for their antagonism to various grape pathogens. A bacterium showing antagonism to *Botryodiplodia* was isolated from grape rhizosphere. Seasonal incidence of major insect pests, viz. flea beetle, thrips and jassids was observed in vineyards of Maharashtra and Andhra Pradesh. Insect incidence showed correlation with weather parameters. Rainfall, minimum temperature and humidity correlated negatively with the population of thrips and jassids. Mealybugs population was negatively correlated with humidity.

Banana

A new wild species of banana, *Musa swarnaphalya*, from North-East region has been identified by NRC for Banana, Truchirapalli. A new variety, Udhayam (ABB), has been released with 40% more yield than Karpuravalli.

As a first step towards development of transgenic banana for resistance to *Fusarium* wilt, regeneration protocol for banana Ney Poovan has been standardized at IIHR, Bangalore. Diagnosis and Recommendation Integrated System (DRIS) chart has been constructed for monitoring nutrient status of banana plants for Tamil Nadu. The fertilizer adjustment equations have been developed with reference to targeted yield for Nendran banana. Entomopathogenic fungi (*Beauveria bassiana*) and nematode (*Heterorhabditis*) were found effective against banana weevils under field conditions involving stem trap as delivery system. *Trichoderma viride* (T-6 strain), *Azospirillum* sp. and *Pseudomonas* sp. were found effective against cigar end disease under *in-vivo* condition. It can be mass produced in rice chaffy grains at 22°C and maintained up to 4 months. Rice husk has been successfully used as a carrier material for *Pseudomonas fluorescens* with a shelf-life of 6 months. Robusta banana can be stored up to 3 months and Rasthali for 4 months at 13.5°C and 90% RH without showing any ripening disorder in fruits. Banana stem juice beverage has been developed, which has 5 months storage life under room temperatures.

Under AICRP on Tropical Fruits, a total of 925 banana accessions were maintained and evaluated. Among the already identified Kanthali clones, clone-I and clone-II were found to be more

Banana Udhayam

potential. Planting of Nendran is remunerative during all the seasons under Kannara conditions. Combina//g/plant) and 50 g/plant each of PSB, *Azospirillum* and *Trichoderma harzianum* with 75% of recommended dose of fertilizer of 200 g N, 50 g P_2O_5 and 200 g K_2O/plant for Rajapuri, Karpurachekkarakeli and 100% recommended dose of fertilizer for Grand Naine was found better for yield. Growing single/double crop of cowpea and its incorporation into soil continued to be effective for weed control. The best crop sequence as intercrops are onion at Arabhavi, cowpea at Jalgaon and cabbage at Mohanpur. Combined treatment of *Paecilomyces lilacinus* along with organic amendment, neem cake @ 250g/plant or FYM @ 500g/plant gave maximum reduction of nematodes in banana Robusta. Effective control of Sigatoka leaf spot was achieved with three sprays of propiconazole (0.1%) at 30 days intervals with *Bacillus subtilis* or *Pseudomonas fluorescens* (0.5%). Tissue-cultured banana plants showed more incidence of banana streak virus (BSV) than plants raised by suckers.

Citrus

In precision-oriented fertilizer management in Nagpur mandarin, lack of soil test-crop response is considered to be the major drawback for inconsistent production response of Nagpur mandarin due to horizontal and vertical heterogeneity in soil properties. Two soil sites in the same orchard were identified through grid samplings, which represented Typic Ustorthent (Ap-A12-A13-C) and Typic Haplustert (AP-A2-A3 ss-A4ss-Ack-Ck) soil types. To rationalize fertilizer-use efficiency through site-specific nutrient management, fertilizer requirement varied from 1200 g N, 600g P_2O_5, 600 g K_2O, 300 g each of $ZnSO_4$, $FeSO_4$ and $MnSO_4$, 100 g borax, 400 g $MgSO_4$ and 100 g elemental S/tree on Typic Ustorthent to as much as 600 g N, 400 g P_2O_5, 300 g K_2O, 300 g each of $ZnSO_4$, $FeSO_4$ and $MnSO_4$, and 100 g borax, 400 g $MgSO_4$ and 100 g elemental S/tree on Typic Haplustert with fruit yield of 61–68

- Disease-free planting material was distributed at the NRC for Citrus, Nagpur
- About 9,862 healthy budgrafts of Nagpur mandarin were distributed

SUCCESS STORY

Multi-K Brings Cheer to Kinnow Farmers

The B and C grade fruits of kinnow do not bring remunerative returns to farmers, whereas 'A' grade fruits get premium returns. Non-availability of sufficient potassium during critical phase of fruit growth is the main reason of low quality fruits. Multi-K was, therefore, sprayed thrice along with other chemicals. First spray was done when the leaves attained two-thirdd of their normal size in March, second when fruitlets attained about 2 cm diameter and third after one month of second spray. Multi-K (2%) and Multi-K (1%) increased the proportion of 'A' grade fruits by 20% over the control.

kg/tree against fruit yield of 34–53 kg/tree with farmers' practices. The cost:benefit ratio of 1 : 2.1 in combined treatment further confirmed its superiority in yield response over farmers' practices.

At NRC for Citrus, Nagpur, 38,341 disease-free planting material of Nagpur mandarin, acid lime and sweet orange were distributed. About 9,862 certified healthy budgrafts of Nagpur mandarins through shoot tip grafting were also distributed to citrus growers. The inclusion of VAM (500g/plant) + PSB (100g/plant) + *Azospirillum* (100g/plant) + *T. harzianum* (100g/plant) with 100% RDF gave highest yield of Kinnow mandarin at Ludhiana, and sweet orange and acid lime at Rahuri and Nagpur mandarin at Akola. The requirement of inorganic fertilizer was reduced by 25% with the inclusion of biofertilizers at Tirupati. Leaf miner in citrus was effectively controlled with spraying of imidacloprid (0.005%) followed by NSKE (5%)/*Bacillus thuringiensis* at 0.1%. Spraying of imidacloprid (0.005%) was effective for blackfly. Lemon butterfly was effectively controlled by spraying of endosulfan (0.07%) or *Bacillus thuringiensis* (0.05–0.1%)/carbaryl (0.15%)/ thiodicarb (0.075%). Treatment with Bordeaux paste to trunk followed by soil application of *Trichoderma viride* follwed by Alphosetyl (0.2%) spray was effective for the management of *Phytophthora*. At Chethalli, indexing and confirmation of citrus tristiza virus (CTV) isolates was done by ELISA, dsRNA and RT-PCR methods. For the management of nymphal population of citrus blackfly, releases of 4-6 eggs of *Mallada boninensis*/shoot was found effective during *Hasta bahar* in Maharashtra.

Sapota

A collection of 92 accessions was maintained and evaluated. Application of 5 kg vermicompost with annual application of 150 g N, 40 g P_2O_5 and 150 g K_2O/plant for 9-year-old sapota and 25 kg FYM/5 kg vermicompost with 300 g N, 50 g P_2O_5 and 200 g K_2O/plant/year for 15-year-old sapota recorded significantly higher growth and yield. Application of 75% recommended dose of fertilizer through drip recorded higher yield (22.96 tonnes/ha) for Kalipatti sapota. Application of DDVP (0.03%) in second fortnight of March followed by polytrin-C (0.044%) in first fortnight of April, monocrotophos (0.05%), DDVP (0.03%) and chlorpyriphos (0.05%) applied in first and second fortnights of April suppressed bud-borer in sapota.

Jackfruit

Evaluation of improved clones revealed two good clones for table, chip and culinary purposes, nine for table purpose, 4 for making chips and two for culinary purpose. Inarching recorded maximum graft take during September and softwood grafting in October under 50% shade condition. Incidence of leaf-feeding caterpillar (*Margaronia bivitralis*), fruit-borer (*M. caesalis*), spittle bug (*Cosmoscarta releta*), bark caterpillar (*Indarbela tetraonis*) and fruit rot (*Rhizopus artocarpi* and *Aspergillus niger*) and leaf spot were reported from different regions.

Mahua

Vegetative propagation of mahua (*Madhuca latifolia*) by veneer grafting gave more success (80%) followed by cleft grafting (40%) on seedling rootstock.

Arid Zone Fruits

A total of six elite genotypes of ber and 10 of aonla were identified. Ber Chhuhara, Tikadi, Kathaphal, Kharki No. 1, Badami, Manukhi, Gloria and Safeda Rohtak scaped frost injuries. A large collection of bael, phalsa, lasoda, pilu, woodapple and khirni were collected and evaluated. The advanced lines of ber, viz. CIAH-Sel 1 and CIAH Hy.1 continued to show promise for yield, earliness, organoleptic taste and quality parameters. Spraying of calcium carbonate and borax aqueous solution 0.4% Ca + B (mixed) gave promising results by increasing fruit setting and reduction in fruit drop in aonla. The allelopathic influence of aonla leaf extract revealed that mustard crop was sensitive to water-soluble allelo-chemicals of aonla leaf extract, while wheat and mothbean were tolerant to it. The combination of vermicompost and inorganic fertilizers in a 50 : 50 ratio gave maximum fruit yield (42.5 q/ha), plant height and tree volume. Inclusion of bulk organic sources of nutrients increased moisture availability in root zone of pomegranate. In Kinnow and pomegranate, microsprinkler and drip irrigation at 75% CPE gave 75–80% increase in fruit yield, saving 25–30% irrigation water over basin pipe irrigation system. The promising isolates of bioagents CIAH-196 of *P. fluorescens* and CIAH-240 of *Trichoderma* were mass multiplied in both culture and subsequently formulated in talc powder with 1%

- A collection of 92 accessions of sapota was evaluated
- Improved clones of jackfruit were evaluated for edible purposes
- Ber CIAH Sel 1 and CIAH Hy 1 were promising for yield
- Six elite genotypes of ber and 10 of aonla were identified
- The promising isolates of bioagents were mass multiplied

cellulose. This formulated product was tested under field conditions for management of ber powdery mildew. CIAH-196 and isolate CIAH-240 showed high germination(80.1 and 78.5%) as compared to the control (60.5%).

Temperate fruits

Apple Oregon Spur, Golden Spur and Prima gave good yield under rainfed conditions at Mukteshwar in Uttranchal. Apple mosaic effected the yield adversely. Firdous, Shreen, Starkrimson, Green Sleeves, Silver Spur, Mollies Delicious, Cooper 4, American Apirouse, Winter Commercial and Starking Delicious apple were found precocious under Kashmir valley conditions. Walnut landraces, viz. LG-5, LG-10, LG-9, LG-7, LG-11, HN-1, SPS-3, LG-18, PPM-4 and YKB-4 were found promising for nut characteristics. Nut weight ranged from 13.73 to 27.16 g, kernel 7.15 to 12.75 g and kernels recovery from 46.96 to 59.39%. Late-blooming almond landraces, viz. BP-7 and GP-10, identified from Kashmir valley possessed 0.35–1.42 g kernel. The percentage of kernel in these land races ranged from 20.89 to 62.06. Walnut Landrace, LG-5, has a potential for commercial exploitation.

