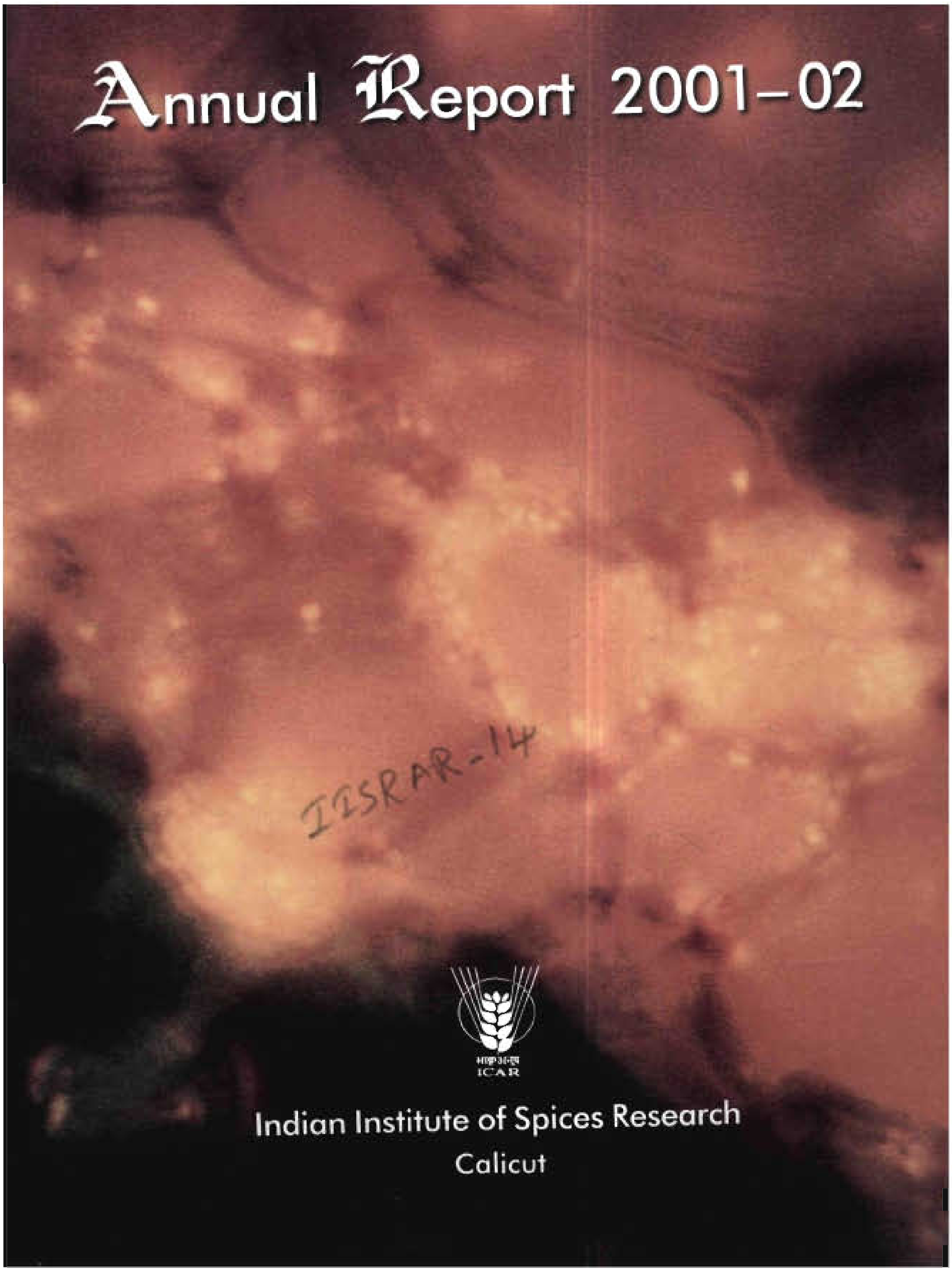

Annual Report 2001–02

ICAR

Indian Institute of Spices Research

Calicut

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Front cover
Fluorescing cells of bacterial wilt pathogen *Ralstonia solanacearum* stained with Nile blue in vascular tissues of ginger

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Contents

Preface

The challenges facing Indian agriculture in recent years, especially in the spices sector, are quite different from that of previous decades. Globalization, liberalization and privatization have become dominant forces shaping trade, economy and society, the world over. The Indian Institute of Spices Research, Calicut, has geared up its research and development programmes to meet the challenges faced by the spices sector in the new millenium.

Collection of germplasm of spice crops particularly indigenous materials, from centres of biodiversity was taken up on a priority. Characterization of germplasm through conventional and molecular means was carried out and the collections were also evaluated for yield, quality and tolerance to biotic and abiotic stresses. Proposals for release of two high yielding lines of ginger and one high yielding line of nutmeg were submitted to the State Variety Release Committee, Kerala. Promising high yielding lines of black pepper, cardamom and cassia were identified.

The institute continued to adopt various strategies to increase production and productivity of spices in view of shrinking natural resources like land and water. Suitable cost effective technologies for cropping systems, drought management, integrated plant nutrient management and water use efficiency for sustainable production were developed. Development of appropriate post harvest management technologies for obtaining a clean and high quality produce was also continued.

A major thrust was given for developing eco-friendly strategies for the management of pests and diseases of spice crops through tolerant varieties, cultural practices, plant products, biocontrol agents and safer pesticides, to obtain a pesticide free produce to suit the global demand. A repository of biocontrol age-nts comprising of bacterial, fungal and nematode antagonists was maintained. These biocontrol agents were characte-rized and evaluated for their potential in pest and disease management.

