Improvement and Management of Horticultural Crops

FRUIT CROPS

Mango

Eight mango accessions were added to field gene bank. Molecular characterization of 45 mango accessions following IPGRI descriptors has been completed and 20 mango hybrids were evaluated for fruit characters. Mango hybrids, 28-7 and 29-6, showed good fruit quality with more than 70% pulp recovery. Under IPGRI, ADB-TFT assisted Project, 125accessions of mango were added to field gene bank, and 194 accessions were documented and characterized.

Twenty accessions were collected, and characterization and documentation of 60 accessions were performed. Hybridization was performed in 28 cross combinations. Germplasm characterization of 254 mango accessions for 54 descriptor list has been published by CISH, Lucknow. Mango Bangalora produced heavy fruits (380 g) and highest yield (95.28kg/tree) at Sabour, while Neelum gave maximum fruit yield (41.62kg/tree) followed by Suvarnrekha (36.78kg/tree) at Sangareddy. At Sabour, Mallika showed superiority over other varieties in yield, average fruit weight and TSS content (52.15kg/tree, 507.39g, and 21.50° Brix). Mango Neeleshan produced maximum number of fruits (374) and yield (72.15kg/tree) at Sangareddy.

- Twenty accessions of mango were collected.
- Germplasm Information System was developed at IIHR, Bangalore.
- Traps consisting of ethyl alcohol, methyl eugenol and malathion in a 6:4:1 ratio soaked in plywood of 5 cm × 5 cm × 5 cm could manage fruit fly effectively.

Germplasm Information System was developed at IIHR, Bangalore, for computerization of central accession register of different horticultural crops. Separate database design structures were developed to store and retrieve information on fruit crops at IIHR, Bangalore.

In a rootstock trial of 22-year-old study employing 8 rootstocks for various growth, yield and quality attributes, polyembryonic rootstock Muvandan recorded maximum plant height and canopy spread, whereas Vellaikolumban least growth, indicating pronounced dwarfing effect for Alphonso mango. Productivity per unit canopy volume and unit land area was maximum with Vellaikolumban rootstock suggesting that this rootstock can be beneficial for induction of dwarfing in this cultivar to accommodate more trees per unit area. Fruit yield of Alphonso mango increased remarkably with increasing planting density from 100 to 1,111 trees/ha during first year of bearing.

Three foliar sprays of 0.1% borax and 0.2% $ZnSO_4$ at pH 5.5 with wetting agent sprayed in June, November and December increased fruit setting and yield. Ragi and Dolichos as intercrops in mango gave additional income of Rs 12,000/ha.Circular basin with 5% slope + ragi straw mulch increased mango yield by 15-20%.Use of biofertilizers + compost enhanced fruit yield in mango by 20% and reduced cost on fertilizers. Poor fruit retention rather than flowering or fruit setting was found to limit the productivity of grown-up Arka Puneet mango trees. Pruning at a height of 5m from the ground level induced maximum number of flushes, giving fruit yield of 145.92 kg/plant.

Paclobutrazol effectively controlled irregular bearing in mango. At CISH, Lucknow, after 28 years of age, Rumani rootstock showed dwarfing effect for Dashehari, while maximum yield was recorded on random seedling rootstock. Five sprays of Micnelf along with 300 g Borocal (a micronutrient preparation) and 60% of recommended fertilizer could result in maximum fruit yield. Maximum cumulative fruit yield was recorded from trees propagated by air-layering followed by veneer grafting at Pantnagar, while veneer grafted trees produced highest yield (118.42kg/tree) at Rewa.

At Rewa, random seedling rootstock, Kalepad and Olour, produced lesser tree volume in Langra, whereas it was maximum in Bappakai rootstock closely followed by Chandrakaran and Vellaikolumban. At Sabour, Latra rootstock imparted maximum dwarfness to Bombai scion against maximum vigour on random seedling. Double hedge- row system of planting gave significantly higher yield than control (square system).

On-farm trial on management of fruit fly (*Bactrocera zonata*) in north-eastern Ghats agro-ecosystem of Orissa was taken up by CHES, Bhubaneshwar. Fruit flies cause heavy loss in mango fruits especially in late-manuring varieties, which is further aggravated by early rains. The infestation level of fruit fly in mango was as high as 40%. The farmers had no idea about infestation. The area is

otherwise an emerging potential locality for mango production tribal region. Being located at higher altitude, mango ripening starts almost one month later than the coastal belt of the state, providing better opportunity for growers to escape from glut in the market and fetching high price. Traps of methyl eugenol comprising ethyl alcohol, methyl eugenol and malathion in a 6:4:1 ratio soaked in plywood of 5 cm × 5 cm × 5 cm could manage the pest.This successful technology was highlighted.

Biopesticides, Praghat (0.05%), Cartap hydrocholoride (0.05%), Ethophenprox (0.005%), Azadirachtin (1500 ppm) proved effective in checking midge and hopper populations. Neem excel (1500 ppm) on mango followed by Endosulfan (0.07%) proved effective against mango hoppers at pre-and post-bloom stages. Mango mealybug was controlled by soil application of *B. bassiana* combined with alkathene banding. Post-harvest treatment with Prochloraz (0.1%) and hot-water treatment (52ºC) for 10 minutes were most effective for post-harvest management of disease in mango. Prochloraz is a safer fungicide for post-harvest treatment of anthracnose on mango. At Paria, higher activity of hopper was observed during flowering stage, while thrips had two peaks (October-November and March - May), coinciding with new flesh period of the crop.

At Sabour, proper orchard hygiene with neem and fungal bioagents controlled mango hopper and produced higher yield. Monocrotophos (0.72%) as well as quinalphos (0.05%) were effective to control shoot gall psylla. Mango hopper is found throughout the year in trunk and leaves/panicles. Maximum hopper population was recorded on trunk (48.0) during first fortnight of May followed by on panicles (85.00) during flowering stage (second fortnight of March) and on leaves (90.17%) in first fortnight of April. Spraying of monocrotophos (0.05%) thrice was most effective treatment in reducing the hopper population producing maximum yield at Vengurle and Sabour.

Banana

A total of 273 banana accessions were collected and conserved at NRC for Banana, Trichy. Database have been updated for 48 accessions in MGIS. Molecular and

SUCCESS STORY

Biodynamic Farming

"Biodynamic Farming" involves certain principles and practices for healthy soil, production and quality. All the cultural activities are performed as per zodiac principles. This includes nutrient, pest, disease management and sowing/ transplanting at appropriate time (agriculture calendar), crop modeling, through training/pruning and crop allelopathy. There has been a continuous improvement in physical, chemical and biological properties of soil, besides an improvement in production and quality of fruits. Following package of practices have been recommended.

- Application of organic manures through NADEP/vermi/ biodynamic compost (BD) /microbe mediated compost (MM compost).
- Use of cakes (neem, karanj, castor, groundnut etc.) as per availability.
- Green manuring and legumes as inter and cover crops as per the requirement.
- Mulching after the application of 5 - 20 kg vermi/BD compost, 100g CPP and release of earthworms in basin.
- Regular use of cow pat pit (CPP) and cow horn manure (BD-500) to refurbish biological properties of soil.
- Need based use of liquid manures prepared from cowdung; cow urine, leguminous leaves or vermiwash to promote growth and fruiting.
- Spraying of biodynamic pesticides prepared through fermentation of cowdung, cow urine, neem, karanj, caliotropis, castor or neem leaves.
- Two sprays of cow horn silica (BD-501) at flowering and fruit development stages.
- Biodynamic tree paste/cowdung paste to control gummosis and dieback.

- A novel technique to feed banana bunches through distal end has been developed.
- A total of 273 banana accessions were collected and conserved at NRC for Banana, Trichy.
- Banana fingers packed with foam in 2-ply card board boxes weighing 13.5 kg each with ethylene absorbents are suitable for export purpose.
- Production technology of organic banana showed promising results.

Morphotaxonomic characterization was completed for 34 accessions collected from Andaman and Nicobar islands using RAPD markers. Protocol has been standardized for surface sterilzation and *in vitro* germination of mature zygotic embryos. The genetic variation and phylogenetic relationships of 25 Silk accessions representatives of both indigenous and exotic origins were analyzed using RAPD markers. Two clusters one each major and minor were recorded. Of the 23 accessions, 11 were synonymous. Mutheli was found to be a mutant of Malbhog. *Musa balbisiana* is a rich gene pool consisting of genes resistance to various biotic and abiotic stresses. These were analysed using OPA11primer adapting RAPD method. The wild B genome from mainland formed Cluster-I, showed 2 major subclusters. The first one represented Borkal Baista, an unique collection from Assam and Bhimkol-1 and Manguthamng as synonym. Cluster II included 13 clones collected from Andaman and Nicobar Island of which, New Wandoor was found to be a unique collection.

Modified high-density planting with 3 suckers/hill at a spacing of 1.8 m × 3.6m (4,500 plants/ha) with 150 : 30 : 225g NPK/plant/year gave 70 tonnes/ha yield with a cost : benefit ratio of 1.74 in Robusta banana grown in wetland. Paired row system with 5,200 plants/ha (2m × 1.2m × 2 m spacing) with 200g N, 30 g P and 300g K recorded 90 tonnes/ha with a cost : benefit ratio of 2.02. Banana bunches covered with polysleeves with 4-6% ventilation produced fruits with uniform attractive pale- green colour without blemishes which had a premium market and are also suitable for export. Application of cement kiln flue dust (0.5 kg/plant) and 30,000 litres of distillery effluent/acre with 60% K recorded 25% increase in bunch weight in both plant and ratoon crops of Ney Poovan banana. An additional profit of Rs 35,000/ha was obtained by adopting this technology. Standardization of technology for organic banana production revealed maximum vegetative parameters in Rasthali and Karpuravalli bananas with a treatment combination of 2.5 kg distillery sledge, 1 kg vermicompost, 1 kg neem cake and 2.5 kg poultry manure. Application of 150 g each of N and K_2 O/ plant / year for Basrai and Grand Naine resulted in a saving of 25% of N and K_2 O.