- Apple Oregon Spur, Golden Spur and Prima gave good yield
- Walnut landrace, LG-5, was promising
- Saffron CITH-S_3 clone was most promising

Saffron

The CITH-S_3 clone was found most promising in yield followed by CITH-S_{43} and CITH-B_{76}.

Post-Harvest Technology

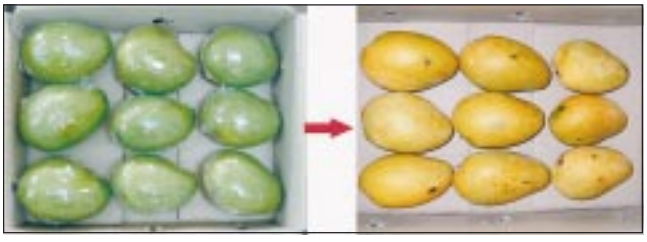
Packaging line for Dashehari mango (1 tonne/hour capacity) was standardized for de-sapping, hot water treatment, washing, drying and grading operations. Protocol for export of Dashehari mango has also been developed. The CFB boxes with 0.5% ventilation were found very effective for prolonging the shelf-life of different stages of mango, i.e. mature green, semi-ripe and fully ripe fruits under cold storage conditions for 24, 10 and 7 days, respectively. Stone jelly formation, a disorder in Dashehari, has been successfully controlled by three pre-harvest spraying of 2% $CaCl_2$ (dihydrate) at 10 days intervals using 0.1% Tween-20 as surfactant. In addition, this treatment also retained more matured fruits and delayed the ripening on tree, by advancement of maturity of fruits.

- The CFB boxes with 0.5% ventilation were found effective
- Individual shrink wrapping prolongs storage life of mango and pomegranate fruits
- The recipe for preparation of guava-aonla blended RTS drink was standardized
- A new protocol was standardized at NRC for Banana
- Several banana-based value-added products were developed

Promising landraces of walnut

Saffron CITH-S_3 clone

Shrink wrapping in pomegranate (*above*) and mango (*below*)



Individual shrink wrapping prolongs storage life of mango and pomegranate fruits. Matured green mangoes of Banganapalli could be stored in fresh, firm and green condition for one month at 8°C by individual shrink wrapping. The fruits ripe normally within a week after unpacking at ambient conditions with good surface yellow

colour, firmness, good taste and without any chilling injury. The storage life of freshly harvested pomegranate fruits of Bhagwa (Kesar), Mridula and Ganesh could be extended to one month at ambient temperature with retention of freshness and quality. At 8°C fruits of Bhagwa and Mridula could be stored for 3 and 2 months respectively without any chilling injury.

The fresh fruits of aonla possessed a high level of antioxidant activity and high content of total phenols (3,189.3 mg/100g), flavonoids (238.4 mg/100 g) and vitamin C (340 mg/100 g). Aonla could be stored for 30 days at 6–7°C with a very little loss to total phenols and flavonoids.The respective radical scavenging activity was 7,349.3, 6,040.6 and 7,293 mg/100 g in fresh fruits 15 and 30 days after storage. Aonla thus appeared to be a very prominent fruit as an antioxidant supplement and also an important constituent of neutraceuticals. Oil-less pickle of aonla could be stored up to 3 months.

The recipe for preparation of guava-aonla blended RTS drink was standardized. It was found that aonla pulp up to a level of 20% could be added to guava pulp for an acceptable quality of drink containing 10% pulp, 12–14 °Brix TSS and 0.28% acidity. The best quality of oilless aonla pickle was prepared with 2.5% added sugar apart from 10% salt, 1% red chilli powder and 1% asafoetida. The pickle could be stored up to 3 months in good condition. After this period, acceptability decreased fast due to high rate of browning and loosening of texture. Aonla juice heated to 80°C, pasteurized and added with 100 ppm KMS, was found to have minimum microbial load as compared to unheated and pasteurized samples. Value-added product like candies and pickles were made from unused rind portion of watermelon by a simple osmosis process and by addition of edible food colours. The candy has good texture, attractive colour, pleasant taste and storability. The product can be used as desserts and fruit salads as well as in chocolates. Candy preparation does not require sophisticated machineries and is an ideal means for generating income from small-scale production by farmwomen.

A new protocol was standardized at NRC for Banana by integrating several post-harvest treatments like, de-handing, heat shock, modified

Fruits of banana Robusta after 90 days of storage

atmosphere packaging and temperature management whereby the storage life of Robusta banana could be extended up to 3 months and Rasthali up to 4 months at 13.5°C and 90–92% relative humidity. At the end of storage period, all fruits could ripe well using ethrel with good eating quality. Several banana-based value-added products like banana fig, banana flower and fruit pickles, ready-to-serve juice, fruit bar, biscuits, flour (powder) and fibres were developed. Most of them have been commercialized and are now being manufactured. Use of banana stem juice as a remedy for renal calculi (kidney stone) is common in Tamil Nadu. A process was developed at NRC for Banana to convert banana stem juice, extracted from whole plant after harvesting of fruits, into a beverage having a storability up to 5 months under ambient conditions. The product is under commercialization by a private entrepreneur.

Tweenty-six varieties developed at IIVR, Varanasi, have been identified for release and notification by Central Varietal Release Committee. They are: Kashi Vishesh, Kashi Amrit, Kashi Anupam, Kashi Hemant and Kashi Sharad (tomato), Kashi Taru (brinjal), Kashi Anmol (chilli), Kashi Param (french bean), Kashi Shyamal

Kashi Vishesh

Kashi Agati

Kashi Pragati

and Kashi Gauri (cowpea), Kashi Mahima, Kashi Mangali, Kashi Vibhuti, Kashi Pragati and Kashi Satdhari (okra), Kashi 2, Kashi 3, Kashi Nandini, Kashi Udai, Kashi Shakti (pea), Kashi Sweta and Kashi Hans (radish), Kashi Kunwari (cauliflower), Kashi Madhu (muskmelon), Kashi Dhawal (ash gourd) and Kashi Harit (pumpkin). A cultivar of *lobia* is becoming popular at farmers fields due to resistance against golden mosaic virus.

At IIHR, Bangalore, tomato hybrid Arka Ananya with resistance to Tomato Leaf Curl Virus (ToLCV) and Bacterial Wilt (BW) was identified for release at national level. Its fruits are round, firm (5.0 kg/cm^2), medium-sized (50–65g) with light green shoulder, the yield being 76 tonnes/ha in 140 days. Suitable for summer and rainy seasons, Arka Anand, a new brinjal hybrid, has resistance to bacterial wilt and identified for release at national level. The fruits are green, medium long (20–22 cm) borne in clusters. The calyx is fleshy and green. Fruits tender with good cooking qualities, it yields 60–65 tonnes/ha in 140–150 days. Two CMS based chilli hybrids, Arka Meghana and Arka Sweta, were identified for release at national level. Arka Meghana is a high-yielding hybrid. Its fruits are long (10–11 cm) with 1.2 cm width, fresh yield 35 tonnes/ha and dry yield of 5.5 tonnes/ha in 140–150 days. Fruits are dark green and turn deep red. Arka Sweta is a high-yielding chilli F_1 hybrid. Its fruits are long (10–12 cm) with 1.1 cm width. Fresh yield is 38 tonnes/ha while dry yield 6 tonnes/ha in 140–150 days. Fruits are light green and turn red after ripening.

- Twenty-six new vegetables were identified
- Tomato hybrid Ark a Ananya and Arka Anand was identified
- Arka Meghana and Arka Sweta chilli were identified
- Chilli local strains were evaluated for Kashmir valley
- Of the 394 primers, 375 produced amplicons
- Primer OPB 16 was useful in determining purity of hybrid NTH 1
- Blanching and drying conditions of okra fruits were standardized

Chilli local strains were identified and evaluated under Kashmir valley conditions. The highest yield of dry chilli was recorded in CC 84 (262g/plant), followed by CC-167 (227g/plant) and CC-39 (202g/plant). The longest fruit was recorded in CC-151 (15.3 cm), followed by CC-132 (15.2 cm) and CC-126 (15.1 cm).

Seedling dipping at the time of transplanting followed by foliar application of bioagents (*Pseudomonas fluorescens*, *Bacillus subtilis* and *Trichoderma harzianum*) at 10 and 15 day intervals, result in lower incidence of disease and enhanced yield in tomato Mruthyunjaya 2. Breakdown of host resistance to tomato leaf curl virus in Mruthunjaya-2 and Avinash-2 was due to occurrence of new strains of virus at different places. The breakdown of resistance in tomato S24 in northern parts was mainly due to occurrence of a new strain of virus which was recombinant of mono and bipartite viruses. Resistance to tomato leaf curl virus has been introduced into four genetic backgrounds, Arka Saurabh, Arka Vikas, Arka Meghali and Pusa Ruby, through pathogen-derived resistance in a transgenic approach. Transgenic tomato Arka Saurabh, Arka Vikas, Arka Meghali and Pusa Ruby have developed resistance to tomato tospo virus (PBNV) through pathogen-derived resistance.

A blend ratio of 100 : 1 of two pheromone components (E)11 : 16-OAc and (E)11 : 16-OH was found most effective in trapping brinjal shoot- and fruit-borer. Pheromone lure set up on water trap was nearly twice more effective as compared to delta traps. Onion Arka Kalyan and SM11 × PBR showed better assimilation rates under water stress conditions, indicating their suitability under water stress. Application of FYM at the rate of 50% of recommended dose of chemical fertilizer equivalent as a combination of organic package for rose onion Arka Bindu yielded 23.12 tonnes/ha, which was at par with yield obtained with the recommended NPK fertilizer applied (23.36 tonnes/ha). Watermelon triploid (seedless) has been developed and evaluated under protected conditions. Its fruits are round, light green with dark green stripes, TSS (12–13%), rind thickness 2.5 cm, pink flesh and very good taste. Average fruit weight is 5–6 kg. Thirteen amaranth lines were evaluated for antioxidants, of which, IIHR-74 recorded maximum total antioxidant capacity (TAOC) of 355 mg/100g AEAC. Flea beetle, *Nisotra* sp. was identified as a major pest in mucuna, which caused severe damage to young plants by feeding and limiting growth of plants, resulting in 60% yield loss.