Digitization, information dissemination and human resources development were achieved through the Integrated National Agricultural Resources Information System (INARIS), Bioinformatics Centre, Agricultural Technology Information Centre (ATIC) and Krishi Vigyan Kendra (KVK).

The institute has completed 25 years of service and can take pride in its remarkable contributions made through innovative research and developmental activities in spices. The research achievements and other activities of the institute during 2001–02, are presented in this publication.

I gratefully acknowledge the support and guidance given by Dr. Panjab Singh, Director General, ICAR and Secretary, DARE, Dr. G. Kalloo, Deputy Director General (Horticulture), ICAR and Dr. R. N. Pal, Assistant Director General (Plantation Crops), ICAR, New Delhi, in all our activities. I owe a lot to the chairman and members of the Research Advisory Committee for refining our research programmes.

I thank Dr. J. Rema and Dr. S. Devasahayam for their painstaking efforts in bringing out this publication.

Calicut
October 2002

V. A. Parthasarathy
Director

Executive Summary

The Indian Institute of Spices Research, Calicut, established in 1975 as the erstwhile Regional Station of Central Plantation Crops Research Institute, Kasaragod, has the mandate to conduct and coordinate research on all aspects of spices. The research programmes of the institute are carried out under various projects that are time bound and with specific objectives. The significant achievements of the institute during 2001–02 are summarized here.

Collection and conservation of germplasm

Explorations were conducted in Siruvani, Anakatti, Sholayur, Attappadi, Silent Valley, Nelliampathy, Idukki (Kerala), Kudremukh (Karnataka) and Nilgiris (Tamil Nadu) and 153 accessions of *Piper* spp. and black pepper cultivars were collected. A rare monoecious type of *P. nigrum* (wild) was collected from Nelliampathy forests. The total germplasm collections available in the conservatory include 2299 accessions of black pepper cultivars and 932 accessions of *Piper* spp. A database of black pepper germplasm was brought out in a CD.

Twenty-six accessions of cardamom and related species were collected from Idukki (15), Silent Valley (9) and Kodagu (2). Three hundred and eighty-five accessions including 11 allied genera of Zingiberaceae were maintained in the conservatory. Seventy-two accessions were evaluated and characterized for 14 characters based on IPGRI descriptor. Twenty-one new accessions of *Zingiber* spp. were collected and 645 accessions of *Zingiber* spp. and 800 accessions of *Curcuma* spp. were maintained in the conservatory. Morphological and yield traits of 50 accessions of ginger were recorded.

Seven cultivated and 10 wild accessions of *Garcinia gummi-gutta* were collected from Kerala and Karnataka forests. Two cultivated accessions of *G. indica* were collected from Taliparamba (Kerala) and Vengurla (Maharashtra). Six accessions of *Myristica fragrans* were collected from Vengurla and Kozhikode District. Three accessions of *M. beddomeii* were also added to the germplasm. One accession of *Syzygium cuminii* var. *gokak* was collected from Vengurla. Two accessions of *Cinnamomum verum* from Vengurla and one accession of *C. cecidodaphne* from Nepal were also collected. The total collections maintained in the conservatory include 302, 482, 223 and 32 accessions of *Cinnamomum* spp., *Myristica* spp., *Syzygium* spp. and *Garcinia* spp., respectively.

One accession each of *Vanilla walkeriae*, *V. tahitensis* and *V. planifolia* were added to the germplasm. Thirty accessions of *Vanilla* spp. were maintained in the conservatory.

Various accessions of black pepper (20), cardamom (1), ginger (9), turmeric (18), vanilla (85), paprika (12) and other spices (81) were added to the *in vitro* genebank. Three hundred and eighty- nine accessions of various spices are now available in the *in vitro* genebank.

Characterization of germplasm

Cytological analysis of 10 accessions of ginger revealed that Accs. 147 and 116 had a chromosome number of 2n=24 while the other accessions had a normal chromosome number of 2n=22. Analysis of five seedling progenies of turmeric showed variable chromosome numbers (2n=42–94).

DNA was isolated from 70 accessions of black pepper germplasm and RAPD profiles were developed in 13 *Piper* spp. using random primers. RAPD profiles of 4 species of *Zingiber* and 12 cultivars and 6 species of *Curcuma* were also developed with five primers. Relatively good polymorphism was evident at the species level. A protocol for isolation of DNA in cinnamon was standardized. DNA was isolated from 100 accessions of cardamom, 50 accessions of vanilla and 10 species of *Cinnamomum* for molecular characterization. A RAPD based molecular marker technique for identification of true hybrids was developed in black pepper. The hybridity of three F1 hybrids namely, HP-34, HP-780 and HP-1411 was confirmed based on the inheritance of the male parent specific RAPD.

Crop improvement

The promising black pepper lines, Coll. 1041, OPKm, HP-780, HP-1411 and HP-813 continued to maintain their superiority with a mean yield of 2–3 kg (fresh berries)/vine during the fourth year after planting. Preliminary yield evaluation of hybrids of black pepper indicated the potential of the hybrid HP-1313 with a mean yield of 2.1 kg (fresh berries)/vine and 41.2% dry recovery during the third year after planting.