The IIHR, Bangalore, has developed a novel technique to feed banana bunches through distal end for increased bunch weight. Nutrient feeding through distal end was confirmed using radio tracers. Blending 5g of ammonium sulphate with 2.5g of sulphate of potash was significantly superior to10g of ammonium sulphate alone in increasing bunch weight up to 78% compared to the control.

Banana pseudostem (longitudinal) @100/ha effectively traps all banana weevils. Cosmolure @5/ha can be used for monitoring banana corm weevil. Entomopathogenic fungi, *M. anisopliae*, was isolated from banana stem weevil (*Odoiporus longicollis*). Application of *Trichoderma viride* @ 20 g/plant, once at planting and after 3 months was found effective in controlling nematodes (*P. coffeae* and *M. incognita*), reducing the incidence of Panama wilt in Rasthali and Virupakshi. Econeem and Nimbicidine showed maximum efficacy in reducing nematode population with increased plant growth and yield. *Verticillium chlamydosporium* culture filtrates successfully controlled second stage juveniles and eggs of *M. incognita* under *in-vitro* conditions. *Tagetes* spp. grown as an intercrop in Nendran banana field resulted in significant reduction in root-lesion nematodes with increased yield. Spraying of native stain of *Pseudomonas* sp. 2 @ 10^6/ml in Robusta prevented the occurrence of crown rot disease. Plant extract of *Solanum torvum* (50%) is recommended to control post-harvest diseases, and increasing shelf-life by 26 days.Spraying of paraffinic oil (5%) + Propiconazole (0.05%) or Carbendazim (0.05%) is recommended to control Sigatoka leaf spot disease on banana.

Citrus

Two hybrids of rough lemon ´Troyer citrange were promising rootstocks for resistance to *Phytophthora*. For determining quantum of water stress in Nagpur mandarin, leaf water potential of –3.5 MPa was found effective for inducing flowering. Paclobutrazol @ 18g/plant was found effective in inducing flowering in problematic high clay soils. Chlormequat chloroide (CCC) (2000 ppm) or stem girdling (0.3 - 0.5 cm) applied in September induced *hasta* flowering in October.

Nagpur mandarin bearing quality fruits

Extracts of *Nerium odorus* and *Vitex negundo* (1%) were found effective against citrus psylla, while these *of Alpinia galanga* and *Acorus calamus* (1%) were safer to *Tamarixia radiata* parasitised psylla nymphs. Similarly, extracts of *A. galanga* and *A. calamus* (1%) were found safer to predators *Mallada boninensis* and *Serangium parcesetosum*. *Trichoderma hamatum* strain 4, *T. harzianum* strain 20,25,37 and *T. reesei* strain 7 were found good root growth promoters of citrus.

Three fungal isolates, one bacterial isolate and botanicals like neem, tulsi and Eucalyptus leaf extracts, were found inhibitory towards *Xanthomonas* when tested by dual culture assay. The highest reduction in citrus greening disease was obtained through soil application of Ledermycin (600 ppm) along with $ZnSO_4$ and $FeSO_4$@200 g each per plant. For molecular diagnosis of citrus Trestiza virus, PCR based method was standardized for its detection. The results demonstrated that RT-PCR

- Paclobutrazol @ 18 g/plant was quite effective in inducing flowering in problematic high clay soils in citrus.
- Maturity indices for *mrig* (monsoon blossom) *behar* in Nagpur mandarin have been standardized.

method is accurate and efficient for CTV detection.

Maturity indices for *mrig* (monsoon blossom) crops of Nagpur mandarin fruits have been standardized. Fruits attained proper maturity 240 days after fruit setting. The extraction methods of essential oil of orange and lemon peel were standardized following hydrodistillation method at 65°C.

Guava

Fifteen guava accessions were added to field gene bank. Characterization and documentation of 30 accessions was performed. Hybrids raised from *Psidium molle* and *P. guajava* crossing were found to be tolerant against guava wilt in artificial testing. The evaluation of germplasm revealed that maximum fruit yield was recorded in Allahabad Safeda and Sardar guavas.

- Fifteen guava accessions were added to field gene bank.
- Cultivation of marigold and garlic in guava basin resulted in reduction of population build-up of spiral nematodes.
- Methy eugenol was ideal for management of fruit fly in guava.

In various guava accessions treating seeds with HCl (35%) for 3 minutes resulted in higher and early seed germination. It was found possible to grow up to 5,000 plants/ ha at a spacing of 1.0 m × 2.0 m coupled with regular topping and heading at Central Institute for Subtropical Horticulture, Lucknow. The maximum yield/ plot was recorded in double hedge row system of planting at Rewa, Sabour and Udaipur.

Cultivation of antagonistic crops like marigold and garlic in the basin of guava plants was found to result in population reduction of spiral nematode identified as a co-factor in guava wilt. Biological control of guava wilt indicated the possibility of its control with *Aspergillus niger*. Methyl eugenol trap was found best for management of fruit fly population.

Grape

Seven wine varieties and 4 natural mutants were added to germplasm collection bringing the total number of accessions to 374 at NRC for Grapes, Pune. Grape accessions were characterized using morphological traits and evaluated for powdery mildew resistance, early ripening, self-bud breaking, raisin and juice quality. Grape Centennial Seedless was found promising for raisin, while Concord and Country Bangalore for juice-making. Several accessions were identified for self-bud breaking. Positive correlation was observed between yield/vine and bunch number, yield and mean bunch weight and juice percentage and berry diameter. Graphical user interface for grape germplasm information system containing menus for application, and input and output forms were designed. At IIHR, Bangalore, embryo rescue technique

- Seven wine varieties and 4 natural mutants were added to grape germplasm.
- Embroy rescue technique has been standardized in grape.
- Metwing 2 software saves as much as 11 sprays in a year in grape cultivation.
- Pre-harvest treatment of grapes with chitosan alone or in combination with *Trichoderma* improved shelf-life of grapes.

has been standardized to incorporate downy mildew resistance in Thompson Seedless grape.

Thompson Seedless and Flame Seedless scions showed maximum compatibility with drought tolerant Dogridge-B and 99 R rootstocks respectively. DRIS norms for vineyards, based on petiole nutrient contents were developed. Among different diagnostic parameters, P/N, K/N, P/Zn had greater physiological rationale during flowering stage, whereas N/P and N/K were critical during bud-differentiation stage. Sodium was most common limiting nutrient. The irrigation schedule using saline irrigation water of EC 1.87 mmhos/cm resulted in 52.5% saving in irrigation water. This irrigation schedule comprises replenishment of water @ 60% of pan evaporation 40 days after back pruning, 40 days after forward pruning and from 56 days through harvesting and @ 20% of pan evaporation during rest of the period from back pruning to harvesting.

SUCCESS STORY

Dogridge: an Ideal Rootstock

Raising a grape garden on Dogridge rootstock is a new concept. It has become very popular in Maharashtra, Andhra Pradesh and northern Karnataka. Use of Dogridge helps mitigate twin problems of salinity and drought. Beside, Dogridge can also take care of nematodes in soil, providing excellent nutritional support to the grafted scion.

Compared to gardens grown on their own roots which can start yielding in one-and-a-half year, the rootstock gardens take 6-8 months more since they have to be first planted in the field and then grafted with suitable scion variety after 6 months. This delay in getting first crop is unavoidable, but is more than made up when grafted vine starts yielding. Digging of trenches, cost of manures/fertilizers, training structures, drip systems and plant-protection chemicals cause an additional cost of Rs 6,000/acre on cost of nursery plants and grafting charges for raising a successful rootstock garden. Thus, there is a 20-25% increase in yield with improvement in quality of the produce. About 60-70% of the total grapes produced in such gardens are exported to European markets compared to 40% produced by traditional gardens. In gardens planned for making raisins, the recovery is 20% more compared to those grown on own rooted gardens.Dogridge has played a key role in many grape-growing regions of Maharashtra and Karnataka this year where drought situation worsened due to failure of monsoon.

Use of mulch and antistress at 75% of the recommended irrigation level saved 25% of irrigation water. Similarly, use of subsurface irrigation resulted in a saving of 25% of water. Application of CPPU on bunch having more than 10 leaves resulted in thick pedicel and higher berry diameter. Quality of Sharad Seedless grape could be improved with the use of GA_3 @ 50 and 30 ppm at 3-4 and 6-7 mm berry size stage respectively along with 6 BA @ 10 ppm. Use of complex stimulants, bioforce and biopower increased bunch weight, brix yield/vine, berry size and shelf-life of Thompson Seedless grapes.

Forecasting-based disease management using Metwin 2 software resulted in a saving of as much as 11 sprays during one year of production cycle. This, in turn, has reduced consumption of pesticide and cost of cultivation.Use of acrylic polymer anti-stress and chitosan improved efficiency of sulphur and hexaconazole has increased the shelf-life of grapes. Potassium bicarbonate (0.5%) and surfactant also improved efficiency of hexaconazole.Use of fungicides, viz. thiophenate methyl, mancozeb and sulphur in combination with hydrogen cyanamide (bud breaker), did not affect sprouting in vines. This approach would reduce the cost of labour in application of various chemicals.

Papaya

Two papaya accessions were added to field gene bank. A total of 49 gynodioecious and 35 dioecious lines of papaya were maintained at Coimbatore. In the

- Two papaya accessions were added.
- The planting density of 555 trees/ha of papaya gave 48% more yield.

improvement of 9-1 (D) papaya (high-yielding, red-fleshed and dioecious line), 4 superior single plant selections have been made in BC5F1 generation for fruit yield and pulp colour. The maximum fruit yield was recorded in papaya Ranchi 1, while maximum TSS (11° Brix) was recorded in Washington. The population density of 555 trees/ha with a spacing of 3.0 m × 6.0m gave 48% more yield compared to planting at 1.5 m × 3.0 m spacing.