Molecular markers for hybrid purity testing

Out of 394 primers used for screening of NTH-1 hybrid and its parents (DVRT-1 Flora Dade), 375 primers produced amplicons, of which only six primers showed polymorphism (1.6%) among parental lines. Data of these primers were analyzed to distinguish primer that produced bands specific to male parent. One primer (OPB 16) was found to be useful in determining purity of hybrid NTH-1. This primer generated five amplicons, out of which one fragment of 1193 bp size was male-specific. For hybrid NTH-7, 253 primers were screened, out of which 51 produced amplicons and six of them detected polymorphism (11.8%). Of these six primers, OPB-19 produced an amplicon of size 2,186 bp which was effective in detecting selfed seeds in hybrid seeds as it was male parent specific.

Regeneration and transformation studies

The genotypes, Punjab Sadabahar, Pant Rituraj, DVRT-2, H-24, H-86, Sel-7 and DT-10 were used for regeneration and transformation studies. Seedling explants such as epicotyl, hypocotyl, cotyledon and shoot tip were used. As a standard procedure to obtain explants, seeds were germinated on MS basal medium and

5–7 days old seedlings were utilized. With hypocotyl explant, MS medium in combination with BA and Kinetin and leaf discs MS medium with BA and kinetin were tested. The genotype, H-24 and H-86, gave best regeneration frequency in both explants. H-86 had best regeneration potential, when cultured on MS medium containing BA. This regeneration procedure was used to facilitate gene transfer through *Agrobacterium tumefaciens* in H-86 using *Cry 1Ac* gene from the T-DNA of binary vector plasmid pBinAR, which also contains gene that encodes neomycin phospho transferase II (*nptII*). More than 45 putative transgenic plants were regenerated and are being maintained under laboratory conditions. These plants will be analyzed for integration of gene and its expression. The transformed progenies are being multiplied for further evaluation and bioassay. The number of shoot buds was recorded in genotypes VR Baigan-9 (IVBL-9) and VR Baigan-1 (IVBR-1) (MS + 2 BA + 1.0 Kin). The elongated explants were transferred on MS basal medium and root induction was achieved. This regeneration procedure was used to facilitate gene transfer through *Agrobacterium tumefaciens* in VR Baigan-9 (IVBL-9) using *Cry 1Ac* gene from T-DNA of binary vector plasmid pBinAR, which also contains gene that encodes neomycin phospho transferase II (*nptII*). More than 20 putative transgenic plants were regenerated and are being maintained under laboratory conditions. These plants will be analyzed for the presence of gene and its expression. The transformed progenies are being multiplied for further evaluation and bioassay.

Drying of vegetables

The blanching and drying conditions of okra fruits were standardized. Hot-water blanching treatment at 80 and 90°C for 2, 4 and 6 minutes resulted in no effect on inactivation of catalase and peroxidase enzymes. However, peroxidase enzyme was inactivated after hot water blanching treatment at 90°C for 4 and 6 minutes along with 0.1% magnesium oxide followed by dipping into 0.1% sodium sulfite solution. The catalase and peroxidase enzymes were inactivated after blanching in boiling water for half and one minute followed by dipping into 0.2% potassium metabisulphite solution. The drying condition in okra was standardized with initial drying of blanched okra at 70°C for 2 hours followed by drying at 60°C for 4 hours. Dried okra fruits upon rehydration showed complete discoluration and texture was adversely affected. However, blanched okra dried at 65°C for 4 hours resulted in retention of green colour and better texture.

Precision nutrient management

The pressmud @ 10 tonnes/ha was applied 15 days prior to field preparation and full dose of chemical fertilizers P @ 60 kg/ha and K @ 60 kg/ha coupled with N@ 60 kg/ha and S @ 25 kg/ha were applied at the time of final field preparation. The micronutrients Zn, B, Fe, Cu, Mn @ 100 ppm and Mo @ 50 ppm were applied thrice at 10 days intervals as foliar spray starting from 30 days after transplanting. The Azotobactor were applied as seedling root dip treatment. Full dose of chemical fertilizers except N was applied as basal dressing. The remaining 60 kg N/ha was topdressed in two equal splits.

Management of bitter gourd fruitfly

The efficacy of bait spray on fruit fly (*Bactrocera cucurbitae*) management in bitter gourd was evaluated under field condition during *kharif* season. Bait spray was initiated from 11 September 2004 at 7 days interval. During the post-bait spray period, the impact of bait application was reflected through relative variation in level of fruit infestation caused by fruit fly. Initially, the effect was not much significant. Later on infestation was very low in plots treated with bait spray of molasses. The average post-treatment fruit infestation was significantly less (35.65%) in molasses bait spray, followed by banana pulp (41.96%) and protein hydrolysate (43.24%). However, infestation level between protein hydrolysate and banana pulp was non-significant. Maximum yield (56.39 kg/plot) of bitter gourd was obtained from the plots sprayed with molasses based bait. There was no significant difference in yield between plots sprayed with protein hydrolysate (49.07 kg) and banana pulp (48.43 kg) based bait.

Biocontrol of shoot- and fruit-borer

The egg parasitoid, *Trichogramma chilonis*, was inundatively released @ 2.5 lakh parasitoids/ha with botanical and insecticide for management of brinjal shoot- and fruit-borer (BSFB). The foliar spraying of insecticide/botanicals was applied 10 days after previous release of parasitoid and parasitoids were released 7 days after foliar spray. Initially, relative level of fruit damage between treated and untreated plots was not prominent. However, effect of both the treatments in reducing fruit damage was prominent 90 DAT. On the basis of t-statistics, cumulative fruit damage over all harvesting indicated marginal superiority of both the treatments over the control. There was no significant difference between two *Trichogramma* releases either with botanical or with insecticide.

IPM Strategy for BSFB

Sex pheromone based IPM strategy for the management of brinjal shoot-and fruit-borer was demonstrated at farmers' fields

- Blanched okra retained green colour with better texture.
- A number of organic farming protocols for vegetables were developed
- Organically-grown cabbage Quisto gave yield at par with inorganically-grown one
- Sex pheromone-based IPM strategy for brinjal shoot-and fruit-borer was demonstrated

Kashi Komal

Kashi Shyamal

Development of Organic Farming Protocols

- The nutrient profile (both major and minor nutrients) of FYM, vermicompost, NADEP compost, press mud, biodynamic compost and activated sludge was estimated
- Application of organic nutrients at different doses, i.e. 5, 10, 15 and 20 tonnes/ha and soil nutrient balance sheet for tomato and cabbage was estimated, and found zero balancing for N and K and negative balance for P and S in a Typic Ustochrept soil
- The nutrients present in labile pool after addition of organic nutrients in time scale was determined. It was found that both P and S limiting except in press mud treated plots, while N, K, Fe, Mn, Zn, Cu are adequate.
- A linear rise in tomato yield with the level of organic nutrient supplementation was recorded
- In tomato open-pollinated variety, H-86, under press mud @ 20 tonnes/ha treated crop recorded an average yield of 454 q/ha, at par to its peer inorganically-grown crop.
- Organically-grown cabbage Quisto was at par in yield with its peer inorganically grown crop
- In qualitative traits for tomato, organically-grown crop showed higher percentage of titrable acidity, vitamin C and lycopene content as compared to tomato grown inorganically
- Soil solarization, seed treatment with *Trichoderma*, addition of neem cake and vermicompost in nursery of tomato and cabbage were found effective
- In tomato, incidence of TLCV infection, severity of leaf spot diseases and incidences of fruit rot in FYM, press mud, vermicompost and sewage sludge treated organic block were tested in H 86, DVRT 1, DVRT 2 and Sel 7 varieties. H 86 outperformed others in terms of resistance or escape to diseases

at 3 pilot project sites constituting 5 ha area each at Sultanpur, Salarpur and Basawn villages of Varanasi and Mirzapur districts. The technology was disseminated among brinjal farmers in Uttar Pradesh, Jharkhand, Orissa, West Bengal and Tripura through pilot demonstration, field days, distribution of technical bulletins, CD shows, newspapers, radio and TV documentaries.

The National Mushroom Repository has been enriched by adding 139 new mushroom cultures. Some of which are new records for India. *Tremella* species, a medicinal mushroom was collected from Western Ghats and reported for the first time. Advanced molecular techniques including sequencing of conserved genes were employed for molecular identification and characterization of mushroom germplasm up to species level. The RAPD markers were used as molecular tools for genetic characterization and selection of genetically diverse parents for breeding. A high-yielding single spore selection, SSI-4035, of *Agaricus bisporus* has been recommended for commercial release.

The composting period of *A.bisporus* was significantly reduced from 18 to 12 days and inoculation of selected strains of thermophilic fungi could further hasten the composting process. Coir pith alone and in combination was found as the best casing material. Preliminary trials on organic farming under environmentally-controlled conditions gave appreciable yields at par with other methods. The physico-chemical requirements for *Lentinula edodes* and *Flammulina velutipes* have been worked out. *Agaricus bisporus* and *Pleurotus sajor-caju* were raised in low-cost bamboo and cloth huts with good yield and demonstrated to farmers. Major pests and diseases of cultivated mushrooms were identified. The putative chemical sterilization technique developed for *Pleurotus* cultivation was found unfit for other speciality mushrooms, *Calocybe*, *Agrocybe*, *Lentinula* and *Auricularia* spp. Although, use of biopesticides in mushroom cultivation is advocated, most of biopesticides tested failed to inhibit spore germination of major mycoparasites. The molecular characterization of green mould

- The National Mushroom Repository has been enriched by its 139 new cultures
- A new mushroom *Tremella* species was collected
- A number of off-campus training programmes were organized
- About 400 farmers including NGOs were benefited by mushroom *mela*

Mushroom selection

disorders validated existence of intra-specific diversity in *Trichoderma harzianum* and *T.virens*. The *Ganoderma lucidum* showed that it is capable of producing lignin, cellulose, hemicellulose, protines, pectins and starch degradative enzymes. The cultivation technology of *G.lucidum* was further refined to enhance B.E. up to 22%. Techniques for Modified Atmosphere Packaging (MAP) to improve shelf-life of *A.bisporus* were standardized.

Questionnaires were sent to KVK, research organizations and mushroom growers to validate indigenous technical knowledge about mushroom cultivation. A number of off-campus trainings were organized in north-eastern states. The Mushroom *mela* was attended by 400 farmers, farmwomen, mushroom growers, researchers, extension workers, businessmen and NGOs from all over the country. Databases on different aspects of mushroom cultivation, growers and research personnel have been developed both in the form of CDs and directory. In addition, information on 1,200 mushroom-based postal stamps from 80 countries of the world have been compiled.