Fifteen hybrid combinations of cardamom were identified based on their *per se* performance, heterosis, combining ability, capsule size, shape and colour and field resistance to mosaic disease. Fifty-three accessions from the germplasm (4 Mysore, 8 Vazhukka, 29 Malabar and 12 compound panicle types) were selected based on biomass, yield, capsule characters and reaction to leaf blight and rhizome rot diseases.

Evaluation of 3 year old clonal progenies of elite *Cinnamomum cassia* lines indicated that there were no significant differences among the four lines (A-2, C-1, D-1, D-3) and the yield varied from 137.6 g to 462.7 g/plant. Evaluation of related species of *Syzygium* as rootstocks for grafting of clove indicated that the growth of the grafts in the field on *S. heynianum* and *S. aromaticum* was satisfactory even after 3 years.

Intraspecific hybridization between *V. tahitensis* (female) and *V. planifolia* (male) and *V. aphylla* (male) resulted in successful development of fruit. Pollination with cryopreserved pollen of *V. aphylla* also resulted in development of fruit.

Proposals for release of two ginger accessions namely, Acc.35 and Acc. 117 with an average yield of 23.2 t/ha and 22.4 t/ha (fresh rhizomes) respectively, were submitted to the State Variety Release Committee, Kerala. These varieties have bold rhizomes with low fibre content. A high yielding nutmeg accession A-9/41 with an average yield of 3122 kg nuts (dry)/ha and 480 kg mace (dry)/ha was also submitted to the State Variety Release Committee, Kerala.

Evaluation of germplasm for quality

Two hundred germplasm accessions of black pepper were evaluated for quality and Acc. 5302 was promising with 8.0% oil, 19.0% oleoresin and 3.7% piperine.

Among the 54 germplasm accessions of ginger evaluated for quality, Acc. 197 was promising with 2.5% oil, 7.0% oleoresin and 2.8% fibre. Evaluation of 11 high curcumin lines of turmeric including six AFT (Alleppey finger turmeric) selections along with the released varieties Prabha and Prathibha indicated that Acc. 585 (AFT line) yielded the highest (29 kg (fresh)/ 3 m^2bed) with 18.6% dry recovery. The activity of phenyl alanine ammonia lyase, the key enzyme involved in the formation of precursors of curcumin was positively correlated with curcumin levels, in high and low curcumin accessions. Cell fractionation studies showed higher activity of the enzyme in the mitocondria.

Among the 37 nutmeg accessions screened for quality parameters, essential oil content varied from 2.4% to 16.5% in nut and from 6.0% to 26.1% in mace. Accession A-9/18 had maximum oil in both nut and mace. The major components in both the essential oils were α-pinene, sabinene, myrcene, myristicin and δ-elemicin. A-9/71 and A-9/95 were promising with high sabinene and myrcene, along with low myristicin and elemicin contents. In elite clove lines, the percentage of bud oil varied from 12.9% to 20.5% and B-76 had maximum bud oil. The oil percentage in pedicel varied from 3.3% to 7.7% and B-59 had maximum pedicel oil.

Drought tolerance

Preliminary screening of 150 accessions of black pepper for drought parameters (relative water content, cell membrane leakage, moisture loss from leaves, catalase and peroxide activities and electrophoretic pattern of proteins) indicated that Acc. 828 was relatively tolerant. Among the various species of *Myristica* evaluated as rootstocks for grafting nutmeg to overcome drought, *M. malabarica* the best.

Integrated nutrition management

Studies on nutrition management in black pepper indicated that availability of Zn in soil increased significantly with levels of soil application of Zn. The available P content reduced significantly with increased levels of Zn application. Adoption of integrated plant nutrition management (IPNM) enhanced nutrient availability in soil and the yield increase varied from 30% (Wyanad) to 40% (Kodagu). The incidence of *Phytophthora* foot rot disease was reduced and quality parameters such as oleoresin and piperine contents of berries were enhanced due to the adoption of IPNM. Foliar application of Zn 0.25% (twice) resulted in high rhizome yield in ginger when compared to soil application. Application of neem cake increased availability of N significantly and the highest available N was recorded in beds applied with half the dose of N as urea along with neem cake @ 2 t/ha. Availability of soil P, Ca, Mg, Zn and Mn increased significantly with application of neem cake, phosphobacteria and P as rock phosphate.

Post harvest management

Drying of mature spikes of *Piper chaba* at 60–65°C for 9 h was essential to reduce the moisture content to a safe level of 5.5% with an oleoresin content of 8.1%. Hot air drying of nutmeg mace at 50°C required 4 h while blanching and drying took only 3.5 h. Blanching of mace in 75°C hot water for 2 min before drying, gave 23% more colour and colour stability, than hot air dried mace. The dry recovery, volatile oil and oleoresin contents of hot air dried and blanched mace were comparable. Evaluation of drying techniques in cassia indicated that hot air drying of cassia required 3 h at 50°C while sun drying took 1–2 days. The dry recovery of hot air dried and sun dried cassia were 34.0% and 33.7%, respectively.

Storage of fresh ginger in polyethylene bags with 2% ventilation and in zero energy chamber was ideal with minimum dehydration compared to cardboard box and other open containers. There was an increase of 40% in dry recovery and decrease of 20% in chemical quality after 4 months of storage. The high yielding variety Varada had 19.8% dry recovery, 1.6% oil, 4.9% oleoresin and 3.9% crude fibre after 4 months of storage. Storage of nutmeg mace in PET containers and polyethylene bags increased the moisture content while volatile oil, oleoresin and lycopene contents decreased.