Litchi

A total of 57 germplasm accessions and 13 superior seedlings were maintained at different centres. Litchi Rose Scented produced high yield with good fruit quality at Pantnagar. Highest yield was obtained in double hedge-row system of planting at Pusa (Bihar) and Pantnagar. Irrigation and sprinkling of water through overhead

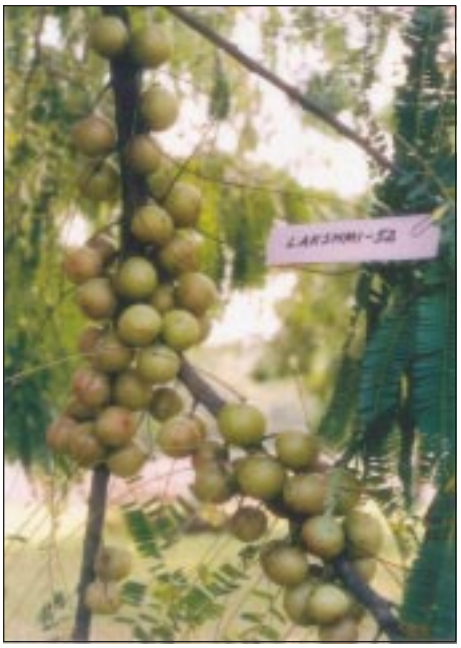
- Litchi Rose Scented produced high yield with quality fruits.

sprinkler had marked influence on minimizing pericrap cracking in litchi Shahi at Pusa. Carbaryl (0.1%) or Endosulfan (0.07%) sprayed twice at 10 days interval was effective in controlling litchi fruit-borer at Pusa (Bihar) and Mohanpur (West Bengal).

ARID ZONE FRUITS

Twelve new frost resistant aonla genotypes were collected from midhill region of Himachal Pradesh. About 322 genotypes of *ber*, 22 of *boradi*, 152 of pomegranate, 43 of *aonla*, 105 of cactus pear, 50 of date palm, 32 of *ker*, 32 of g*onda* and 4 of phalsa and kinnow mandrin were maintained in field gene bank at Central Institute for Arid Horticulture, Bikaner. Six varieties of pomegranate, and 3 of fig and *A. cherimoya* were introduced by Bangalore centre.

- Twelve new frost resistant aonla genotypes were collected from midhills region of Himachal Pradesh.
- Kaithali and Gola ber varieties have been recommended.
- APK 1 custard-apple is suitable for commercial cultivation.
- Pomegranate DKS/H/97/003 is a promising hybrid.
- Indian aloe was integrated with ber for cultivation.
- Apricot selection, Suka, having red cheeks has been collected.



Lakshmi 52 aonla yields 2–2.5 q/tree

A seedling selection of aonla, Lakshmi 52, has been identified in the village Bhadausi, Garwara, district Pratapgrah, Uttar Pradesh. Its tree growth is semi-erect and branches are semi-spreading which do not droop. The fruit matures during November-December and is free from necrosis having a yield potential of 2-2.5 q/tree (10 years

onwards). The fruit weighs 40-60 g containing 90.4% pulp, 82.5% moisture, 11° Brix TSS, 1.7 % acids, 512 mg/100g vitamin C and 3.3 % tannins. The fruits have great processing potential due to bigger size and high nutritive quality. Aonla NA 10 recorded best growth and highest fruit yield/plant,while NA 7 was superior under rainfed cultivation.

Ber Kaithali and Gola and custard-apple APK 1 are recommended for commercial cultivation in rainfed vertisol in Arupukkotai region. Twenty collections of bael and 41 of ker and 6 of lasora were collected at Bawal.

Selection of better type in aonla for earliness and yield was made at Godhra, Gujarat. Selection 6 had high yield (98.66 kg) /tree. Internal necrosis in aonla fruits due to boron deficiency was noticed up to 23% in Jobner.

Pomegranate hybrid (DKS/H/97/003) showed potential of high fruit quality traits like sweet, soft, bold and dark red aril. Vermicompost either alone or in combination with sheep manure helped check the depletion of soil moisture in active root zone of pomegranate. Best plant growth was achieved with same yield level with 0.75CPE irrigation along with 75% recommended dose of N fertilizer through drip. Thus in aridisol soils, 25% irrigation water and 25% nitrogen fertilizer could be saved through drip fertigation in pomegranate.

Indian aloe (*Aloe barbadensis*) was integrated with ber Gola planted at 3 spacings, i.e. 16 m × 4 m, 8 m × 8 m and 6 m × 6 m. Vegetative growth of ber plants was better with Indian aloe as compared to sole plantation of ber under the same spacing. It was observed that growing of groundstorey crops had positive influence on survival and vigour of ber plants. The clusterbean-mustard had given second best response but its adoption is practically feasible at farmers' fields, as it requires less input than other combinations. Indian aloe and clusterbean-mustard are good intercrops for ber under irrigated hot arid ecosystem. Ber Umran was high-yielding compared to other cultivars.

In fig, spraying of 500 ppm ethryl immediately after pruning resulted in higher yield. Date palm Medjool recorded maximum yield of fruits at *doak* (37.65 kg / palm) under 1:6 bunch:leaf ratio at Bikaner. Date palm Halawy is recommended for fresh fruits and Medjool for dry dates. Date palm fruits of *khala* stage of Halawy can give quality *chhuhara* if they are dipped for 10-15 minutes in boiling water followed by drying in air circulating drier at 45°C for 60-65 hours. Barhee was observed best for making *pindkhajoor*. It was also recommended that low to medium quality date varieties are useful for preparing good quality beverages.

Maximum temperature of 23.1°C and minimum of 6.0°C were congenial for the development of Graphiola leaf spot of date palm. The predator *Chilocoru nigritus* reduced the population of scale insect. Biochemcial basis on aonla rust resistance revealed that Mn and Zn were high and Fe was less in resistant cultivars. Dusting or spraying of 0.2% sulphur is recommended to control powdery mildew on ber.

TEMPERATE FRUITS

Apricot selection, Suka, has been made from Ladakh region, which has very attractive appearance due to red cheeks. This selection has 22 g fruit weight, 3.61 cm length, 3.64 cm diameter and 31.26° Brix. The average pulp weight is 20 g and pulp stone : ratio being 10. Its kernels are also sweet.

The fruits of Apricot Suka have red cheeks

VEGETABLE CROPS

Muskmelon NDM 15 for north-western alluvial plains and garlic DARL 52 and G323 have been released for humid western Himalayan region and arid western plains respectively. Besides, 5 open-pollinated (LCA 334 chilli, NDCP 13 cowpea, VRO 6 and VRO 5 okra, and DPP 9411 pea) and 7 hybrids (KTH 2 tomato, BH 2 and VRBHR brinjal, ARCH 228 chilli, DARL 202 capsicum, Pusa Hybrid 2 bittergourd and DCH 541 cauliflower) have been identified for release. Tomato Arka Meghali suitable for rainfed cultivation and bacterial wilt resistant tomato hybrids, Arka Shreshta and Arka Abhijit, were released. Frenchbean Arka Anoop with a pod yield of 18-21 tonnes/ha and resistance to rust has been identified for release. A chilli hybrid (developed by using male sterile line MSH 96), yielding 18 tonnes/ha green pods and 7-8 tonnes/ha dry pods with resistance to powdery mildew and viruses is in the advanced stages of testing. Three advanced breeding lines, TLBR 1, TLBR 3 and TLBR 6, of tomato were evolved for combined resistance to tomato leaf curl virus and bacterial wilt.

Eight new varieties of vegetable crops were released by Delhi State Variety Release Committee for commercial

cultivation in north Indian plains. These are: cauliflower Pusa Sharad (November maturity) and Pusa Meghna (September maturity) with compact curd and average yield of 240 and 125q/ha respectively. Vegetable mustard Pusa Sag 1 with an average yield of 700q/ha; ash gourd Pusa Ujwal with 485 q/ha in *kharif* season; Pusa Shandar, the first variety of snapmelon with 400 and 370 q/ha in summer and rainy season respectively; cucumber Pusa Uday with light green, smooth-skinned fruits and average yield of 157 q/ha in sprig-summer and 96 q/ha in *kharif* season; sponge gourd, Pusa Sneh with dark green fruits and average yield of 125 q/ha; and Pusa Rohini, a determinate tomato, with attractive red colourd fruits of 412 q/ha yield, have also been released.

Two advanced progenies of bottle gourd (AHLS Round

- In vegetables, 5 open-pollinated and 7 hybrids have been identified for release.
- Eight new vegetable varieties were released by Delhi State Variety Release Committee for cultivation.
- Technology for producing quality tomato and capsicum has been standardized.
- Packaging of onion in netted nylon sheet bags was better than open weaved hessian bags.
- A new species of begomovirus causing leaf curl on tomato was discovered.
- Sex pheromone-based IPM technique has been developed for brinjal shoot-and fruit-borer.

Arka Anoop provides 18–21 tonnes/ha quality pods

Varieties/Hybrids identified for release

Crop	Entry	Source	Zone(s) for which recommended
		Varieties	
Chilli	LCA 334	ANGRAU Reg. Res. Station, Lam (Andhra Pradesh)	III, IV, V, VII
Muskmelon	NDM-15	NDUA&T, Faizabad	IV
Cowpea	NDCP-13	NDUA&T, Faizabad	II, III, IV, VII
Garlic	DARL-52 G-323	DARL, Pithoragarh NHRDF, Nasik	I VI
Okra (YVMV)	VRO-6	IIVR, Varanasi	IV, V
Okra (YVMV)	VRO-5	IIVR, Varanasi	VI
Pea (mid-season) (powdery mildew)	DPP-9411	HPKV, Palampur	I
		Hybrids	
Tomato (indeterminate)	KTH-2	CSAUA&T, Kanpur	IV, V
Brinjal (round)	BH-2 VRBHR-1	PAU, Ludhiana IIVR, Varanasi	IV, V IV, VI
Chilli	ARCH-228	Ankur Seeds	IV, V, VI
Capsicum	DARL-202	DARL, Pithoragarh	I, IV
Bitter gourd	Pusa Hybrid-2	IARI, New Delhi	IV, V, VI
Cauliflower	DCH-541	IARI, New Delhi	II, IV

1 and AHLS Long 1) developed at CIAH, Bikaner, showed high potential under hot arid environment. For improvement in drought hardy *mateera* (watermelon), evaluation of advanced family block revealed the superiority of F6/a/10 (*mateera* AHW 19 × Sugar Baby). Seed production of *mateera*, *kachari*, snapmelon and *salad kakdi* were undertaken. About 300 kg of foundation seed was produced.