Potato

Germplasm collection was augmented by adding 9 parental lines from Sturgeon Bay, Wisconsin, USA, and 27 advanced hybrids from AICPIP, raising the total collection to 2,700 accessions. Three parental lines, QB/A 9-120, QB/B 92-4 and MP/99-322, developed at CPRI, Shimla, have been registered an as elite germplasm by ICAR/NBPGR Germplasm Registration Committee. Excellent tuber keeping quality was observed in 30 accessions, while good chipping quality was found in four accessions after six months of storage at 4°C. A hybrid, MP/98-31, with high dry matter (>22%), early maturity (80 days) and extra dwarfness (height 15–25 cm) was identified. Hybrids, MP/97-583 and MP/97-644, performed well in plains and hills, respectively. Hybrid, MP/97-583, was recommended for release as Kufri Chipsona 3. Advanced hybrids, SM/92-338, SM/93-237 and SM/91-1515, were found promising both in hills and plains. Hybrid, SM/97-1515, was recommended for release in hills as Kufri Himalini.

About 137 hybrids were evaluated and 56 were selected. Hybrids, J 96-278 and J 97-124, produced good quantity of baby potatoes 53 days after planting. Four TPS families, viz. HPS-26/54, HPS-32/54, HPS-44/13 and HPS-47/54, were found promising. A full-length ADPGlc pyrophosphorylase (glgC) gene was cloned from *E. coli* K12 strain and mutated by site-directed mutagenesis. Post Transcriptional Gene Silencing (PTGS) transgenic lines of Kufri Badshah were developed using *Agrobacterium* - mediated genetic transformation to identify transgenic lines of Kufri Badshah having resistance to bacterial wilt and late blight. Likewise, 14 transgenic lines tolerant to cold induced sweetening were identified.

- A database were developed
- Kufri Chipsona 3, a new chipping potato, was released
- Four TPS families were found promising
- Fourteen potato transgenic lines tolerant to cold were identified
- A hybrid was released as Kufri Himalini

Precision fertilization based on soil test increased fertilizer-use efficiency and benefit : cost ratio by 109 and 3.3%, respectively, over the recommended fertilization without affecting tuber yield. Winter potato acreage and production in India were assessed using Advanced Wide Field Sensor (AWFS) data from Indian Remote Sensing Satellite (IRSS) in collaboration with Space Applications Centre, ISRO, Ahmedabad. In northern plains, green manuring saved 61–139 kg N/ha under different potato cultivars. Kufri Badshah was poor user of N, whereas Kufri Sutlej has highest capacity to use N from green manure. Integrated use of 100% N (inorganic) and 50% P and K from inorganic fertilizers and balance from FYM was best for tuber yield, macro and micronutrients uptake and improved proteins and vitamin C under rainfed conditions in midhills of Shimla. In north-western plains, combination of 25 and 75% of NPK through vermincompost and inorganic fertilizer gave highest tuber yield in Kufri Anand and Kufri Chipsona 1, respectively.

Potato Kufri Chipsona 3: Ideal for Processing

Potato Kufri Chipsona 3, a superior chipping hybrid, is an improvement over hitherto very popular processing cultivars, Kufri Chipsona 1 and Kufri Chipsona 2. Its tubers having high dry-matter content of 22% or more, results in crispy low oil chips. The hybrid produces superior quality chips as evident by industrial frying. The chips are free from all internal and external defects with negligible browning. The hybrid is robust during storage at intermediate temperatures, as shown by superior quality chips made even after six months of storage.

In furrow irrigation, 38% saving in irrigation water was achieved by applying water to alternate furrows at the expense of 10.8% decrease in yield, which was further minimized to 6.2% with paddy straw mulch application. Sprinkler fertigation with N economized 25% of N dose along with water economy in irrigation water. Fertigation with N and K saved 40 kg N and 50 kg K_2O/ha beside 40% saving in irrigation water. In Indo-Gangetic plains (Modipuram), production of organic potato varied from 273–363 q/ha in Kufri Sutlej and 316–399 q/ha in Kufri Anand, when 180, 80 and 100 kg N, P_2O_5 and K_2O/ha were supplied through vermincompost. Adoption of biodynamic approach of nutrients application also reduced underground water pollution due to NO_3 leaching.

Two potyviruses isolated from *Solanum nigrum* and *Physalis floridana* were identified as Chilli vein banding mottle virus and PVY^N, respectively, based on sequence of coat protein genes. Print capture and immuno-capture based RT-PCR for detection of PVY and PLRV were standardized. Accessions, CP1444 and 1492, showed resistance to PVX, while 1492, 1342, 1574, 2012 and 2037 to PVY for second year. One *Fusarium* sp. from russetted tubers causing disease was isolated from potato sprouts, whereas eight isolates of *Actinomycetes* spp. isolated at Shimla did cause scab-like lesions on tubers but pathogen could not be re-isolated from diseased tubers. Adverse effect of water stress on russet disease was confirmed. Though *Trichoderma viride*, *B. subtilis* and *B. cereus* were effective in reducing incidence and severity of black scurf, their combination with 1 or 2% boric acid did not provide any additional advantage over only 3% boric acid. Accessions, NJ-12 and NJ-75, were found promising against PTM whereas hybrid, E/79-42, showed high resistance to potato cyst nematode under greenhouse at Ooty. Spraying potato crop with imidacloprid + summer oil or Thiomethoxam + summer oil was best in controlling white flies and leaf-hopper in early crop and aphids in main crop at Modipuram.

Single applications of CIPC fog in heaps significantly reduced sprouting and sprout growth in tubers up to 100 days of storage. Double application, in addition, reduced total storage losses also. Single spray application of CIPC also remained equally effective up to 70 days. Acceptable chip colour of 3 or below was observed in two advanced hybrids, viz. MP/97-583 and MP/97-644 after six months of storage at 10–12ºC with two CIPC fog treatments. Weight loss was within the acceptable limit of 10% after 120 days of storage at 8, 12 and 16ºC with CIPC, but the chip colour deteriorated in all cultivars. Two doses of irradiation (0.1 and 0.5 kGy) were as effective as CIPC in checking sprout growth. Reducing sugar content decreased with 0.5 kGy as compared to CIPC at 8 and 12ºC.

Tropical Tuber Crops

Six new varieties of tuber crops were recommended for release by State Sub-Committee on Variety Release and Crop Standards, Orissa, for cultivation in Orissa. They are: Goutam (20–30 tonnes/ha, 105–110 days), Sourin (16–32 tonnes/ha, 105–110 days) and Kishan (17–26 tonnes/ha, 110–120 days) (sweet potato); Panisaru 1 (16 tonnes/ha, 180–210 days) and Panisaru 2 (13 tonnes/ha, 180–210 days) (Colocasia) and Orissa Elite (yield 22–25 tonnes/ha; 180 days) (greater yam). Two triploid hybrids of cassava, 4-2 and 5-3, were identified for higher and stable starch yield (29–32%) and tuber yield (36 tonnes/ha) from on-farm trials conducted at six locations in three districts in Tamil Nadu under irrigated conditions.

Protocol for regeneration of popular cassava, H 226 and H 165, through somatic embryogenesis was standardized. High frequency somatic embryogenesis was induced in MS medium supplemented with picloram (50 µM). Regeneration of normal plants was obtained by transferring embryogenesis callus to MS medium supplemented with BAP (2 µM) + NAA (1 µM) followed by culture in hormone-free medium. Cloning of ICMV coat protein gene in bacterial expression vector was done. Serological and nucleic acid based techniques for detecting viruses infecting cassava, sweet potato, yams and elephant-foot yam were standardized. Yam and elephant-foot yam-growing areas in Andhra Pradesh and Orissa were surveyed for disease incidence. During *kharif* season, anthracnose caused by *Colletotrichum gloeosporioides* was found to be severe which caused die-back in a local variety in sandy soil in Orissa. In Andhra Pradesh, severe mosaic symptoms were found in *D. alata* variety Bombay Yam. In elephant-foot yam, leaf rot caused by *Selerotium rolfsii* was observed. Deep ploughing with chisel plough, ridge planting, application of neem cake and *Trichoderma* and proper drainage were found to be effective in reducing the incidence of cassava tuber rot. Leaf curl virus infection in sweet potato was diagnosed and detected through PCR and NASH.

- Six new tuber varieties were recommended for Orissa
- Protocol for regeneration of popular cassava varieties was standardized
- Leaf curl virus in sweet potato was diagnosed and detected through PCR and NASH
- Growing of elephant-foot yam organically was on a par to conventional practices
- Over 4,000 collections of 16 species of tubers were maintained
- IGSP-11, an accession of sweet potato, gave highest carotene content

Green manuring *in situ* with cowpea C 152, application of indigenous rockphosphate (Mussoorie phosphate) and use of biofertilizers (*Azospirillum* and *Phosphobacterium*) could save about Rs 3,000/ha in the cost of production of cassava. Cassava genotypes, CE-33, CE-54 and CI-308, could yield more than 30 tonnes/ha under drought conditions of Tamil Nadu. For continuous cultivation of cassava, a fertilizer dose of NPK @ 75 : 37.5 : 75 kg/ha was found to be sufficient under rainfed situation of Kerala. *Pseudomonas fluorescence* was found to be efficient in elaboration of hydroximate type of siderophore. Organic farming of elephant-foot yam resulted in an yield of 66 tonnes/ha on a par with the conventional practice, but significantly high over traditional practice (50 tonnes/ha). Chinese potato responded up to 100 kg N/ha producing a tuber yield of 12.5 tonnes/ha.

Texture profile analysis was done on germplasm accessions of cassava. They were grouped based on textural properties. Also texture profile studies were done on food products from different cassava flour-based formulations. Cold water miscible starch technology from cassava was perfected and the product was released under the name 'Texcool'. An instant gulab jamun mix was made from sweet potato and product was released under the name' 'Nutrigulab jamun mix'. Mucilages were characterized from taro, tannia and yams. These were found to have pharmaceutical effects like serum lipid and triglyceride lowering action. New proteins synthesized in taro plants, as a consequence of water stress were characterized through gel documentation studies.

Farmers participatory evaluation of cassava in tribal settlements of Pachamalai and Siddheri hills of Tamil Nadu indicated that cassava entries, 9-1, 14-4, CI 800, CI 138, U-1 and KM-94, gave relatively high starch (27–29%) and tuber yield (30–32 tonnes/ha) compared to popular cassava H 165 (starch 25%; yield 28–30 tonnes/ha). Techno-economic feasibility reports on cassava starch as well as sago was completed and is being sold. Total Factor Productivity of cassava in Kerala was estimated to show a declining trend.