Evaluation of dried leaf powder of various plant species for prevention of infestation by cigarette beetle (*Lasioderma serricorne*) during storage of dried ginger rhizomes indicated that storage in leaf powders of *Glycosmis pentaphylla* and *Azadirachta indica* and in sealed PET containers was more effective.

Four black pepper threshers were evaluated for their threshing efficiency and capacity and the drum type thresher developed by Tamil Nadu Agricultural University, Coimbatore, gave the highest efficiency of 99.6% and could thresh 150 kg of spikes per hour.

Management of diseases

Phytophthora *foot rot*

Four hundred and seventy-two isolates of *Phytophthora* from various hosts were maintained in the National Repository of *Phytophthora*. One hundred and seventy isolates of *Phytophthora* infecting black pepper were characterized morphologically among which 159 isolates belonged to *P. capsici* and the rest to *P. palmivora*, *P. parasitica* and atypical isolates. Biochemical characterization of *P. capsici* from black pepper using isozyme analysis revealed the existence of two sub populations in this species. Protocols were standardized for RAPD analysis of *Phytophthora* isolates from black pepper and cardamom.

Screening of 343 black pepper hybrids, 7 cultivars and 9 wild accessions for their reaction to *P. capsici* indicated that 9 hybrids, 4 cultivars and 2 wild accessions were tolerant. Thirty-one promising hybrids were further tested for their reaction to *P. capsici* and 6 hybrids (HP-293, HP-400, HP-674, HP-1372, HP-1375 and HP-1389) were tolerant. Seedling progenies of P-24 (resistant line) and KS-27 (susceptible line) were screened against *P. capsici* and a higher percentage of seedlings of P-24 showed a tolerant reaction.

Trials on rejuvenation of *Phytophthora* foot rot affected black pepper garden indicated that the establishment and yield of vines was higher in plots under clean cultivation (97.7%) compared to plots with weeds (88.9%). In disease affected plots, where replanting was done after solarization, growth of vines was better compared to plots under clean cultivation and with weeds. The population of *Trichoderma* was also higher in solarized plots compared to plots with weeds and under clean cultivation.

Trials with resistant rootstocks of *Piper colubrinum* in a farmer's field indicated that there was no deterioration in growth of grafts 5 years after grafting. The average yield obtained from these grafts (cv. Karimunda) was 11 kg (green) per standard. Histological studies of 1 year old grafts indicated that the graft union between *P. colubrinum* and *P. nigrum* showed no incompatibility.

Studies on sensitivity of 29 isolates of *P. capsici* obtained from various areas of Kerala and Karnataka to potassium phosphonate indicated that there were significant variations in the sensitivity of the isolates and sporulation was the most sensitive stage. The *in vitro* and *in vivo* compatibility of *Trichoderma sp. and potassium phosphonate* was studied and the chemical did not show any deleterious effect on *T. harzianum* (up to 60 and 1200 mg/ml in *in vitro* and *in vivo* studies, respectively). Protoplast regenerated colonies of *Trichoderma* spp. tolerant to copper oxychloride and metalaxyl were also developed.

Four hundred and seventy-three isolates of *Trichoderma* and other antagonists of *Phytophthora* were maintained in the Repository of Biocontrol Agents. The *Trichoderma* isolates obtained from Silent Valley were classified based on morphological characters into two sections namely, *Trichoderma* and *Longibrachiatum* and included seven species namely, *T. harzianum, T. koningii, T. pseudokoningii, T. parceramosum, T. aureoviride, T. citrinoviride* and *T. longibrachiatum*. Molecular typing of *Trichoderma* spp. using 12 random primers indicated that all the 22 isolates could be grouped into three clusters, the predominant being *T. harzianum*.

Screening of 222 isolates of *Trichoderma* spp. *in vitro* for their antagonism to *P. capsici* indicated that the inhibition of *P. capsici* by the isolates varied from 20% to 84%. Among the 79 promising isolates tested *in vivo* for growth of black pepper, 29 isolates were growth promotive, the increase in growth of black pepper over control varying from 31.6% to 184.7%. Eight isolates were disease suppressive, the disease incidence varying from 0% to 30% as against 80% to 100% in control. Bioassays conducted with promising *Trichoderma* spp. to determine the dose required for application of biocontrol agents indicated that a concentration of 10^4 cfu/g of soil was required for *T. harzianum* and *T. virens* 17 whereas, *T. aureoviride* 25 and *T. virens* P-12 required 10^7 cfu/g of soil to reduce the incidence of the disease significantly. Application of various combinations of biocontrol agents (*T. harzianum, T. virens, T. aureoviride* and *T. pseudokoningii)* resulted in 107.5–132.5% increase in growth of black pepper vines over control and 75% disease suppression as against 0% in control; in individual applications, the disease suppression ranged from 50% to 75%.

A few strains of Plant Growth Promoting Rhizobacteria (PGPR) (IISR-310, IISR-314 and IISR-331) from Silent Valley could increase the growth of black pepper cuttings by 147–228% in greenhouse studies. The strain IISR-331 showed a maximum of 82.7% inhibition of *P. capsici in vitro*. The fluorescent pseudomonad strains IISR-8, IISR-11 and IISR-51 could effectively rejuvenate black pepper cuttings when treated alone and also in combination and when supplemented with the fungicide, metalaxyl-mancozeb. The fluorescent pseudomonad strains, IISR-8, IISR-13 and IISR-51 were also resistant to many of the antibiotics.