A total of 1,835 onion and garlic germplasm collected from indigenous and exotic sources are being evaluated against biotic and abiotic factors. Five hybrids with heterosis (75-100%) was developed and currently under trial in different cropping seasons to know G × E interaction.

Technology for producing quality tomato and Capsicum has been standardized. Pre-harvest application of benzyl adenine @ 25 ppm on broccoli Pusa Broccoli 1 was found effective in retaining green colour of heads up to 6 weeks in cold stores (4°C). Packaging of onion in netted nylon sheet bags was found comparatively better than open weaved-hessian bags for onion bulbs storage. In low-cost polyhouse cultivation of vegetable, cucumber hybrid Pusa Sanyog, capsicum hybrid Pusa Deepti, tomato hybrid DTH 7, and summer squash hybrid Pusa Alankar, were observed to be most promising with yield of 1764, 312, 744 and 1670 q/ha, respectively during off-season. Tomato genotypes, H 86, H 24, Bilali 1 and 6-11 B, showed tolerance to leaf curl. Hybrids, DTEH 2, DTEH 8, DTEH 9, DTEH 18 and DTEH 19, showed resistance to early blight. Three lines/variety, NF 31, VFN 8 and Pusa 120, showed resistance to root-knot nematode.

A regeneration protocol was developed using epicotyl and hypocoytl explants, which effectively regenerated five commercially grown eggplant cultivars. This regeneration procedure was used to facilitate gene transfer through *Agrobacterium tumefaciens* in eggplant var. Pusa Purple Long using gene from T-DNA of the binary vector plasmid *pBin AR*, which also contains gene that encodes neomycin phospho transferase II (*npt II*). The explant were co-cultivated with *Bin AR - Cry 1AB* and the shoots were regenerated on MS medium containing 4.44 uM/I BAP and1.14 uM/l IAA. The selection was done on a medium containing 50 mg/l cefotoxime. The Ro brinjal plants were normal and tested positive for NPT II enzyme activity through PCR with *npt II* specific primer. The NPT II positive transformants were further subjected to ELISA, which indicated that *Cry 1AB* protein is present in protein extracts of progeny plants. The southern blot analysis revealed that five of the putative transformed plants have single copy insertions of the transgene. The southern blot with *Cry* gene specific probe showed the presence of 2.4 kb fragment specific *Cry* gene suggesting its integration with plant genome.

A new species of begomovirus *(Tomato leaf curl Gujarat virus)* causing leaf curl disease of tomato in Varanasi was discovered which appears to be a recombinant one. It shares many fragments of its genome with several Asian begomoviruses, confirming that recombination is an essential molecular component for geminivirus evolution. Tomato leaf curl disease (TLCD) is a very significant problem for tomato growing regions in India. During November 2001, a severe tomato leaf curl disease (TLCD) manifesting yellowing of leaf lamina with upward leaf curling, leaf distortion, shrinking of the leaf surface and stunted plant growth was observed in the research farm of the Indian Institute of Vegetable Research and surrounding tomato growing areas in the Varanasi and Mirzapur districts of eastern Uttar Pradesh, causing yield losses up to 100%. The full-length genome of DNA-A and DNA-B of the virus was cloned in pUC18. Sequence analysis revealed that DNA-A (GenBank accession number AY190290) is 2757 bp and DNA-B (GenBank accession number AY190291) is 2688 bp in length. The virus could infect and cause symptoms in tomato, pepper, *Nicotiana benthamiana*, and *N. tabacum* when the partial tandem dimeric constructs of DNA-A and DNA-B were artificially inoculated through particle bombardment. This sap transmissible begomovirus is mono-bipartite in nature, indicating that DNA-A alone is infectious, but association with DNA-B increases symptom severity and shortens incubation period. ORFs in both DNA-A and DNA-B are organized similarly to other begomoviruses. DNA-A and DNA-B share a common region of 155 bp with only 60% sequence identity. DNA-B of the present isolate shares overall 80% identity with DNA-B of *Tomato leaf curl New Delhi virus*-Severe (ToLCNdV-Svr) and 75% with *Tomato leaf curl New Delhi virus*-[Lucknow] (ToLCNdV-[Luc]). Comparison of DNA-A sequence with different begomoviruses indicates that the present isolate shares a maximum of 98% homology with another isolate from the same region (ToLCGV-[Mir]; AF449999) and 97% with one isolate from Gujarat (ToLCGV-[Vad]; AF413671). All three viruses belong to the same species that is distinct from all the other geminivirus species described so far in the genus Begomovirus of the family Geminiviridae and the name *Tomato leaf curl Gujarat virus* (ToLCGV) is proposed, as the first sequence was taken from an isolate of Gujarat, India. The isolate here described has therefore been named *Tomato leaf curl Gujarat virus*-[Varanasi] (ToLCGV-[Var]), as it was isolated near Varanasi.

Attempts were also made to evaluate the putative recombination events that occurred between ToLCGV-[Var] isolate and the 21 Asian begomoviruses considered in this study. For example, when the full-lengths of ToLCGV-[Var] and ToLCKV were compared, there was high nucleotide sequence identity for their IR (approx. the first 100 nts), 5'-end of AV1 (200 nts), and a long stretch of 1350 nts from the 5'-end of AC3 to the 5'-end of the IR, indicating that at these sites, recombination events possibly took place between these two tomato infecting viruses or with a third unknown virus. Within the subset of viruses studied

here, one can recognize two clusters of viruses relative to putative recombinations with ToLCGV-[Var] : the first cluster would comprise the top 14 viruses would include ToLCGV- [Var], for which there is a substantial amount of recombination culminating to about 60% of the genome length with ToLCKV; the second cluster includes the bottom 8 viruses of the tree and would include ToLCKV; for which there is little or no apparent recombination with ToLCGV-[Var]. The pattern of these recombinations is very similar within the first cluster with two major blocks: the first one in the CP and the second one, with variable lengths, over the AC2-AC1 region of the genome. It is also remarkable that in the case of 4e CP, the segments look almost identical and at the same place in the ORF, possible indicating biological and structural constraints for recombinations to occur. Finally, ToLCGV-[Var] shares many fragments of its genome with several Asian begomoviruses, confirming that recombination is an essential molecular component for genminiviurs evolution.

Sex pheromone based IPM technique has been developed for management of brinjal shoot-and fruit-borer. Four tomato genotypes, H 86, H 24, Bilali 1 and 6 11B, showed tolerance to leaf curl. Hybrids, DTEH 2, DTEH 8, DTEH 9, DTEH 18 and DTEH 19, showed resistance to early blight. NF 31, VFN 8 and Pusa 120 showed resistance to root -knot nematode. Brinjal hybrids, DBHL 135 and DBHL 137, were found tolerant to shoot- and furit-borer and phomopsis blight respectively. Caluliflower, selection, Kn 81, BR 2 and 3-5-1 showed resistance for downy mildew, black rot and *Sclerotinia* rot.

TUBER CROPS

Potato

Germplasm collection was augmented by adding 20 accessions, raising its strength to 2,600 of cultivated and wild species from 30 countries. Potato hybrids, JW 160, MS/92-2105, SM/87-185 and HT/92-621, have been recommended for release. HT/92-621 is heat tolerant, resistant to leaf hopper and mites. Since it has high dry-matter content, it is most suitable for French fries. It is suitable for cultivation under early planting conditions in northern plains and warmer areas. JW 160, a high medium-maturing white hybrid having field resistance to late blight, possess wide adaptability and excellent keeping quality. It can be cultivated in plains and plateau region of the country. MS/92-2105 is a red skinned, high-yielding hybrid with oval attractive tubers having field resistance to late blight. It is suitable for cultivation in Indo-Gangetic plains, replacing late blight susceptible varieties Kufri Sinduri and Kufri Lalima. SM/87-185 is a late blight resistant white tuber hybrid having higher dry-matter content and better keeping quality.

Integrated use of vermicompost and inorganic fertilizers improved dry-matter content, specific gravity and chip colour in Kufri Chipsona 1 and Kufri Anand. A vermicompost production unit using *Eisenia foetida* species of earthworm was established at Modipuram, which produced about 15 tonnes of vermicompost and vermiculture worth Rs 50,000.

Totally virus-free mericlones (plantlets) and fully-grown plants of Kufri Jawahar, Kufri Lauvkar and Kufri Bahar were also confirmed using immune electron microscopy. A potyvirus isolated from *Physalis floridana* was characterized and identified as PVY. Another potyvirus from *Solanum nigram* was partially characterized which showed seroaffinity with Peru tomato virus. Both the isolates caused veinal necrosis in tobacco under short days.

Tropical Tuber Crops

The germplasm wealth of tuber crops has been enriched to 3,987 by adding 50 new accessions at CTCRI, Thiruvananthapuram and 685 by adding 15 new collections at Regional Centre, Bhubaneswar. Under *in vitro* active gene bank, 474 accessions have been brought. Twenty-five elite breeding lines were selected for registering with NBPGR, New Delhi. DNA fingerprinting of germplasm accessions and their molecular characterization using RAPD are in progress.

- Twenty accessions of potato were added to germplasm.
- The technical programme of IVLP was implemented in Rampuri and Baghi *panchayats* of Shimla, and Alampura, and Goanpur *panchayats* of Patna district in Bihar covering 300 and 700 farm families respectively.
- *Kisan melas* were organized at Modipuram, Patna and Gwalior centres of Potato
- Special trainings for State Government officers were organized at Shimla, Jalandhar and Gwalior centres
- A training course on research methodology on potato for scientists of AICPIP was arranged at Shimla
- Eight training programmes — one for officers of NEH states at Shimla and 7 farmers' training camps — were organized at Gangtok, Shillong, Agartala, Jharnapani, Aizwal and Imphal

About 113 species of various tubers have been collected from the 8 germplasm trips undertaken during the year

H-13 is a promising taro hybrid

including a trip to Andaman and Nicobar Islands under NATP project. Currently, 1,094 accessions have been conserved, 620 under shade net house and 474 *in vitro*.