Over 4,000 collections of 16 species of tuber crops were maintained at 12 centres. Twenty-two sweet potato, three colocasia, two elephant-foot yam, four each of swamp taro, taro, and giant taro and one each of Xanthomonas and yam were newly added to germplasm at different centres. Accession IGSP-11 (sweet potato) registered highest carotene content of 13.31 mg/100 g. In cassava, application of half P + full N and K + FYM + phosphate-solubilizing bacteria (10 kg/ha) recorded significantly superior tuber yield (26.6 tonnes/ha) followed by application of half P + full N and K + FYM + AM fungi (10 kg/ha) which was superior to treatment with recommended dose of NPK. In elephant-foot yam, growing cowpea as green manure crop and incorporation *in situ* recorded highest yield of 47 tonnes/ha followed by polythene mulch treatment (35.77 tonnes/ha).

Pusa Gaurav and Arunima (rose); Hyb. 84-7-11, 86-3-4, 84-4-8, Arka Kesar, 87-22-1, Swarnima and Shagun (gladiolus); Baggi (Chrysanthemum); and Prajwal and Vaibhav (tuberose) performed well at many locations. Eco-friendly management strategy for control of two-spotted spider mite, *Tetranychus urticae* on rose in polyhouse, bioagents and botanicals were developed. Predatory mite, *Amblyseius tetranychivorus* @ 20/plant significantly reduced population (94.73%). Entomopathogenic fungus, *Verticillium lecanii* at 3g/litre was effective resulting in 61.13% reduction in population. Among various plant extracts tested, prickly poppy and pongamia oils at 1% caused 80–85% mortality, while pongamia oil in combination with garlic at 1% (1 : 1) caused 88% mortality. About 400-200-200 ppm NPK/plant/week in rose gave more number of flowers with better stalk length.

- Rose Pusa Gaurav and Arunima performed well
- The CS 1, a carnation hybrid, was developed
- Four pruning treatments in jasmine were satisfactory in overcoming season barrier

Carnation

Carnation CS-1, an interspecific hybrid of *Dianthus caryophyllus* and *D. chinensis*, has been developed which was found promising as a mini carnation. This can be cultivated in open field without any support. Planting carnation under cover with 200 ppm N in April was good for quality flower production.

Jasmine

To overcome season barrier in jasmine, four pruning treatments (August, September, October and November) prolonged flowering, while staggered pruning at monthly intervals resulted in continuous flowering during the lean season.

The $Al_2 (SO_4)_3$ (300 ppm) was useful for pulsing and $Al_2 (SO4)_3$ + kinetin (25 ppm) + sucrose (5%) as holding solution for anthurium; $Al_2 (SO_4)_3$ (1,000 ppm) for gerbera; $Al_2 (SO_4)_3$ (300 ppm) + sucrose (4%) + NaOCL (bleach, 25 ppm) for gladiolus; and $Al_2 (SO_4)_3$ (300 ppm) + sucrose (10%) for 8 hour pulsing of carnation or STS (50 ppm) + 8-HQC (50 ppm) + sucrose (2%) as holding solution for carnation had good promise. Good spike length can be obtained by employing BA 100 ppm and GA_3 50 ppm in Dendrobium Sonia 17. For gladiolus *Fusarium* wilt, Benomyl (0.2%), Carbendazim (0.2%), Thiram (0.3%) and Captan (0.3%) were found best. Kavach (0.2%) against *Botrytis* grey mould of rose and gladiolus, and Dithane M45 against gladiolus were reported best. Benomy (0.2%) was found best for controlling *Sclerotium* wilt of tuberose. *Trichoderma harzianum* (20 g/m^2) followed by Benomyl (0.1%) + Captaf (0.2%) was effective against gerbera rust rot. Monocrotophos (0.2%) against *Aphelenchoids* foliar nematode of tuberose and Chlorpyriphos (0.2%) against *Helicoverpa* infestation of carnation are quite effective.

Coconut

Coconut germplasm was strengthened by adding 12 distinct coconut types. These included tender nut varieties, Uddha Gangapani and Chitta Gangapani, and another rare type from Bassakal, Bassakal Orange Dwarf, bearing elongated orange fruits. A mutant

coconut palm was identified at farmers' plots in Kasaragod district. In coconut, plantlets regenerated from plumular tissues of Tall (WCT) and Dwarf (CGD, MYD) cultivars were field planted at Kasaragod. A total of 125 plantlets retrieved from exotic embryos collected from Sri Lanka and 91 plantlets from Bangladesh were field planted at Kidu. Cryopreservation of WCT embryos gave maximum retrieval after 18 hours desiccation in silica gel or 24 hours desiccation in Laminar Air Flow. The young inflorescences (10–12 cm in length) extracted from mature trees and rachilla explants of about 10–15 mm length cultured on media containing Picloram, TDZ and high level of sucrose in dark resulted in transformation of floral primordia into shoots. Ten farmers' varieties and five germplasm accessions were characterized by microsatellite primer analysis, which resulted in molecular marker data. Nei's gene diversity varied from 0.010 in Pathitennampattai Vayalar Green Dwarf (VGD) to 0.582 in Pallikere Kuttiyadi Tall. Proportion of heterozygotes varied from 0.000 in Chowghat Green Dwarf (CGD) to 0.448 in Kappadam Tall.

Higher nut yield in coconut was obtained when 50% of the recommended dose of fertilizer was applied through drip irrigation (102 nuts/palm/year) though it was on a par with 75% (99 nuts/palm/year) and 100% (97 nuts/palm/year) of fertilizer applied through drip irrigation and 100% (101 nuts/palm/year) of fertilizer applied through conventional soil application in coconut gardens raised in sandy loam soil. In coconut-based high-density multispecies cropping systems, coconut yield ranged from 165 nuts/palm/year under one-fifth of the recommended fertilizer dose to 184 nuts/palm/year at one-fourth of the dose. The net return was highest when two-thirds of the recommended fertilizer dose (Rs 152,465) with a benefit : cost ratio of 3.83. Bajra napier fodder grass (CO_3) (96.83 tonnes/ha) and pumpkin can be successfully grown as intercrops in coconut gardens raised in coastal littoral sandy soils. One layer of dried coconut husk buried in trenches and planting of grass, resulted in higher green fodder yield, whereas pumpkin yield was higher with coir pith application.

Chowghat Green Dwarf (CGD) and Malayan Green Dwarf (MGD) were identified as resistant to root wilt disease. Both of them showed lowest disease incidence. However, MGD is better than CGD because of its higher yield and large size of nuts. MGD recorded maximum nut yield of 57 nuts/palm/year with copra content of 185 g/nut, oil content of 65.5% and oil yield of 1.2 tonnes/ha. MGD has good quality, sweet and tasty and more quantity of tender nut water (200 ml/nut). Large-scale cultivation of MGD will substantially increase coconut production and its productivity in the root (wilt)-prone tracts of Kerala.

Enzyme Linked Immunosorbent Assay (ELISA) was refined to a more rapid and highly sensitive diagnostic test. In the modified procedure, results could be obtained within 24 hours. The test is very economical, requiring only 1 ml primary antibody for testing 1,200 samples with replications. The test is widely used for selecting root (wilt) disease-free coconut mother palms for developing root (wilt) disease resistant/tolerant varieties. RAPD characterization of isolates of *Ganoderma* causing stem bleeding in coconut was done using OPA 01, OPA 02, OPA 03, OPA 04, OPD 03, OPD 04, OPA 11, OPA 18, OPF1 and OPG 15. Variation was observed in almost all the primers except OPD 03 and OPF1.

Vermicomposting trials with a 3 : 1 ratio of coconut leaves and banana pseudostem/pineapple/sugarcane bagasse/glyricida leaves showed that the earthworm *Eudrilus* sp. is able to compost these substrates efficiently. During vermicomposting of coconut leaves in cement tanks placed in the field, vermicompost turnover, *Eudrilus* number and worm biomass harvested were found to be negatively correlated to atmospheric temperature (–0.87, –0.74, –0.74 respectively) and positively correlated to relative humidity (0.89, 0.79, 0.79 respectively). Vermiwash prepared from coconut leaf vermicompost increased fresh biomass weight (36%), nodule number (30%) and nodule fresh weight (43%) in cowpea, when applied to soil. In maize, increase in cob yield (5–10%), and fresh cob weight increase (29–64%) was recorded in vermiwash-

- Coconut germplasm was strengthened by adding 12 distinct types of coconut
- A number of germplasm accessions were characterized by microsatellite primer analysis
- Bajra napier fodder grass and pumpkin were ideal intercrops in coconut gardens
- Chowghat Green Dwarf and Malyan Green Dwarf coconut were resistant to root wilt
- The ELISA was refined as a more rapid and highly sensitive diagnostic tool
- A prototype electronic water salinity detector was developed.
- A coconut chip slicer was fabricated
- Training programmes on drying of copra were conducted

Income-generating Programmes

The CPCRI, Kasaragod, successfully implemented a poverty-reduction programme sponsored by IPGRI/COGENT entitled "Developing Sustainable Coconut-based Income-Generating Technologies in Poor Rural Communities" in two coconut communities, viz. Ariyankuppam (East Coast) and Pallikkara (West Coast) during 2002–04. The communities realized additional net return of Rs 4,000–30,000/ha by means of intercropping of cereals and vegetables in coconut gardens. The community could also earn a profit of Rs 1,000 through the sale of Snow Ball Tender Nuts and Rs 6,700 through the sale of coconut chips. The farmers also produced 1,800 coconut seedlings and realized a profit of Rs 9,000.

applied plants. Okra yield could also be enhanced from 21.6 to 33%.

Root feeding of neem formulation containing Azadirachtin 5% @ 7.5 ml mixed with equal quantity of water caused 76% reduction in eriophyid mite incidence in coconut. Maximum mite population were recorded in sample nuts collected from the field during March–May.

A prototype electronic water salinity detector was developed to measure salinity of water with graphite electrodes as conductivity sensors. A coconut chip slicer has been fabricated and trials are being conducted. The know-how of 'coconut chips making' has been transferred to five entrepreneurs, and technology of snowball tender nut to two entrepreneurs. One training programme was conducted for farmers on product diversification of coconut at Calicut. Training programme on drying of copra using copra dryers was also conducted to five Kudumbasree units (women empowerment programme). Fresh coconut kernel and paste prepared from fresh kernel gratings were canned in canning industry for testing its shelf-life. Gas formation was observed in the control cans, whereas treated cans were free from fermentation.