Fluorescent pseudomonads and *Trichoderma* isolates induced *Phytophthora* wall degrading enzymes such as lipases, β-1,3 glucanases and β-1,4 glucanases. The two efficient biocontrol agents, fluorescent pseudomonad (IISR-51) and *Trichoderma* spp. (IISR-1369) were also compatible. The combination of *Trichoderma* sp. (IISR-1369) and fluorescent pseudomonad (IISR-11) collected from black pepper rhizosphere could impart greater protection against soil-borne pathogens in ginger and cardamom also.

Phyllody disease

A survey for incidence of phyllody disease in Kodencherry Panchayat (Kozhikode District) showed that a few gardens were severely affected with about 90% of the plants showing the symptoms of the disease. The disease was confined to areas adjacent to forests. There was a very faint band in the samples from phyllody affected vines when DNA from affected plants was isolated and subjected to PCR test using universal primer for *Phytoplasma* disease, thereby indicating the phytoplasmal etiology of the disease. Among the 12 species of insects collected from phyllody affected plants, 2 plant hoppers (unidentified) were consistently associated with diseased vines.

Vein clearing disease

Studies on mechanical transmission of vein clearing virus of cardamom in six host plants including *Nicotiana* spp. and *Physalis* sp. indicated that virus cannot be transmitted mechanically. Aphids such as *Myzus persicae, Aphis* spp. and *Toxoptera* sp. also could not transmit the virus.

Bacterial wilt disease

A RFLP-PCR technique was standardized for identifying strains of *R. solanacearum* causing bacterial wilt of crop plants. RAPD-PCR using random primers revealed that most of the ginger isolates of *Ralstonia solanacearum* from different ginger growing locations of Kerala, Karnataka and north eastern states were related. Polyclonal antibodies were developed against the protein as well as heat and glutaraldehyde treated *R. solanacearum* cells. Western blot analysis showed that each of the developed antibody reacted with its own antigen besides reacting with the other two antigens used in the study.

Serological studies were carried out to detect the survival of *R. solanacearum* in ginger rhizomes stored at different temperatures for 3 months. Rhizomes stored at 0°C and 4°C sustained minimum bacterial population throughout the study period as observed by plate count and ELISA studies and negligible disease incidence was observed under pot culture conditions.

A simple screening technique for isolating sources of resistance was developed by directly inoculating the bacterial wilt pathogen, *R. solanacearum* in tissue cultured ginger somaclones. About 250 ginger germplasm lines were screened against bacterial wilt and none were resistant. A protocol was developed to evaluate the sensitivity of ginger calli to the toxic metabolites of the bacterial wilt pathogen to select tolerant cell lines of ginger.

Trials on rhizome solarization conducted in farmers fields indicated that solarization of seed rhizomes for 2 h during 9–11 am resulted in negligible disease incidence (<1%) and another treatment with 2 h of solarization from 10 am–12 noon was completely free from disease after 3 months of planting as compared to unsolarized rhizomes where 33.6% mortality of plants was observed.

Management of nematodes

Sixty black pepper accessions were screened against *Radopholus similis* and six accessions namely, C-1204, W- 254, W- 348, HP-39, HP-47 and HP-532 gave a resistant reaction. Six each of ginger and turmeric accessions were screened for their reaction to *Meloidogyne incognita* and two turmeric accessions (Accs. 1 and 8) gave a resistant reaction.

Evaluation of 11 promising antagonistic fungi and 1 bacterial isolate (*Pasteuria penetrans*) in black pepper, turmeric and ginger fields for suppression of *M. incognita* indicated that all of them caused significant suppression of nematodes. *Verticillium chlamydosporium*, *Fusarium* sp. and *Scopulariopsis* sp. also significantly increased the yield of black pepper and ginger besides controlling the nematode. The optimum pH and temperature conditions for growth and multiplication of *V. chlamydosporium* were determined to be 5 and 26°C, respectively. Maximum growth of the fungus was observed in Czapok-Dox agar medium. The fungus multiplied well in starch water and coconut water. The most preferred carbon and nitrogen sources by the fungus were fructose and sodium nitrate, respectively; tolerence to copper (copper oxychloride 2000 ppm) was also observed in this isolate.

Sixteen *Pseudomonas* spp. and 20 *Bacillus* spp. were isolated from rhizosphere of nematode antagonistic plants such as *Chromolaena odorata*, *Pimenta dioica*, *Piper colubrinum* and *Strychnos nux-vomica* and 4 unidentified bacteria were obtained from black pepper. Twenty isolates of rhizobacteria were screened against *R. similis* and 52 isolates were screened against *M. incognita* under *in vitro* conditions. Several isolates were highly effective against *M. incognita*, but only a few were promising against *R. similis.* In a greenhouse trial, 21 rhizobacterial isolates caused 100% suppression of *M. incognita* among the 84 isolates evaluated.

Evaluation of organic amendments for management of nematodes indicated that incorporation of *P. colubrinum* and *S. nux-voima* leaves in black pepper basins controlled the nematodes.

Management of insect pests

Pollu *beetle*

Screening of 186 cultivars, 34 hybrids and 3 somaclones of black pepper accessions to isolate sources of resistance against *pollu* beetle (*Longitarsus nigripennis*), a major insect pest of black pepper, indicated that all the accessions were susceptible to the pest. The biochemical profile of leaves from resistant and susceptible black pepper accessions revealed higher concentrations of carbohydrates, phenols and free amino acids in the resistant accessions. Surface wax components were also higher in resistant accessions and wild species (*Piper chaba*, *P. colubrinum*, *P. barberi* and *P. longum*).