Two triploid cassava clones 4-2 (3x) and 5-3 (3x) having higher extractable starch (>27%) were identified for industrial use. In sweet potato, 3 high carotene

Pre-released accession of greater yam

(5,700 IU) lines, S 1156, S 594 and S 1289, are under advanced stage. Of the 124 taro accessions, 13 have been identified which are tolerant to *Phytophthora* leaf blight.

Sweet potato entries, 90/101, 90/704, 90/566 and local, were tested at 5 locations in West Bengal. Of them, 90/101 recorded an average yield of 23.04 tonnes/ha followed by 90/704 (19.38 tonnes/ha). IB-90-15-9 (Indira Orange) recorded highest tuber yield in all the 5 locations in Chhattisgarh with an average yield of 22.43 tonnes/ha. This entry has been identified for release as Indira Sakarakand 1 for Chhattisgarh. In a multilocational trial of colocasia at Jagadalpur, IGCOL 3 was superior to others with an average yield of 19.00 tonnes/ha. Kadma Local was superior with an average yield of 11.16 tonnes/ha over all the locations.

The application of two-thirds of recommended dose of N along with 10 kg/ha *Azospirillum* as soil application alone or in combination with 2 kg/ha *Azospirillum* as vine dipping gave highest marketable tuber yield and dry

A promising hybrid of elephant-foot yam

weight of tubers. In an on- farm trial of sweet potato-based cropping system at Jagadalpur, cowpea – sweet potato combination was found ideal which produced 24.00 tonnes/ha tubers and 57.33 tonnes/ha green pod yield. The plots treated with half of the recommended dose of P (30.0 kg/ha) and full of N and K (120:120 kg/ha) + FYM (15 tonnes/ha) + mycorrhizal fungi recorded maximum tuber yield of 12.81 tonnes/ha followed by the plots treated with half dose of P (30) and full of N and K (120 : 120) + FYM (15 tonnes/ha) + mycorrhizal fungi + phosphate- solubilizing bacteria) (11.57 tonnes/ha). These treatments were at par with each other. On-farm trial of intercropping vegetable cowpea in *Amorphophallus* indicated that the mean tuber yield of *Amorphophallus* was 47.85 tonnes/ha under intercropping system against 45.25 tonnes/ha in pure crop. The cost analysis of intercropping system showed that an additional net return of Rs 11,225 can be obtained by intercropping vegetable cowpea over pure crop system of *Amorphophallus*.

The IPM package developed against sweet potato weevil

- Sweet potato Sree Arun, Sree Varun and Co-CIP 1 have been recommended for Kerala.
- X 109-2 sweet potato has been recommended for Tamil Nadu.
- Sequential cropping of vegetable cowpea with cassava under varying levels of FYM indicated the superiority of the treatment.
- Neem- coated urea is recommended to cassava growing farmers of Tamil Nadu.

incorporating indigenously developed (by BARC) pheromone septa (@ 1 mg/cm of 4 mm ID rubber tube) gave higher marketable tuber yield over the control. The population of biocontrol agents in IPM field that include entomopathogenic nematode, *Heterorhabditis indica* and *Rhaconotus menippus*, was comparable to that of untreated sweet potato fields. During storage, taro was found more severely damaged by *Araecerus fasciculatus* compared to other tuber crops. Parasitoids *Bracon*, *Pteromalus* sp., *Anisopteramalus calendrae* and *Anastatus* sp. were observed to parasitise *A. fasciculatus*. Two species of *Encyrtid parasitoids* were collected from mealybugs infesting elephant-foot yam during storage.

Application of neem cake or cassava leaf powder at the time of planting reduced root-knot nematode infection in elephant-foot yam. Aqueous extracts of *Gliricidia sepium* and *Eupatorium odoratum* caused 100% mortality of root-knot nematode even at 25 times dilution under *in-vitro* conditions. Yam-bean seed extract and cassava seed extract stored for a long time retained their toxicity even after 75 days. While 3 and 5% concentration of yam bean extract was highly effective against first and second instar larvae of *Spodoptera litura*, concentration of cassava seed

extract was effective against first instar larvae.

Whitefly transmission of yellow netting symptom from sweet potato to sweet potato was achieved. The symptom expression of sweet potato feathery mottle virus was found high during August-September. The plants subjected to hot-water treatment (40°C) were free from sweet potato feathery mottle virus. Application of neem cake @ 1 kg/ pit at the time of planting was effective in controlling tuber rot in elephant-foot yam. The seed tuber treatment and foliar application of rhizo-bacterial cultures controlled *Phytophthora* leaf blight and rotting of tubers by other fungi during storage of taro. New records of leaf spot pathogens, viz. *Pestalotiopsis* sp. and *Curvularia lunata* var. *aeria*, were reported from greater yam. The rust pathogen, *Canna edulis*, was identified as *Puccinia thaliae* which is a new record in India. *Rhizoctonia solani* causing severe leaf blight in yam bean was isolated and its pathogenicity was proved.

On-farm trials on IPM package against sweet potato weevil was conducted at Hyderabad, Coimbatore, Dapoli, Dholi, Ranchi, Bhubaneswar and Kalyani. The IPM package recorded higher yield of uninfected tubers and low tuber damage than chemical treatments and control. Percentage of crown damage was least under IPM package. The IPM package has been found cost effective at all the locations. Planting material of recommended varieties were multiplied at farmers' fields. Presently, *Amorphophallus* (Gagendra), cassava (Co 2, Co 3, Co 4 and (TP) -4), and sweet potato (C0 3, Co CIP 1) are included in seed production programme at TNAU, Coimbatore. The planting material was distributed to 100 farmers.

SUCCESS STORY

Nutritional Security

The sweet potato has been widely recognized as a 'saviour crop' due to profitable yield for sustaining food and nutritional security in Sujeli village of Kandhamala district in Orissa.It has brought a revolution by minimizing malnutrition and improving nutritional security. With the launching of NATP project *Horticulture and Vegetable Gardening for Food and Nutritional Security* during 2002-03, the Regional Centre, Bhubaneswar, has popularized high-yielding Gauri, Sankar and Sree Bhadra sweet potatoes. Within a span of one year, these varieties have spread faster and replaced the local ones. The tribal farmers who were hitherto getting around 7-8 tonnes/ha of sweet potatoes, are now getting 11-15 tonnes/ha. The income level too has enhanced from Rs 30,000 – 32,000/ha, to Rs 48,000 – 56,000/ha. The vegetable consumption of 150-200 g/day/ family of 4-5 members has doubled (300-450 g).

MUSHROOM

Twenty-one new wild mushroom species were collected. Two high-yielding single spore selections of *Agaricus bisporus*, SSI-689 and SSI-17, produced 18.5 and 15.6 kg mushrooms from 100kg compost respectively in 6 weeks, while hybrid 1 yielded 22.7kg mushrooms. Successful hybridization was obtained between strains NCB-6 × NCB-13 and NCB-14 × NCB 15. Of the 90 crosses, 46 interspecific hybrids were identified. These are being evaluated for mushroom yield and fruit body quality.

The DNA fingerprinting of 22 strains of *Agaricus bisporus* was accomplished with reproducible polymorphic bands at several loci using 20 decamer primers of OPO series. All the strains could be distinguished with aggregate primer data analysed by UPGMA and Jaccard's coefficient analysis. White pileal strains formed a separate cluster, whereas brown strains showed high degree of genetic diversity. All the 8 putative species of family Morchellaceae namely, *M.esculenta*, *M.crassipes*, *M.spongiola* var. *dunensis*, *M.vulgaris*, *M.conica*, *M.angusticeps*, *Mitrophora semilibira* and *Verpa conica* showed significant polymorphism and could be distinguished from each other by primer OPP-6 (5'-GTG GGT TGA C-3') and Custom primer (f'-CGC ACC GCA G-3'). These primers can be used as molecular markers for species identification in morels.

High-yielding mushroom selection

Yield data before preservation of mushroom stock culture and after 30 months of preservation showed static biological efficiency, vigour and fruit body weight. The comparison of Random Amplified Polymorphic DNA (RAPD) and Internal Transcribed Spacers (ITS) PCR amplified products did not show scorable variations at intraspecific levels in banding patterns during preservation

- Twenty-one new wild mushroom species were collected.
- The DNA fingerprinting of 22 strains of *Agaricus bisporus* was accomplished.
- Sugarcane bagasse with straw in a 1:1 ratio gave higher mushroom yield of white button mushroom.
- The cryopreservation for long-term preservation of mushroom stock has been developed.
- The low temperature sensitive edible mushroom, *Volvariella* and *Morchella*,can be preserved satisfactorily.

of stock cultures by either of the methods. The germplasm can be preserved safely under liquid nitrogen conditions for many years.

Sugarcane bagasse in combination with straw in a 1:1 ratio gave higher yield (17.53kg mushroom/100 kg compost) of white button mushroom compared to wheat straw alone (15.4 kg). Eight different isolates of thermophilic fungi isolated from compost samples were categorized based upon their RAPD profiles. Well-decomposed farmyard manure, spent mushroom substrate, combination of two (3:1, w/w) and coirpith gave significantly higher mushroom yield over the municipal garbage, vermicompost and wastes from coir industry. The casing materials fermented with thermophilic microbes at thermophilic temperature range gave significantly higher mushroom yield over unfermented casing materials.

Oyster mushroom has been successfully grown on wheat straw, paddy straw and maize stalk and leaves. Supplementation with deoiled soybean cake has given 85% biological efficiency. Higher yield of *P.eryngii* was obtained on wheat straw supplemented with deoiled soybean @ 5% wet weight basis. The paddy straw-based compost substrate gave higher mushroom yield than wheat straw, sugarcane bagasse and wheat straw+sugarcane bagasse-based composts. The strain, Ovv-01, obtained from OUAT, Bhubaneshwar, gave higher mushroom yield than other strains of different origins. Highest colonization of substrate by medicinal mushroom (*Ganoderma lucidum*) was recorded at 70% moisture level. Sawdust substrate supplemented with wheat bran @ 20% was best substrate for *Ganoderma lucidum*. Lyophilized cultures of edible fungi showed anti-dementia activity under *in-vitro* conditions.