Arecanut

A total of 126 germplasm accessions were characterized using different molecular markers, RAPD, ISSR and SSR. Repeatable protocol for somatic embryogenesis of arecanut Mangala, Sumangala, Mohitnagar and South Kanara Local from various tissues has been standardized.

The application of fertilizer at the rate of two-thirds of recommended fertilizer through drip irrigation once in 20 days gave maximum yield (7,112 kg chali/ha) as compared to soil application of full recommended dose (6,549 kg chali/ha). In cultural-cum-manurial long-term experiments, higher nut yield (102 nuts/palm/year) was recorded when organic manures + inorganic fertilizers were applied with two tillages, under rainfed conditions in red sandy loam soils, which was 155% more compared to the control. The substitution of chemical fertilizer with vermicomposted areca wastes on nutrition and productivity of arecanut showed that 100% vermicompost alone could supply full nitrogen requirement of the crop.

In arecanut plantation, lemon grass, palmarosa, vetiver, basil, davana, patchouli, long pepper, shatavari, brahmi, periwinkle, aloe and *Nilagirianthus ciliatus* performed better as intercrops. Eleven turmeric cultivars were evaluated in areca-based cropping system in Sub-Himalayan Terai Region of West Bengal. Turmeric Suguna gave highest yield (29.04 tonnes/ha) followed by CLS-2A (27.41 tonnes/ha) and Kasturi (26.22 tonnes/ha) under areca shade. The variety Suguna was also found to be tolerant to *Cercospora* leaf spot under partial shade of areca canopy.

SUCCESS STORY

Quality Copra Making

The farmers in Kasaragod district generally follow either sun-drying or use local copra choola for making copra. In these methods, copra is contaminated with dust as well as smoke causing discolouration of copra, which in turn leads to poor quality of coconut oil due to rancidity. This could be overcome by the use of copra dryers of different capacities. The KVK is popularizing copra drying technology developed by CPCRI, Kasaragod. Copra drying technology helps farmers to utilize dry agricultural waste as fuel; controlled combustion ensures economic use of fuel, drying can be done during monsoon season, smoke-free copra can be obtained; good quality oil can be extracted fetching premium price. This was mainly taken up by Self Help Group (SHG) of women organized under the local self-help group government programmes. The KVK Kasaragod, organized a total of 106 training programmes with the participation of 2,236 trainees including practicing farmers, farmwomen, rural youth, and extension functionaries. Of these training courses, 50 were on-campus and 56 off-campus, wherein 873 (313 men and 560 women) and 6,363 (632 men and 5,731 women) trainees participated, respectively.

Cocoa

Five high-yielding and drought tolerant lines of cocoa were identified. Hybrids I-56 × II-67, ICS 6 × SCA 6 and clone NC 45/53 recorded high dry bean yields of 1.48, 1.12 and 2.5 kg/tree/year respectively. Hybrids II-67 × NC 29/66 and II-67 × NC 42/94 with 1.45 and 1.25 kg dry bean yield/tree/year respectively were drought tolerant. These varieties are suitable for cultivation in Karnataka, Andhra Pradesh, Tamil Nadu and Kerala. Softwood grafting technique for cocoa was standardized and a total of 280,850 grafts of high-yielding clones were supplied to farmers, demonstration farms, regional nurseries and developmental agencies. In seedling progenies, the height of main stem may be maintained at 1.0–1.5m, before allowing the first jorquette. When budded-clonal planting material is used, it is advisable to keep 2–3 strong upright stems for good pod yields. Bean yield was positively correlated with plant canopy area and leaf area.

Oil Palm

Ganoderma disease incidence was observed in oil palm gardens raised in the vicinity of coconut gardens, palmyrah plants and

- The RAPD, ISSR and SSR (molecular markers) were used for arecanut
- A number of suitable intercrops for arecanut cultivation were identified
- Five high-yielding and drought tolerant cocoa lines were identified
- Softwood grafting technique has been standardized

cashewnut gardens. The fungal growth was more on malt extract agar compared to potato dextrose agar and Czapek dox agar media and in acidic pH than in alkaline pH. *Trichoderma harzianum* was found more effective than *T. viride* and *T. hamatum* against *Ganoderma*. The insecticides were more dangerous to oil palm pollinating weevil population as compared to bioagents. At high temperature and low relative humidity during summer no weevil population was observed in oil palm plantations. This leads to heavy bunch failure or bunch abortion.

Photosynthesis and related parameters were measured using portable photosynthesis system in ninth leaf from 7.00 AM to 5.00 PM. The photosynthetic rate ranged from 10.07 to 0.64 mmols/m^2/second The highest photosynthetic rate was observed during 9.00–10.00 AM and decreased thereafter with increase in leaf temperature. The lowest photosynthetic rate was observed at 5.00 PM. Maximum transpiration rate and stomatal conductance were observed at 7.00 AM and decreased with increase in leaf temperature. The photosynthetic rate, transpiration and PAR decreased from 3.00 to 5.00 PM. Photosynthetic water-use efficiency was highest at 9.00 AM and decreased as the day proceeded. A settling and sedimentation tank of 75 cm depth was designed and fabricated for conducting studies on settling characteristics of POME in the laboratory. The total solid sludge and residual oil were estimated and per cent oil and sludge removal/accumulation at different depths were derived and plotted against time.

Cashew

A total of 320 cashew accessions were evaluated. Cashew accessions collected from North-Eastern Hilly region (13) and Puttur (3) were planted in National Cashew Field Gene Bank bringing the total number of accessions conserved to 494. A total of 1,274 diverse germplasm accessions have been conserved in Regional Cashew Field Gene Banks. Cashew hybrids, H-1250, H-2438 and H-2453, were found promising at Puttur with a cumulative yield of 37.22 kg/tree (10 harvestings), 18.40 and 17.28 kg/tree (6 harvestings). About 47 F_1 hybrids were obtained from nine cross combinations at Bapatla centre. At Bhubaneswar centre, 813 hybrid seedlings were planted. A total of 666 hybrid nuts were obtained at Chintamani from 57 crosses. At Vengurle and Vridhachalam, 175 hybrid seedlings and 193 hybrid nuts were obtained from 22 and 9 cross combinations, respectively.

Rootstocks of Taliparamba-1, Brazilian dwarf, Koddippady-2 and H-4-7 were established in greenhouse and *in vitro* cultures (nodal cuttings) were initiated in Brazilian dwarf and Taliparamba-1. A total of 10 accessions including four species of cashew, cultivars of *Anacardium occidentale* and interspecific hybrids were screened for isozyme pattern of 14 enzymes. Pectin extracted from cashew apple pomace (2.59%) contained Ca, Mg, K, Na and Fe.

Eight training programmes were organized for farmers which included demonstration and farmers' meet (2), thematic campaigns on soil and water conservation measures, high- density planting and pruning in cashew (2), thematic campaigns on plant protection in cashew (2), skill training on vegetative propagation of cashew (1) and a cashew day (1). A total of 700 farmers were trained. Seven trainers' training programmes were organized which included cashew production technology (5), vegetative propagation of cashew (1) and pruning and top working in cashew and composting of cashew biomass (1). A total of 70 officials of development departments were trained. Socio-economic impact of cashew cultivation in Kannur district of Kerala was assessed apart from collecting training needs and constraints in cashew cultivation by cashew growers.

The spices germplasm was enriched by addition of 97 accessions of *Piper* spp., 9 of ginger, 11 of *Curcuma* spp; 25 of *Garcinia* sp; 6 of *Cinnamomum* sp; 2 of *Myristica beddomeii;* 11 of indigenous and 5 of exotic germplasm of paprika-alike chilli and paprika. *Piper nigrum* with bold berries, *P. argyrophyllum*, with long spikes and *Piper hymenophyllum* with profuse hairiness were important accessions of *Piper* spp. added to the gene bank.

Fifty cultivar accessions of black pepper were characterized and evaluated based on IPGRI descriptors. One accession of *Piper nigrum* collected from natural forests of Nelliampathy (Palaghat district) has been registered as a unique germplasm for its high oleoresin content (28.15%) and bold berries (INGR. 04111 and IC-370011). Seven elite black pepper lines, IISR Girimunda, HP-728, HP-780, IISR Malabar Excel, HP-1411, OPKm and IISR Thevam, were discriminated using RAPD markers and morphological characters. Inter Short Sequence Repeat (ISSR) Markers were found to discriminate *Piper* species, *Piper* hybrids HP 780 × *P. nigrum* (wild), IISR4176 × IISR 430, Panniyur 1 × Karimunda and their parents. Yield evaluation of 10 black pepper lines, OPKm. HP-780, HP-1411, Coll.1041, HP-1, HP-2, Coll. 4133 Coll. 1365 and Coll. 889 along with Sreekara (control) revealed superiority of OPKm, HP-1411 and Coll. 1041, yielding 4.05, 3.87 and 4.14 kg (fresh berries)/vine respectively as compared to Sreekara which yielded 2.94 kg/vine.

- The germplasm of spices was enriched by adding new accessions of many spices
- Fifty accessions of black pepper were documented based on IPGRI descriptors
- Various accessions of black pepper were found promising for essential oil, while others for oleoresin

Black pepper accessions, Acc. 1637, Acc. 1566 and Acc. 1493,

contained 4% oil, while Acc. 1602 contained 19% oleoresin, followed by KS-127, 4073 and KS 147 with over 16%. W-3001 contained 5.6% piperine, followed by HP-1523 with 4.3% and Acc. 836, 1261 and KS-139 with more than 3.6% piperine. In drought susceptible black pepper accessions, chlorophyll fluorescence started declining on increasing the stress intensity, while tolerant accessions showed relatively stable values. Correlation between black pepper yield and weather parameters (weekly rainfall, maximum temperature and maximum relative humidity) was established with multiple regression models. Weekly rainfall during crop period (June–January) had a positive association with yield (R^2=0.834), whereas weekly maximum temperature during crop period had negative relationship with yield (R^2=0.6113). Maximum relative humidity showed negative relationship during initial 18 weeks with subsequent positive association (R^2=0.9997).

- Molecular profiling was done in cardamom
- Ginger accession, Acc 578, from Nepal gave highest yield
- Ginger and turmeric were cultivated organically by applying FYM, vermicompost, ash and rockphosphate
- The C_5, a line of cassia, was found superior in yield, bark oil, leaf oil and bark oleoresin
- A new disease on vanilla was identified first time from the country
- Planting material of different spices was distributed among farmers

Raising of rooted black pepper cuttings in potting mixture applied with *Trichoderma* and application of *Pseudomonas fluorescens* strain IISR 6 at the time of planting and one and two months after planting in polythene bags is recommended for the production of healthy black pepper rooted cuttings.