Evaluation of seed and leaf extracts of various plant species against feeding activity of *pollu* beetle indicated that methanol and hexane extracts of *Annona squamosa* seeds were the most promising resulting in complete deterrence of feeding activity at 1% concentration.

Root mealybug

Evaluation of four insecticides for the management of root mealybug (*Planococcus* sp.) on black pepper at Wyanad indicated that drenching of affected vines with chlorpyriphos 0.075% was effective for the management of the pest.

Shoot borer

The pesticide residues in ginger in which the recommended spraying schedules were adopted for the management of shoot borer (*Conogethes punectiferalis*) were determined. Spraying of 4 rounds of malathion 0.1% and monocrotophos 0.075% or 2 rounds of these insecticides along with pruning of infested shoots resulted in non deductible levels of pesticide residues in dried ginger rhizomes.

Rhizome scale

Dried leaves of various plants were evaluated as storage materials for the management of rhizome scale (*Aspidiella hartii*) on ginger during storage. The trials indicated that dipping of seed rhizomes in quinalphos 0.075% and storing in dried leaves of *S. nux-vomica* was more effective for obtaining a higher recovery of rhizomes, higher number of sprouts and lesser incidence of rhizome scale.

Storage pests

Surveys conducted in traders godowns in Calicut and Kochi indicated that *Lasioderma serricorne*, *Rhizopertha dominica*, *Tribolium castaneum*, *Araecerus fasciculatus* and *Tenebroides mauritanicus* were the major species of insects associated with stored dry rhizomes of ginger and turmeric.

Economics

Surveys conducted in Kerala and Karnataka indicated marked increase in cost of production of major spice commodities. Production of black pepper was found profitable with a benefit-cost ratio of 1.9. However, production of ginger and turmeric resulted in a benefit-cost ratio of <1 because of the drastic fall in prices. A digitized database providing information on area, production, prices, demand and supply, export and incidence of pests and diseases on various spices was prepared.

Planting material production

Black pepper rooted cuttings (25,000), cardamom seedlings (14,000), cardamom seed capsules (100 kg), ginger seed rhizomes (6 t), turmeric seed rhizomes (5 t) and nutmeg grafts (6,800) were produced and distributed to farmers and different agencies. About 1000 kg each of seed rhizomes of ginger (Varada, Mahima and Rejatha) and turmeric (Prabha and Prathibha) varieties were also produced through progressive farmers and developmental agencies.

Extension

The institute organized training programmes in spice production technologies for the benefit of progressive farmers and officers of the State Department of Agriculture and Horticulture and private agencies. Extension pamphlets on cultivation of various spices were brought out during the year. The technology for the production of *Trichoderma* spp. was sold to 14 entrepreneurs. A sum of Rs. 2 lakhs was obtained through consultancy services offered by scientists of the institute.

Krishi Vigyan Kendra

Sixty-six short term courses in crop production, horticulture, animal sciences and fisheries were conducted. Frontline demonstration with improved variety of tapioca namely, Sree Vijaya, indicated that the new variety yielded higher, less susceptible to mosaic disease and also of shorter duration when compared to the local variety. On-farm testing of technologies for the management of rhinoceros beetle and red palm weevil infesting coconut indicated that use of pheromone traps was effective resulting in reduction in damage to coconut. Use of glyricidia extract along with neem oil was effective for the management of ectoparasites on farm animals. Demonstration units of improved black pepper varieties, arecanut seed garden, anthurium cultivation, cashew scion bank, medicinal plant unit and model homestead garden were also maintained. The KVK assisted in self-employment of rural youth in planting material and vegetable seed production, vermi-composting and goatary. An amount of Rs. 2.68 lakhs was realized through sale of planting materials and also through the services rendered by the Plant and Animal Health Centres.

All India Coordinated Research Project on Spices

The germplasm of spices was enriched by exploratory surveys and exchange and promising accessions were identified. Acc. 239 was identified as a promising line in black pepper. In cardamom, high yielding (Accs. 8-4-D11 and 7-24-D11) and drought tolerant (CL-668, P-6, D-237, 2-2-D11) accessions were identified. $V_3 S_1$-8 in ginger and PTS-59 and PTS-55 in turmeric were identified as promising lines and were in an advanced stage of release. The ginger variety $V_1 E_8$-2 and turmeric varieties PTS-43, TCP-1 and TCP-2 were proposed for release. The turmeric varieties Alleppey and BDJR-1260 were selected for their high curcumin content and yield. The exotic line of coriander EC-2-32666 was identified as the best for leaf type. The highest volatile oil content in cumin was recorded in EC-232684 (4.4%) and in JC-147 (3.9%) and UF-144 in fennel.

Irrigation and fertilizer schedules were developed and recommended in black pepper. A fertilizer schedule of 100:100:175 kg NPK/ha was recommended along with organic and inorganic manures in cardamom. Application of micronutrients increased the yield in coriander and fennel.

A package of plant protection practices was developed and recommended for the management of *Phytophthora* foot rot in black pepper. A low-cost technology for mass multiplication of *Trichoderma* sp. was developed. Rhizome rot of ginger under storage could be managed by storing seed rhizomes of ginger in sand layered pits mixed with Dithane M-45 and Bavistin. The coriander varieties RCr-441, RCr-435, RCr-436, UD-446 and UD-684 were resistant to root knot nematode. Sowing cumin on 10 th November was ideal to minimize wilt incidence and to obtain a high yield. Guj. Cum. 3, Acc.1136, Acc.1145 and Acc.1165 were moderately resistant to *Fusarium* wilt.