Of the 10 plant extracts evaluated under *in-vitro* conditions against edible fungi, extract of *Gardenia* sp. caused maximum inhibition of *L.edodes* mycelial growth, followed by *M.procera* and *A.bisporus* (U-3). However, extracts of *Eucalyptus* sp., *C.lanceolatus* and *C.sativa* stimulated mycelial growth. In case of *P.sajor-caju*, no inhibition in mycelial growth was recorded from the extracts of *Cathranthus* sp., *C.lanceolatus*, and berries of *C.lanceolatus*. Of the 3 neem products, viz. Neemactin, Neemjeevan and Rakshak tested under *in-vitro* conditions against moulds and diseases of button mushroom, Neemactin caused maximum inhibition (37.55%) in *V.fungicola*, followed by *Chaetomium* sp. (36.92%). Neemjeevan caused maximum inhibition (44.88%) in *M.perniciosa*, followed by *C.dendroides* (42.22%). Rakshak caused 47.11% inhibition of mycelial growth of *T.viride* followed by *Chaetomium* sp.

SUCCESS STORY

Cryopreservation of Mushroom Cultures

A cryopreservation technique for long-term preservation of mushroom stock cultures has been developed at NRC for Mushroom, Solan. The mushroom stock cultures are invariably preserved as mycelial cultures. These mycelial cultures are required for preservation of spawn (seed) for mushroom cultivation. Repeated subculturing at 3-6 months interval often leads to loss of desirable traits, degeneration (slow growth) and genetic erosion. The technique involves multiplication of mushroom mycelium on water-soaked autoclaved cereal grains (preferably wheat grains) pre-treated with clacium salts for 3 weeks at 25°C. These cereal grains containing concealed mushroom mycelium are then submerged in sterilized cryovials containing cryoprotectants (Glycerol, Ethylene glycol, Dimenthyl - sulfoxide). These cryovials are then slowly cooled for several hours at 4, -20 and –70°C and finally plunged into big vessel containing liquid nitrogen at (-196°C). As and when stock cultures are required, these can be retrieved on malt extract culture medium, following rapid thawing by pluging into water blanks maintained at 37°C.

The low temperature sensitive edible mushroom stock cultures of *Volvariella* and *Morchella* which are otherwise maintained at room temperature, were also preserved satisfactorily by this technique. After comparing DNA fingerprinting profiles by Random Amplified Polymorphic DNA (RAPD) technique confirmed no genetic changes during cryopreservation in 11 edible mushrooms strains. Since this technique had no adverse effect on yield potentials of commercially important mushroom strains, it can be effectively utilized for conservation of mushroom germplasm of the country. Timely phylogenetic cataloguing and cryopreservation efforts may provide legal protection to indigenous mushroom germplasm both at national and international levels.

FLORICULTURE

Rose

Six new rose varieties, Pusa Mohit, Pusa Abhishek, Pusa Manhar, Pusa Muskan, Pusa Urmil and Pusa Ranjana, were released by IARI, New Delhi. Of them, Pusa Mohit is a Hybrid Tea which produce red coloured flowers on long stems suitable for cut flowers while others 5 are floribundas. The plants of Pusa Abhishek are hardy and tolerant to powdery mildew and black spot. Pusa Manhar is medium- growing floribunda which produces creamy white flowers with magenta shade. It is also tolerant to powdery mildew and black spot. Pusa Muskan produces creamy white flowers in clusters having pink shade and red coloured edges. Pusa Urmil is a bud sport 'Jantar Mantar' which produces a large clusters of 40-45 brown pink coloured flowers. Pusa Ranjana, a dwarf floribunda, produces dark pink flowers in a big clusters. It is suitable for pots and bedding pruspses. Pusa Gaurav for cut flower, Neelambari and Arunima for loose flowers and Arunima and Banjaran for garden display were found promising under Bhubaneswar conditions.

Gladiolus

Five new gladiolus varieties — Urmi, Jyotsana, Gulal, Shabnam and Urvashi — were released by Delhi centre. Application of Captaf (0.3%) controlled corm rot disease

significanly at Ludhiana and Pune. The bioagent, *Trichoderma herzianum*, controlled corm rot effectively at Pune and Kahikuchi. Benomyl (0.2%) Carbarandum and Bagalot (0.02%), were found most effective fungicides against *Fusarium* wilt.

Carnation

Pinching of carnation Impala growing under protected condition with pinch and foliar feeding of N (150 ppm) at fortnightly interval were found best. For controlling Fusarium wilt, Bordeaux mixture followed by mixture of Benomyl + Captaf and Bavistin + Captaf was found effective. Vase-life of carnation Impala and Tasman increased with pulsing treatment with glucose 10% + STS (2mM) for 8 hours and storage of cut spikes at 1°C in vase solution + STS (50 ppm) + HQC (50 ppm) for 24 hours.

Anthurium

Spadix explant cultured on MS medium supplemented with 2,4-D (3 mg/litre) and kinetin (0.3mg/litre) and kept under dark produced friable and nodular calli while petiole explant of Nitta Orange produced same on MS medium + Adenine (5 mg/litre). Pulsing solution with sucrose @ 2% (Meningue) to 8% (Lima) holding solution having BA (25 ppm) packing in polythene cover were found to be promising for increasing the vase-life at Vellanikkara.

Tuberose

For control of *Sclerotium* wilt disease of tuberose, treatment of *Trichoderma viride* @ 20g/m^2 followed by Carbendazim (0.1%) + Captan (0.2%) were found to be effective. Chemical treatment of tuberose spikes with sucrose (2%) + Al_2SO_4 ($_3$) (300 ppm) and wrapping them in newspaper increased post-harvest life at Pune, Kalyani and Vellanikkara.

Gerbera

Gerbera cultivars grown under low-cost polythene performed better than those grown under shade net and open field conditions. Leaf spot disease of gerbera could be controlled by treating the plants with Benomyl (0.1%) followed by Kavach (0.2%). Spraying of copper oxychloride (0.3%), followed by Mancozeb (0.2%) was found superior in reducing leaf spot/ blight disease in gerbera.

- Five gladiolus varieties have been released by Delhi centre.
- Vase-life of carnation could be increased by pulsing treatment with glucose for 8 hours.
- Gerbera grown under low-cost polythene performed better than those grown under shade nets and open field.
- About 450 species of 93 genera of orchids were collected.
- Eighty hybrids of cymbidium were characterized for mass multiplication.
- A mixture of brick chips, leaf manure, charcoal and coconut husk (1:1:1:1), and rotten log with moss (1:1) performed better growth and flowering in Cymbidiums.
- About 11 diseases of orchids have been identified.

Orchids

About 450 species of 93 genera of orchid were collected. Of them, 393 species of 90 genera are evaluated and characterized. These plants are maintained for further studies in *ex-situ* conservatories. Other than orchid species, 80 hybrids of Cymbidium are also collected and characterized for mass multiplication. The selected hybrids are Soul Hunt, Golden Girl, Show Girl and Lunavian Atlas. About 1,000 plantlets of Cymbidium hybrid Soul Hunt are ready for further experiment.

Low-cost Bamboo Polyhouse

A low-cost bamboo- based polyhouse has been evaluated for commercial cultivation of Cymbidiums. The bamboo-based orchid structure with 200 μ polysheet on top is able to accommodate 500 grown plants or 1,000 one-year-old seedlings. The poly structure of size 50′ × 20′ costs about Rs 25,000 for its construction with local materials.

Planting of Cymbidium in raised bed comprised brick chips, leaf manure, charcoal, coconut husk (1:1:1:1) and rotten log with moss (1:1) also equally performed better of overall growth and flowering of Cymbidium hybrids and significantly influenced height of plant, length of leaves and length of spike. Maximum height of plant, length of leaves, number of pseudobulbs, spikes and number of flowers/spike were recorded in raised beds. It is also observed that coco pith with perlite (1:1) gives better growth performance for Cymbidium hybrids.

About 11 diseases of orchids are identified from Sikkim and Darjeeling districts of West Bengal. Orchid wilt caused by *Sclerotium rolfsii* is a serious disease to commercial hybrids of Cymbidium. Other serious disease recorded is black rot caused by *Phytophthora* species. This disease is a serious problem for orchid growers in Darjeeling district.

PLANTATION CROPS

Coconut

Somatic embryogenesis and plantlet development were achieved from inflorescence and adult leaf tissues of arecanut Mangala, Sumangala, Mohitnagar and South Kanara Local. Coconut using DAF (DNA amplification fingerprinting) analysis, a putative marker for resistance to root (wilt) disease in coconut, has been identified.

Technology of sweet, ginger and vanilla flavoured chips was transferred to coconut entrepreneurs. Twenty entrepreneurs have already purchased this technology. Of them, 6 have already started production and marketing of chips. A solar-cum-electric-dryer has been fabricated. This dryer works with solar energy as the main source of energy and electrical or agricultural waste as another

source whenever sufficient solar energy is not available.

Participatory technology transfer of integrated root (wilt) management practices were demonstrated in 25 ha area owned by more than 200 farmers. The average yield increased from 25 nuts to 46 nuts/palm/year (91% improvement). The participant farmers expressed their confidence in the adoption of technology in improving the health and vigour of root (wilt) affected palms.

Oil palm

Genetic diversity was studied with 25 palms from 5 different accessions, 98C-254D (ASD Costa Rica), GD-3 (Palode), 98C-208D (ASD Costa Rica), 240D × 281D (Palode), 80D × 281D (Palode) using Randomly Amplified Polymorphic DNA (RAPD). RAPD analysis using 10 deca nucleotide random primers revealed that no two palms from the same accession or from different accessions were genetically similar. Maximum similarity of 0.917 was observed between 2 palms in accession No. 80D × 281D from Palode. Maximum genetic diversity (0.583) was observed between P8 and P12, which were 2 different palms from GD3 from Palode and 98C - 208D from ASD Costa Rica. However, P12 cand P13 from 98C - 208D accessions from ASD Costa Rica also showed maximum genetic divergence (0.583). Dendogram from cluster analysis showed 6 major clusters (groups).