Phytoplasma with phyllody symptoms was detected in black pepper using PCR. A 1.20 kb DNA fragment encoding portion of phytoplasma 16S rDNA consistently amplified by nested PCR was cloned and sequenced. The sequenced region contained 1,230 nucleotides. Sequence analyses showed that the gene was most closely related to members of aster yellows group (16Sr I) of phytoplasma. Citrus mealybug commonly found associated with black pepper was shown to transmit the Badnavirus associated with stunted disease. The transmission of virus was confirmed by symptoms and PCR using Badnavirus specific primers. Wild accessions Acc. 3283 and Acc. 3290 and one hybrid (HP 125) of black pepper were found to be resistant to *R. similis*. Field evaluation of promising accessions confirmed the resistance of Acc. 820 (IC No. 316481), Acc. 1090 (IC No. 316635) and HP 39 to *R. similis* infestation.

Larvae of *Spalgis epius* were observed to predate on root mealybug colonies of black pepper in field in Calicut and Wyanad districts. Squash (*Cucurbita moschata*) indicated its suitability for mass culturing of *Planococcus* sp.

In cardamom, molecular profiling using RAPD, ISSR and PCR-RFLP revealed two major divergent clusters, Kerala collections and Karnataka Collections. *Amomum subulatum* and *A. microstephanum* were found clustered with *Elettaria cardamomum*, indicating that *Amomum* is closest to cultivated cardamom. Field reaction of 42 cardamom entries against leaf blight (*Colletotrichum gloeosporioides*) showed that while glabrous selections of Malabar type MA-15, MA-18 and MA-20 were moderately resistant, compound panicle types, CP-9 and CP-2 were resistant to the disease. The most popular land race Green Gold (Neljiani Gold) also showed resistance to disease. Three cardamom accessions (CP, HY-2 and NHY-2) had high levels of essential oil (7.8, 6.8 and 6.4% respectively). Four collections (CP1, NKE 19, RR1 and NHY-15) with bold capsule size recorded high biomass and low relative water content. Drip irrigation @ 8 litres/clump/day recorded higher yield (575 kg/ha), followed by sprinkler irrigation once in 12 days (395 kg/ha) and once in 15 days (378.8 kg/ha). Thus, irrigating cardamom with drip (8 litres/clump), daily or sprinkler irrigation once in 12 days leads to higher yield in cardamom. Cardamom plots with contour staggered trenches (2 m × 0.45 m × 0.30 m) in alternate rows recorded less run-off (43.8 mm) and soil loss (148.09 kg/ha) compared to unplanted treatment (fallow), wherein maximum run-off (216.0 mm) and soil loss (944.12 kg/ha) were recorded. In trials with trench system of planting less run-off (10.8 mm) and soil loss (66.34 kg/ha) were recorded.

Ginger accession, Acc. 578, from Nepal gave highest yield (15.25 kg/3 m^2) with a dry recovery of 23.5% and fibre content of 1.5%. Acc. 162 was found to be superior to others in oil content (2.3%). The critical levels of Zn were found to be 2.1 mg/kg for soil and 27 mg/kg for foliar concentrations. Ginger and turmeric were cultivated organically by applying FYM, vermicompost, ash and rockphosphate, and *Pseudomonas* sp. as biocontrol agent for rhizome rot disease control. The mean yield recorded in ginger Varada was 7.5 kg/3 m^2 with a reduction of 26 and 22.8% rhizome yield as compared to chemical and integrated farming, respectively. In turmeric Alleppey, a mean yield of 15.5 kg/3 m^2 was recorded under organic cultivation with a reduction of 15.3% rhizome yield as compared to conventional system.

Three different curcuminoids (curcumin, demethoxy curcumin and bis demethoxy curcumin) could be separated from oleoresin of turmeric rhizomes by employing chromatographic techniques. Purity was confirmed based on UV absorption maxima, which were identical to authentic values. Cytological analysis of true turmeric seedlings of mother lines (Acc. 126) revealed a somatic chromosome no. of 84 or 78. Turmeric accessions, 773, 715, 772, 781, 727 and 445, had higher levels of oleoresin and curcumin

Promising *Gucinia morella*

(<5%). Turmeric was identified as one of the hosts of *Ralstonia solanacearum*. When *Pythium*, *Ralstonia* and *Fusarium* were inoculated simultaneously, symptoms of bacterial wilt incited by *Ralstonia* were found to be dominating in ginger. Among 93 putative endophytic bacteria isolated from ginger and turmeric rhizomes, 19 were found to inhibit rhizome rot pathogens (*Fusarium oxysporum*, *Pythium myriotylum*, *P. ultimum*, *Rhizoctonia solani* and *Ralstonia solanacearum*). For large-scale disinfection, rhizome solarization methodology was modified wherein the bulk of the ginger rhizome material was spread on a polythene sheet (100–200 kg) directly under sunlight. The rhizomes were covered with another sheet of polythene and borders were sealed with wet soil. The lethal temperature for *Ralstonia solanacearum* was achieved within 60 minutes when the rhizomes were exposed from 12.00 noon onwards. This methodology is easy and can accommodate large volume of rhizome material for heat treatment at a time.

Storage of ginger rhizomes in dried leaves of *S. nux-vomica* alone, *G. pentaphylla* alone, *S. nux-vomica* + sawdust (1:1) and *G. pentaphylla* + sawdust (1:1) were as promising as storage in sawdust alone. *In vitro* screening of endophytic bacteria for nematicidal activity indicated that mortality of nematodes ranged from 0 to 31.03%. Among root-knot resistant turmeric and ginger accessions, Acc. 43, Acc. 56 and Acc.57 in turmeric and Acc. 36 in ginger were superior in yield and other characters. The rDNA of *R. similis* was amplified using 18S primers P1 and P2. Species-specific primers were designed using bioinformatics tools for detection of *R. similis* and *Pratylenchus* species. The *Trichoderma* mass production venture with 10 years life period resulted in a net value of Rs 2,42,618 with less than 2 years of payback period, 121% internal rate of return and 1.84 B : C ratio.

Of the elite lines of cassia, C_5 was found to be superior in yield (475 g), bark oil (5.0%), leaf oil (3.09%) and bark oleoresin (10.70%). Highest oil (8%) and oleoresin (14%) were present in Acc. 57 and Acc. 60. Of the 106 nutmeg accessions evaluated, A9/18 (933 fruits/tree) was found to be superior. Approach grafts of dwarf clove (Acc. 197-IC 438344) using normal clove as rootstock was produced. Softwood grafting in *Garcinia xanthochymus* was standardized on nine months old *G. xanthochymus* rootstocks with 90% success. Grafts had a compact plant type and born fruits at an early age. The grafted plants flowered within two to three years after grafting, while seedling trees did not flower even seven years after planting.

White and pink flowered varieties of *Vanilla andamanica* were self and cross-compatible besides showing compatibility with *V. planifolia*. Cytological analysis of *Vanilla andamanica* revealed 2n = 40 as most frequent chromosome number. A new disease of vanilla caused by a fungal pathogen (*Cylindrocladium quinqueseptatum*) was identified and reported for the first time from India. Cucumber mosaic virus (CMV) on vanilla (*Vanilla planifolia*) was characterized on the basis of biological and coat protein nucleotide sequence properties. DAS ELISA method was standardized for detection of CMV infection in vanilla plants.

About 23,000 rooted black pepper cuttings, 8,047 cardamom seedlings, 1,000 cardamom suckers, 20 kg cardamom capsules, 4 tonnes of ginger seed rhizomes, 11 tonnes of turmeric seed rhizomes and 6,498 nutmeg grafts were distributed to farmers.

The All India Coordinated Research Project on Spices recommended six varieties namely, DH-246 (coriander); RZ-223 (cumin), HF-33 (Hisar), GF-11 (Jagudan) and RF-143 (Jobner) and Rmt-305 (fenugreek) Jobner, six varieties namely, IISR-Thevam, IISR-Malabar Excel, IISR-Girimunda and P-24 (black pepper) and IISR-Kedaram and IISR-Alleppey Supreme (turmeric) at IISR, Calicut; five entries namely, AN-01-1 (nigella), AD-01-43 and AD-01-6 (dill), and AA-01-61 and AA-01-19 (ajowan) at NRC Seed Spices, Ajmer, for state release. Five varieties of ajowan, dill and nigella were also released

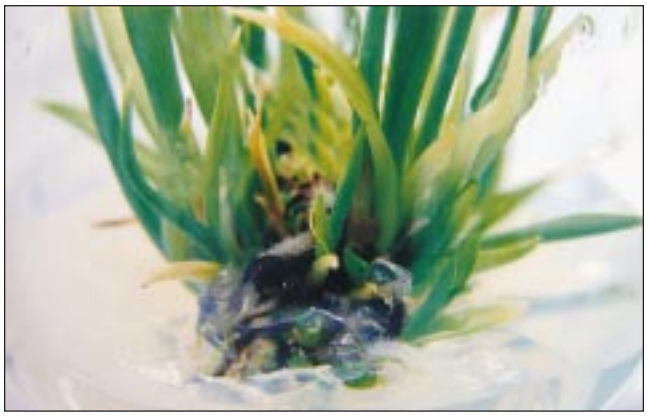
Empowering Farmwomen

In thematic campaigns and cashew day more than 200 farmwomen beneficiaries participated and got benefited. About 60% of the prize winners were farmwomen. All prize winners were presented with a certificate and a radio set so as to encourage the participation of women beneficiaries in cashew developmental activities

Aloe

Aloe accession, NMRM2, was found to contain high alin A, among all the existing accessions. Clonal propagation with a single shoot bud as explant, it was possible to obtain 28 shoot

buds after 2 weeks of cultures on half MS basal medium supplemented with different concentrations of BA, IAA and sucrose.



Mass multiplication in Aloe

Ashwagandha

In ashwagandha, total biomass yield/plant varied from 63.4 to 308.4 g at Hisar. In genotype GP-27-Local, highest root yield (38.5 g/plant) was recorded followed by WS-218 (26. 5 g/plant) and WS-90-125 (25.0 g/plant), whereas check (JA-20) yielded 15.0 g/plant. Maximum fresh and dry root yields were 3,542 and 828 kg/ha, respectively with a seed rate of 12 kg/ha. At Mandsaur, MWS-308, MWS-324 and JA-134 were superior in dry root yield. Similarly, seed yield ranged from 222 (MWS-333) to 694-kg/ha (MWS-308 and JA-134). Highest alkaloids content (0.68%) was in JA-134 followed by MWS-223 (0.6%). Highest root yield (642 kg/ha) was obtained with the application of vemicompost (5 tonnes/ha). At Udaipur, JA-20 was found to be superior over JA-134 in root yield. The seed rate of 8 kg/ha produced significantly highest fresh (1,290 kg/ha) and dry (465 kg/ha) root yields. Sowing on 1 September and harvesting on 1 April recorded significantly highest root yield (1,625 kg/ha). At Akola, highest root yield was recorded with harvesting at 100% flowering stage (563 kg/ha). The yield of total alkaloids was significantly highest at 100% flowering stage (350 kg/ha).