Silver Jubilee celebrations

The institute has completed 25 years of service to the nation especially towards research and development of spices and the Silver Jubilee celebrations were held during 8–9 October 2001. Prof. M. S. Swaminathan, the renowned agricultural scientist, was the chief guest during the function and the main laboratory buildings of the institute was dedicated to the nation by him. A Silver Jubilee Hall was inaugurated by Dr. G. Kalloo, Deputy Director General (Horticulture), ICAR, during the occasion. An exhibition depicting the achievements of the institute during the past 25 years was organized and various publications on research achievements and technologies developed by the institute were released. Two interfaces, one between scientists and exporters of spices and another between scientists and farmers were held during the occasion.

Introduction

Spices are high value export oriented products extensively used for flavouring food and beverages and also in medicines, cosmetics and perfumery. Over 100 plant species are known to yield spices and spice products among which more than 50 are grown in India playing a crucial role in the economy of the country. India is the largest producer, consumer and exporter of spices in the world. Spices are grown in about 27 lakh hectares in the country with a production of about 34 lakh tonnes annually. India exported 2.30 lakh tonnes of spices and spice products during 2000–01 valued Rs. 1612 crores.

History

A major step in initiation of intensive research on spices was the establishment of a Regional Station of Central Plantation Crops Research Institute (CPCRI) at Calicut, Kerala, during 1975, exclusively for conducting research on spices by the Indian Council of Agricultural Research (ICAR). This Regional Station was upgraded as National Research Centre for Spices (NRCS) in 1986 by merging with it the Cardamom Research Centre of CPCRI at Appangala, Karnataka. The NRCS was further elevated to the present Indian Institute of Spices Research (IISR) during 1995.

The laboratories and administrative offices of the institute are located at Chelavoor (50 m above MSL), 11 km from Calicut (Kozhikode), Kozhikode District, Kerala, on the Calicut-Kollegal road (NH 212), in an area of 14.3 ha. The research farm is located 51 km North East of Calicut at Peruvannamuzhi (60 m above MSL), on the Peruvannamuzhi-Poozhithode road in Kozhikode District, in an area of 94.08 ha. The Cardamom Research Centre, Appangala (920 m above MSL), is located at Appangala, Kodagu District, Karnataka, on the Madikeri-Bhagamandala road, 8 km from Madikeri, in an area of 17.4 ha.

Mandate

- To extend services and technologies to conserve genetic resources of spices as well as soil, water and air of spices agroecosystems.
- To develop high yielding and high quality spice varieties and sustainable production and protection systems using traditional and non-traditional techniques and novel biotechnological approaches.
- To develop post harvest technologies of spices with emphasis on product development and product diversification for domestic and export purposes.
- To act as a centre for training in research methodology and technology upgradation of spices and to coordinate national research projects.

- To monitor the adoption of new and existing technologies to make sure that research is targeted to the needs of the farming community.
- To serve as a national centre for storage, retrieval and dissemination of technological information on spices.

The crops on which research is being conducted at the institute include black pepper (*Piper nigrum*), cardamom (*Elettaria cardamomum*), ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), cinnamon (*Cinnamomum verum*), cassia (*Cinnamomum cassia*), clove (*Syzygium aromaticum*), nutmeg (*Myristica fragrans*), allspice (*Pimenta dioica*), garcinia (*Garcinia gummi-gutta* and *Garcinia indica*), vanilla (*Vanilla planifolia*) and paprika (*Capsicum annuum*).