Carotenoids from crude palm oil could be recovered without affecting the edibility of the oil by using specific adsorbents. Adsorbed carotenoids were recovered using specific solvents. Of the 11 adsorbents, fullers earth showed maximum adsorption and recovery. Among different solvents used to recover the adsorbed carotenoids, acetone was found to be the best. Recovered carotenoids were further concentrated up to 160 times under nitrogen using rotaty vacuum flash evaporotor. Concentrated carotenoids were obtained in powder, gel and liquid forms.

Preliminary results showed a wide variation in the degree of unsaturation as well as fatty acid composition among the oleifera palms. Few oleifera palms were found superior as they had more unsaturated fatty acid content (specially oleic and linoleic acid) in oil. Oleifera oil (American palm oil) contains more unsaturated fatty acids compared to Guineensis oil. Iodine values were determined for the oil samples from different oleifera palms and also analyzed by GLC. The Iodine value showed the degree of unsaturation, whereas GLC analysis revealed the individual fatty acid composition.

Cashew

Cashew accessions, Anagha, Akshaya, Sulabha and Dharashri, were planted in National Cashew Gene Bank (NCGB) for conservation, which raised the total number of accessions to 478. A total of 12 trees with higher yield and bold nut characters were identified for collection and conservation during survey of north- eastern region. Promising hybrids and Tea Mosquito Bug (TMB) tolerant material were planted in a new multilocational trial in 6 AICRP centres. Multiple shoots have been induced from cotyledonary and shoot tips. Shoot cultures from nodal explants of grafts were established.

In organic farming trial, highest biomass (6.8 tonnes/ha) was obtained from *Sesbania* followed by *Glyricidia* (3.25 tonnes/ha). In cashew orchard, turmeric was found to be a promising intercrop with a yield potential of 8 tonnes/ha.

Cashew growing luxuriantly after pruning

At Jhargram, yield/tree was maximum in widest planting (10m × 10m rectangular system), whereas yield/unit area was maximum in 6m × 6m × 6m triangular planting. At Vengurle, highest yield/unit area was obtained from 5m × 5m square planting and highest nut yield/tree was in 8m × 8m square planting. At Bapatla, clusterbean was found most economical intercrop

- Twenty entrepreneurs purchased technology of making ginger and vanilla flavoured chips of coconut.
- A solar-cum-electric-dryer has been fabricated.
- Oil palm empty bunch decorticator with a decorticating capacity of 45 kg empty fruit bunches/hour has been developed.
- Carotenoids from crude palm oil could be recovered without affecting edibility of oil by using absorbents.
- A total of 478 accessions of cashew have been conserved in the National Cashew Gene Bank.
- In cashew orchard, turmeric was found to be a promising intercrop.

Oil Palm Decorticator

An oil palm empty fruit bunch decorticator was developed and fabricated for separation of fibres from oil palm empty fruit bunches. The decorticator has a capacity of decorticating 450 kg of empty fruit bunches/hour and can produce about 180 kg of dry fibres. Its cost is Rs 1.40 lakhs. The fibre obtained from decorticator can be used for various value-added products like blended yarn, fiberboard and rubberized mattresses. The rubberized mattresses were of extra firm grade as per the Indian standards with indentation hardness of 15.88.

in *kharif* season and blackgram was remunerative in *rabi*. Groundnut was found economical intercrop at Jhargram and Vridhachalam, whereas bitter gourd was highly profitable at Vengurle.

Crude fibre from cashew apple pomace was extracted and studied in order to develop fibre rich value-added products from cashew apple. The crude fibre shaved higher water absorption capacity. Extent of *in vitro* digestibility of carbohydrate in crude fibre was found to be less compared to protein, which was digested completely. A total of 28 released varieties were analyzed for P, Ca, Mg, Na, K, Cu, Fe, Se and Mn.

SPICES

Two high-yielding and high quality ginger varieties, IISR Mahima and IISR Rejatha and a high-yielding and high-quality nutmeg clonal selection, IISR Viswashree, were released for cultivation in Kerala.

Sixty-eight accessions of *Piper* species and cultivated black pepper types were collected from Kerala and Andaman Islands. One hundred accessions were characterized and catalogued based on IPGRI descriptors. Twenty-five accessions of cardamom,11 of related genera, 5 *Zingiber* species and one cultivated turmeric type,7 *Garcinia* species, one collection of *Cinnamomum sulphuratum* and 6 wild species of *Myristica* were added to the germplasm. Twenty accessions of black pepper, 18 of turmeric, 15 of ginger and 100 of vanilla were added to *in-vitro* gene bank.

New germplasm collections of ginger, turmeric, coriander and fenugreek were collected at Pundibari.

- Two high-yielding ginger varieties and one nutmeg clonal selection were released for cultivation.
- A number of accessions of various spices — ginger, cardamom, turmeric, Garcinia, cinnamon etc. — were added to germplasm.
- About 991 accessions of 9 seed spices were collected, evaluated and maintained at NRC for Seed Spices.

Cardamom clones, CL-629, CL-681 and CL-730 and OP progenies, D-237, CL-730, 8-4-D-11 and 7-24-D11, were identified as promising at Mudigere. The promising clones, P-6, D-237 and CL-746, were drought tolerant. Germplasm accessions tolerant to various diseases were identified in ginger, turmeric, coriander and cumin. Turmeric accession, SG 685, gave high dry recovery and coriander, Jco 331, high oil (0.45%) content.

In cardamom, 15 hybrid combinations were identified as promising for yield and tolerance to leaf blight. *Garcinia gummigutta* grafted on *G. hombroniana* and *G. cowa* by softwood grafting gave 90% success and *G. indica* grafted on *G. gummigutta* gave 54.5% success.

In *Piper*, Acc. 5411 yielded 31.0% oleoresin and 6.2% piperine followed by Acc. 5442 with 21.0% oleoresin and 6.0% piperine. Acc. 60, 63, 75 and 273 had more than 8.0% volatile oil and Acc. 257, 258, 259, 277 and 325 had about 30% á-terpinyl acetate and about 25% 1,8-cineole. In ginger, Gurubathani, Kozhikkalan and Accs. 121, 260, 340 and 342 had above 5.5% oleoresin and Kozhikkalan and Gurubathani had 4% crude fibre.

In nutmeg, essential oil content ranged from 7.67 to 13.89% and that in mace from 7.48 to 20.99%. The colour value of paprika accessions ranged from 42 to 171 ASTA units and 33 to 176 ASTA units for indigenous and exotic germplasm collections, respectively.

Application of vermicompost @ 1.25 kg/pot significantly increased build-up of soil P from 2.1 to 55.0 mg/kg, K from 103 to 262 mg/kg and yield by 51% over chemical fertilizer sources in bush pepper. Black pepper hybrid, HP-29, maintained higher water status, lower membrane damage and higher SOD activity during water stress. Cardamom genotype, APG-18, was superior in withstanding drought stress. Pineapple as live barriers in between cardamom showed promise for soil and water conservation in cardamom-based cropping systems.

Metalaxyl Gold MZ and *Trichoderma* sp. were effective for the management of *Phytophthora* foot rot of black pepper. Two sprayings of either monocrotophos (0.05%) or dimethoate (0.05%) at fortnightly intervals after harvesting of berries were effective for the management of mussel scale (*Lepidosaphes piperis*) on black pepper at high ranges of Idukki district in Kerala.

Five accessions (Accessions 6, 17, 130, 155 and 208) were found promising against rhizome rot of ginger. ITS-PCR and RAPD analysis confirmed the narrow genetic base of bacterial wilt pathogen in ginger. A protocol was refined for isolation of DNA *R. solanacearum* from soil. The Thermal Death Point of *R.solanacearum* was determined as 45.8°C at 30 minutes of exposure. The time and duration of rhizome solarization was optimized.

Field evaluation of promising fungal (*T. harzianum* and *Verticillium chlamydosporium*) and bacterial (*Pasteuria penetrans*) isolates indicated that black pepper vines treated with *V. chlamydosporium* yielded highest compared to other treatments. Four promising fungal isolates (*V. chlamydosporium*, *T. harzianum*, *Paecilomyces lilacinus* and *Scopulariopsis* sp.) and rhizobacteria (IISR 853 and IISR 859) also reduced foliar yellowing in black pepper vines.

Evaporation cool chamber (a double-walled brick structure filled with sand between the walls, frequently moistened with water) was found ideal for storing fresh ginger.

About 991 germplasm accessions of 9 seed spices were collected, evaluated, maintained and conserved at NRC for Seed Species. Coriander ACr 256 has been identified promising for high yield and resistance. Fennel Sel-01-87 was identified for better yield and Sel-01-119 was found suitable for cultivation during *kharif* season. New selections of fenugreek, AM 10 and AM 35, were identified having early maturity, large pod size and high yield potential, and field tolerance to powdery mildew. New

ajowain selections, AA-19 and AA-61, have been identified for earliness, high yield and resistance to powdery mildew.

New superior selections have been isolated in Indian dill and European dill. The European type of dill AD-43 identified for quality was found suitable for export. New selection of cumin AC 167 isolated for high yield possessed wilt resistance. The agro-techniques for minor seed spices, viz. *ajowain*, dill and kalongi were standardized.

BETELVINE

Betelvine germplasm was maintained and catalogued raising to total accessions to 269. Betelvine Swarna Kapoori was found superior in vine growth (40.5 cm/ month), leaf yield (93.63 lakh/ha), and low incidence of *Phytophthora* foot rot disease.

The plant population density of 1.5 lakh plants/ha produced maximum number of leaves/plant (14.85) at JNKVV centre. However, maximum number of leaves /ha (23.65 lakh) was obtained with 2.0 lakh plants/ha. The cost : benefit ratio was maximum (1:4.43) with 1.5 lakh plants/ha. At AAU centre, 2 lakh plants/ha produced maximum number of leaves (48.64). At OUAT, 2.00 lakh plants/ha showed significantly higher leaf yield (55.6 lakh) /ha. Shelf-life of leaves was more (13 days) in 1.75 lakh plants /ha. Leaf yield was maximum (35.29 lakh/ha) at the plant population of 1.75lakh/ha at RAU centre. Maximum disease incidence (27.6) was, however, recorded at 2 lakh plants /ha. The plant population of 1 lakh/ha was found to be optimum for higher leaf production and better cost : benefit ratio at ANGRAU and

- Betelvine germplasm was catalogued, raising its total number to 269.
- Swarna Kaprori betelvine was found superior in vine growth, leaf yield and low disease incidence.