Asalio

In asalio, highest seed yield was obtained in MLS-7 (2066 kg/ha), followed by MLS-1 (1,823 kg/ha) and MLS-3 (1,703 kg/ha). The highest seed yield of 658 kg/ha was recorded with 0.6 IW : CPE, which was at par with 0.8 and 1.0 IW : CPE (609 and 602 kg/ha, respectively at NRCMAP.

Asparagus

In asparagus, dry weight of fasciculated roots/plant ranged from 0.57 to 1.39 kg/plant and saponin content from 4.50 to 5.34% at Hisar. Highest dry fasciculated root yield/plant was in HAR-7 (1.39 kg), followed by HAR-3 (1.23 kg), HAR-2 (0.998 kg) and HAR-6 (0.91 kg). At Akola, maximum saponin was observed in oven-dried samples in air-tight container (4.76%).

Chirayata

Extraction and estimation method of bitter compounds in chirayata, was standardized at Solan.

Isabgol

In Isabgol, highest seed yield/plant was recorded in genotype EC-41181-37 (7.2 g), followed by P-96 (6.9 g), PB-10-4 (6.5 g), PB-31 (6.4 g), DM-7 (6.3 g), PS-19 (6.2 g) and P-79 (6.1 g), whereas in the best check GI-1 seed yield of 4.7 g/plant was recorded at Hisar. At Mandsaur, swelling factor (ml/g) varied from 6.0 (SPS-19) to 9.6 (SLS-16) and days to 50% flowering from 56 (SLS-01) to 69 days (SLS-63). Seed yield ranged from 297 kg/ha (SLS-65) to 1,450 kg/ha (SLS-59). Sowing on 21 November produced significantly higher seed yield (834 kg/ha). Maximum seed yield was produced with three (689 kg/ha) and two (687 kg/ha) irrigations. At Akola, sowing on 20 November produced significantly highest seed yield (3,660 kg/ha). At Udaipur, application of three irrigations (at tiller initiation, full tiller and 75% flowering) produced highest seed (1,468 kg/ha) and straw (3,031 kg/ha) yield compared to others. Spraying of brassinosteroid (0.4 ppm) yielded significantly highest seed (1,189 kg/ha) and straw (2,461 kg/ha) compared to 0.2 ppm (1,023 kg/ha seed and 2,323 kg/ha straw) and control (864 kg/ha seed and 2,135 kg/ha straw).

Kalmegh

In kalmegh, significantly higher yield was obtained in Acc. No. 3 (2844 kg/ha) at Anand. In 43 accessions evaluation, fresh and dry herbage yields were highest in IC 342136 (290.6 g/plant and 99.16 g/plant) and lowest in IC111286 (120.8 g/plant and 32.12 g/plant). Andrographoloide content (%) in stems was highest in IC 260035 and IC 210635 (0.365) and lowest in IC-342141 (0.09). However, andrographoloide content in leaf was highest in IC 342141 (4.67%) and lowest in accession from Bhubaneshwar (1.281%).

Lemongrass

In lemongrass, genotype H-10 gave highest herb yield/plant

- A total of 43 accessions of kalmegh were evaluated
- The H-10, a lemongrass genotype, gave highest herb yield
- The NOP 03-1 genotype of opium poppy gave maximum seed yield
- Geraniol in palmarosa ranged from 70.33 to 92.94%
- The NMRM 2, an accession of aloe, contained high alin A

(1,174.31 g), followed by HL-9 (1,136.09 g) and HL-5 (1,085.28 g) against best check OD-58 (1,084.23 g). In genotype CKP-25, highest oil content of 0.81% and oil yield of 6.54 ml/plant were recorded. Application of nitrogen significantly increased yield and yield-attributing characters. Herbage yield was significantly high (4,223 kg/ha) with application of 200 kg/ha of N. Herbage (44.81 tonnes/ha) and oil (205 kg/ha) yield were found to be highest in LS-1.

Liquorice

At Hisar, fresh liquorice, stolon yields were higher (161.11 q/ha) in genotype HMK-6-2 followed by HMK-1-3 (136.11 q/ha), HMK-7-1 (125.00 q/ha), HMK-7-4 (111.11 q/ha), HMK-1-2 (108.33 q/ha) and HMK-7-5 (105.55 q/ha) against check HM-1 (94.44 q/ha).

Opium Poppy

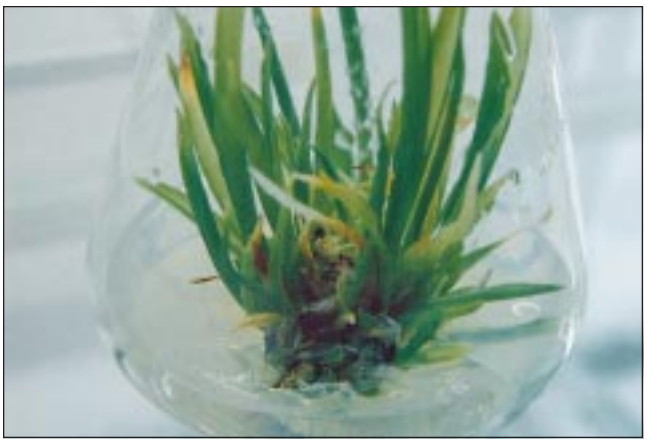
In opium poppy at Faizabad, maximum latex yield (42.70 kg/ha) was recorded in the genotype 1385. Maximum seed yield was recorded in genotype NOP 03-1 (958 kg/ha) and maximum husk yield (833 kg/ha) was recorded in N.D-20. At Mandsaur, latex yield ranged from 11.91 kg/ha (IC-19) to 77.45 kg/ha (MOP-1069) and seed yield from 208 kg/ha (IC-95) to 1,249 kg/ha (NBRI-5). Morphine content ranged from 12.4 to 17.3%, while thebain content was recorded low in MOP-1074, medium in MOP-575 and high in MOP-513. Highest latex yield was obtained with 75% of N supplementation through FYM and among the treatments receiving vermicompost, highest latex yield of 21.42 kg/ha was recorded with 75% N supplementation. Among vermicompost applications, highest seed (659 kg/ha) and husk (517 kg/ha) yields were obtained from 100% organic source. IC-114 and MOP-541 were found to have higher concentrations of morphine, thebine and codeine.

Palmarosa

In palmarosa, maximum herbage (4,769 kg/ha) and oil yield (241.39 kg/ha) were recorded with 150 kg N/ha. Geraniol content in oil ranged from 70.33 to 72.94%, while geraniol acetate varied from 15.73 to 19.00. At Hisar, fresh herb yield was highest in RH-03-67 (2.488 kg/plant) and lowest in RH-03-47 (0.156 kg). Oil content on fresh-weight basis ranged from 0.25 (RH-03-38) to 0.60% (RH-03-29). Computed oil yield ranged from 1.5 (RH-03-47) to 10.7 ml/plant (RH-03-67). Geraniol content ranged from 9.90 to 82.50%. Geranyl acetate content ranged from 1.10 to 10.76%.

Safed Musli

In safed musli, fresh fasciculated root yield ranged from 5.77 g/plant in GUJ 1 to 23.77 g/plant in RAJ 11. Number of fleshy roots/plant was highest in GUJ 2 (20.43) and it was lowest in GUJ 1 (4.30). Length of fleshy root ranged from 1.97 cm (GUJ 1) to 9.26 cm (MP 4). Two safed musli lines (NRCCB 1 and NRCCB 2) registered by National Germplasm Registration Committee as INGR No. 04113 and INGR No. 04114. At Anand, fleshy root yield was 6,764.56 kg/ha after detopping compared to 5,136.19 kg/ha. Highest fleshy root yield (11,855 kg/ha) was obtained from 10 cm × 10 cm spacing. Increase in fleshy root yield increased total income, highest being Rs 2,265,400 recorded from closest spacing and minimum (Rs 1,343,800) from 10 cm × 10 cm spacing. However, cost: benefit ratio was highest (1 : 6 : 16) with lowest plant population. At Udaipur, significantly higher fresh root yield (6,657 kg/ha) was obtained from the variety MCB-405 compared to MCB-412 (6,064 kg/ha). Closest spacing produced significantly highest fleshy root yield (7,743 kg/ha). Maximum fresh root yield (7,952 kg/ha) was obtained by MCB-405 planted at a plant-to-plant distance of 10 cm. Similarly, significant highest dry root yield of 1,590 kg/ha was recorded in variety MCB-405 with closest spacing. The yield attributes and fresh fleshy root yield were recorded maximum in ridge planting. At Akola, quality of fleshy root powder, in saponin content decreased with storage. Significantly lowest content was recorded after 12 months of storage (5.79%). Highest saponin was found in oven-dried material kept in air-tight container (6.13%). At Mandsaur, to develop proper management of fleshy root rot disease, soil application of potash @ 60 kg/ha and *Trichoderma viride* @ 5 kg/ha and or seed treatment with Bavistin @ 0.15% were used either singly or in different combinations. Combined treatment of potash, *Trichoderma* and Bavistin produced significantly lowest fleshy root rot disease incidence (14.15%).



Tissue culture in safed musli

Sankhpushpi

In sankhpushpi, polymorphism in terms of flower colour was recorded. Three distinct colour types were recorded. Eight different types of corolla shape were observed in the population namely

mucrunate, acute between, acute, retuse, obtuse and serrated, semi-gamopetalous. Chemical fingerprinting results showed 11 bands in HPTLC plates of different plant types collected from four subplots.

Giloe

In giloe (*Tinospora*), polymorphism in leaf shape was very much pronounced. Leaf base varied from cordate, subcordate or deeply cordate or truncate, while leaf apex varied from obtuse, mucronulate or apiculate. Males were in full bloom in December, however, females were not in flowering during this month. Maximum anthesis was in the afternoon, i.e. 12.00 to 4.00 PM. Pollen transfer in species is through wind. Floral visitors identified were aphids and black ant (*Dolichoderus* spp). Flowers opened at 6.00 PM gave maximum germination (69.09%). Chemical fingerprinting showed the presence of seven bands in leaf and nine bands in stems.