75,000 plants/ha (45 lakh leaves/ha) at TNAU centres. However, the PDI was maximum (11.52) under this population density.

The keeping quality was maximum with application of Azotobacter 5kg+100 kg N through oil cakes, phosphobacter 5 kg + 50kg P_2O_5+ 100 kg K_2O/ ha and vermicompost (200kg N), 100 kg P_2O_5+ 100 kg K_2O/ ha.

The recommended dose (200 kg N + 100 kg P_2O_5 +100 kg K_2O/ha) yielded significantly more number of branches (32.75), maximum leaf yield (105.82 lakh/ha) and weight of 100 leaves (258.79 g) and increased keeping quality of leaves (17.2 days), followed by application of biofertilizer Azotobacter 5 kg + phosphobacter 5 kg + 100 kg K_2O/ha. Maximum cost: benefit ratio (1: 2.51) was received with Azotobactor + phosphobacter + K_2O.

Leaf yield was maximum (48.30lakh/ha/year) in phosphobacter (5kg/ha). Application of vermicompost @ 2.0 tonnes/ha helped in increasing the leaf size (16 cm×13.30cm). Shelf-life of leaves was found to be longer (13.4 days) with the application of phosphobacter (5kg/ ha) remaining at par with Azotobacter (5kg /ha) + phosphobacter (5kg/ha) and vermicompost application. The disease incidence was lowest (7.4%) with the application of phosphobacter (5kg/ha) which remained at par with Azotobacter (5kg/ha) and Azotobacter (5kg/ ha) + phosphobacter (5kg/ha). The cost: benefit ratio revealed that an increased return of 1:3.86 could be achieved with incorporation of phosphobacter (5kg/ha) followed by vermicompost application.

The leaf yield was significantly highest (48.00lakh/ha/ year) remaining at par with application of NPK (kg/ha) : 150 (oil cake +urea) : 100:125. The percentage of disease incidence was significantly lowest with NPK (kg/ ha) : 150 (oil cake) : 100:125 and highest with NPK (kg/ ha) : 150 (oil cake + urea) : 100:125. The cost : benefit ratio indicated that an increase return of 1:0.77 could be obtained with application of NPK (kg/ha) : 150 (oil cake + urea) : 100:125. Application of 200 kg N/ha (oil cake) + 100: 100 P and K kg/ha gave maximum leaf yield/ha at MPKV. At TNAU centre with NPK (kg/ha) : 150 (FYM) : 50: 50, better leaf yield (30.23 lakh/ha) was recorded.

Phytophthora foot rot disease in betelvine could be best managed with sanitation + 1 application of BM% at the monsoon + application of biological agent (*T.harzianum*) one month later + 1 additional BM after 2 months of 1st BM. Aplication of oilcakes + carbofuran + 3 inoculations of *P.lilanus* inoculated oil cakes showed best control of root-knot nematode and increased leaf yield compared to other treatments at JNKVV, AAU, OUAT and RAU.

MEDICINAL AND AROMATIC PLANTS

A total of 380 accessions of medicinal and aromatic plants were maintained in the genebank. In safed musli, a number of promising lines; MCB 405,412,414 (Mandsaur), CBI 5,7, 12, 24 and 15 (Indore) RC 62, 74, 77 and 86 (Udaipur) and NRCCB 1 (NRCMAP) were identified. Yield of fresh fleshy root varied from 2.44 to114.85g/plant. Maximum yield of fresh fleshy root was found in Vireswar lines (2,506 kg/ ha). Total steroidal sapogenine content ranged from 0.562 to 1.21%.

Fresh fleshy root yield was found significantly superior (2,130 kg/ ha) in MCB 412 at Mandsaur. However, maximum (1.025 %) sapogenine content was in MCB 405. Highest yield (2,979 kg/ha) of fleshy root was recorded in RC 62 at Udaipur.

- A total number of 380 accessions of medicinal and aromatic plants were conserved.
- Safe musli, isabgol, guggal, aloe, kalmegh, aswagandha, opium poppy, valeriana etc. plants were evaluated for their high yield potential.

Two species were studied morphologically, physiologically, cytologically and chemically. Saponin profile was studied by HPTLC method. Eight saponin components were present in *C. arundinaceum* and *C.borivilianum*.

Planting on ridges was superior over others at Udaipur and yielded highest (1,735 kg/ ha) fleshy roots. At NRCMAP, double-row raised bed planting gave highest (1,911 kg/ ha) fleshy root yield. It was also found that planting on 1 July yielded significantly highest yield of fresh fleshy roots (1,537 kg/ ha). Neem leaf mulch produced maximum (1,677 kg/ ha) fresh fleshy roots. At Anand, removal of floral parts increased vegetative growth and length of fleshy roots. Detopping enhanced fleshy root yield by nearly 30%.

In kalmegh (*Andrographis paniculata*), fresh and dry herbage yields were maximum (923.28 and 307.76 g/ plant respectively) in Attarsumba accession.

Aloe (*Aloe barbadensis*) has maximum (1,565.87 mg) total aloin (aloin A) /plant. *Aloe* species, used as vegetable in Rajasthan, had aloin only in negligible quantity (4.07 mg/plant). Other species had 713.13 mg of aloin/plant. An artificial inoculation method (detached leaf inoculation method) was also developed for easier and quicker screening of germplasm for disease resistance.

In guggal (*Commiphora wightii*), highest rooting success was observed in cuttings raised in soil medium (53.33%). Quick dip method in 1500- 2000 ppm IBA gave highest (60-65.33%) cutting success in soft wood cuttings. It was also found that semi hard wood cuttings (up to 10 days old) could effectively cause good rooting success (66.7-72.00 %).

Isabgol (*Plantago ovata*) at Mandsaur, swelling factor was found to range from 6.2 (SPS 20) to 10.1 in SLS 59. Three lines at Mandsaur and 2 at Udaipur were found resistant to disease.

In aswagandha (*Withania somnifera*), dry root yield was highest in MWS 216 (833 kg/ ha). Alkaloid content (%) of dry root was found to range from 0.310 (MWS 312) to 0.604 (MWS 226). Highest root yield was in RAs 11 (5.63 g/ plant) at Udaipur. Total alkaloid content was highest in RAs 10 (0.68) followed by RAs 11 (0.60).

In opium poppy (*Papaver somnifera*), seed yield ranged from 379 (IC11) to 1,041 kg/ ha and morphine content varied from 9.6 (NGRI 10 and ND 1001) to 14.1% (MOP 587). Latex yield varied from 16.33 (ND 25) to 78.79 kg/ha (UO 1585), seed yield 145 (UO 1,285) to 1,333 kg/ ha (ND 17) and husk yield 124 (UO 1285) to 958 kg/ ha (ND 35, ND 43, ND 17 and MOP 539) at Faizabad.

Maximum disease index was recorded in 15 November-sown crop (68.02%), whereas in 25 October sowing, it was lowest (49.62) and crop sown on 25 October to 1 November produced highest latex (6,573-6,398 kg/ ha) at Udaipur. At Mandsaur, minimum disease (14.30%) and maximum latex (53.54 kg/ ha, seed (1,443 kg/ ha) and husk (690 kg/ha) yields were observed in 2 November sowing.

In Valeriana (*Valeriana jatam ansi*), maximum rhizome width was in VJ-99-UHF-8 and VJ-2K2-UHF-20 (0.60cm). Rhizome length varied from 6.30 cm in VJ 2K1-UHF-3 to 9.80 cm in VJ 99-UHF-10 (9.80 cm) and maximum rootstock yield per plant was maximum in VJ 2K2-UHF-19 (17.80 g) and minimum in VJ 2K2-UHF-28 (2.60g).

POST-HARVEST MANAGEMENT

The fruits of Baneshan at mature green stage could be kept in unripe condition for 45 days at 8°C under controlled atmosphere storage of 5% O_2 +2.5–3.0%CO_2 as against a week at ambient conditions.Chlorinated water was found best disinfectant for reducing surface microflora of mango fruits followed by actinomycetes. Mango, EC 95.862, Ambika, H 1591, H 1612 and H-533, were found suitable for processing. Good quality mango-bael blended bar could be prepared by blending 20% bael pulp with mango pulp.

Mango stones left after processing, still have 6-7% pulp adhering to them, which attract moulds that make stones unhygienic to handle. One cheap device has been developed by CISH, Lucknow, to utilize this waste pulp for baker's yeast production by using solid-state fermentation technology. The baker's yeast thus obtained may be used by the baking industry or added to low quality rice flour for making protein enriched animal/poultry/fish feed supplement. The stones, thus obtained are clean and can be utilized for raising seedlings. Yeast treatment of stones has no adverse effect on seed germination.

Ney Poovan, bananas treated with GA (100ppm) and stored at ZECC had highest green life (6 days) and yellow life (5 days). The untreated fruits stored at RT had highest PLW. The organoleptic score was highest in fruits packed in polybags with ventilation and stored at ZECC. Virupakshi bananas treated with Ethrel (500 ppm), sealed in polybags and stored at RT failed to ripen normally even after 7 days while those without polybags ripen within 3 days after treating with Ethrel. Banana fingers packed with foam in 2-ply cardboard boxes weighing 13.5 kg with ethylene absorbent is suitable for export.

Drenching of *Botryodiplodia* affected vines with Bavistin significantly increased brix yield in affected vines. Pre-harvest treatment of grapes with chitosan alone or in combination with *Trichoderma* improved shelf-life of grapes.

The individually shrink-wrapped pomegranate fruits retain their freshness up to 3 weeks at ambient condition and up to 12 weeks at 7-8°C storage. The weight loss during storage is highly reduced, which makes up for the cost of wrapping individual fruits. Individual shrink wrapping also prevents the spread of rots and spoiling of fruits.

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