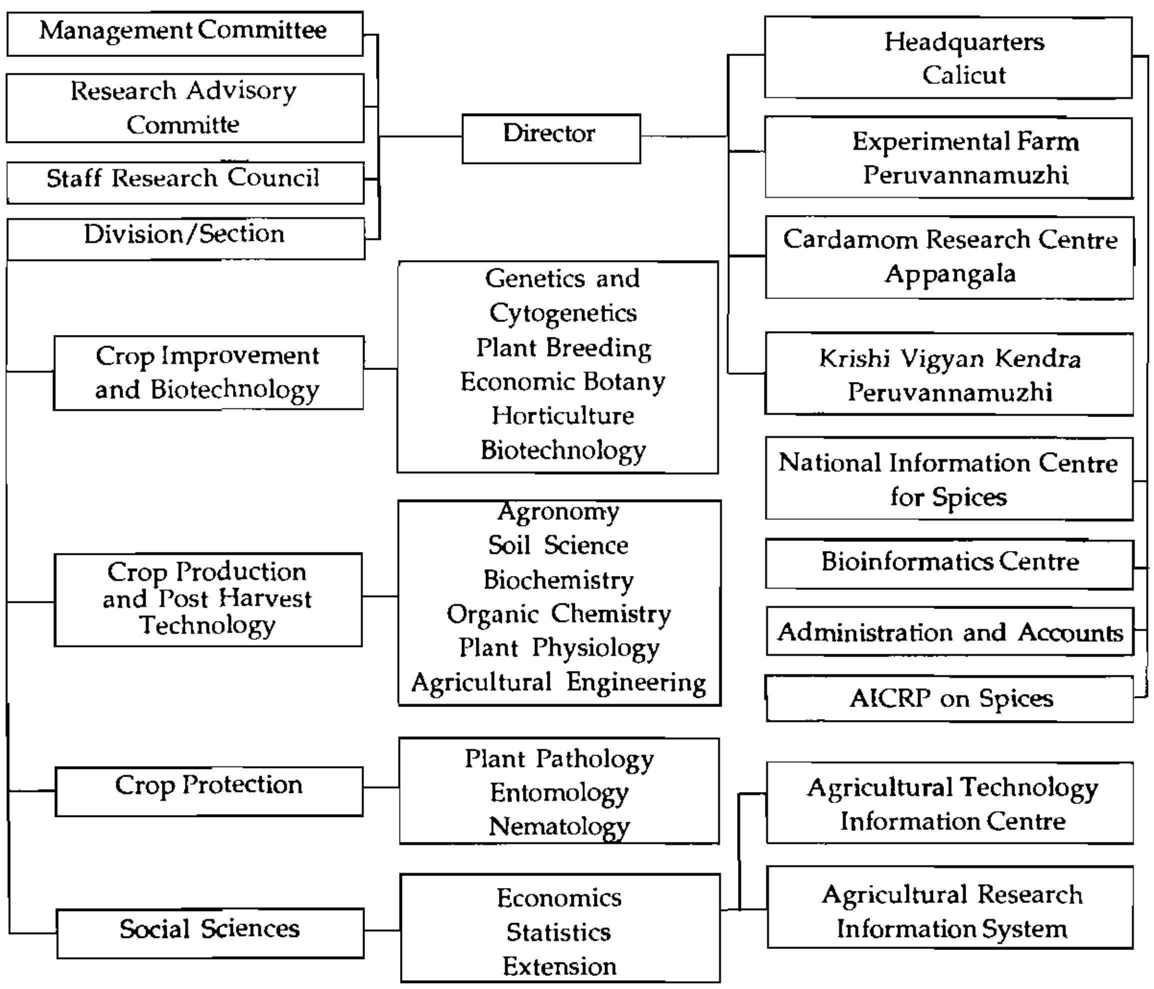

Fig. 1. Organization of IISR

Organization

The Director is the administrative head of the institute. The Institute Management Committee, Research Advisory Committee and Staff Research Council assist the Director in matters relating to management and research activities of the institute (Fig. 1).

Research on various aspects of mandate crops is conducted in three divisions, namely, Division of Crop Improvement and Biotechnology, Division of Crop Production and Post Harvest Technology, Division of Crop Protection and a Social Sciences Section. The other facilities available at the institute include Agricultural Technology Information Centre, National Information Centre for Spices, Agricultural Research Information System, Bioinformatics Centre and Krishi Vigyan Kendra. The institute also functions as the headquarters of the All India Coordinated Research Project on Spices, National Network on *Phytophthora* Diseases of Horticultural Crops and Indian Society for Spices. The institute has linkages with several universities, research institutes, and developmental agencies for collaborative research and developmental activities in spices.

Table 2. Funds received from external agencies

Particulars	Amount (Lakh Rupees)
AICRP Spices	117.00
KVK	19.66
ICAR Cess Fund	38.50
NATP	32.74
DBT	30.00
IPDS	4.21
Pepper Technology Mission	7.48
Emeritus Scientist Scheme	1.96
Pension and gratuity	13.69
Total	265.24

Budget

The total budget of the institute was Rs.456.5 lakhs during the year which included Rs. 200 lakhs under Plan and Rs. 256.5 lakhs under Non Plan (Tables 1 and 2). In addition, Rs. 265.24 lakhs was also received as funds from external agencies.

Staff

The institute has a sanctioned strength of 41 scientific, 21 administrative, 37 technical and 67 supporting staff (Table 3).

Table 1. Budget of the institute

Particulars	Amount		
	Plan (Lakh Rupees)	Non Plan (Lakh Rupees)	Total (Lakh Rupees)
Establishment	-	204.0	204.0
Travelling allowance	5.0	5.0	10.0
Works	60.0	-	60.0
Other charges	135.0	47.5	182.5
Total	200.0	256.5	456.5

Table 3. Staff position of the institute

Category	Sanctioned	In position			Vacant
		Chelavoor	Peruvannamuzhi	Appangala	
Scientific	42	28	2	3	9
Technical	37	19	13	5	-
Administration	21	15	-	2	4
Supporting	67	26	16	19	6
Total	168	88	31	29	19

Past achievements

Surveys were conducted for collection of germplasm that were conserved in germplasm conservatories and *in vitro* genebank. The collections include 3097 black pepper, 313 cardamom, 637 ginger, 786 turmeric, 478 nutmeg, 227 clove, 300 cinnamon, 30 cassia, 31 garcinia, 180 allspice, 30 paprika and 32 vanilla accessions. The germplasm was characterized for yield, quality and resistance to pests, diseases and drought.

Various improved varieties with high yield and quality were developed that had a great impact in increasing the production and productivity of spices in the country. Four high yielding and high quality varieties of black pepper namely, Sreekara, Subhakara, Pournami and Panchami were released, among which Pournami is tolerant to root knot nematode. Suvasini, a high yielding variety suitable for high density planting, Avinash, a variety resistant to rhizome rot disease and Vijetha, a variety resistant to *katte* disease were released in cardamom. A ginger variety with high yield and low fibre namely, Varada and five high curcumin and high yielding turmeric varieties namely, Suvarna, Sudarsana, Suguna, Prabha and Prathibha were released. Two high quality cinnamon varieties, Navashree and Nithyashree were also released.

Protocols for micropropagation of several spice crops and improved vegetative propagation methods were standardized in black pepper, cardamom, clove, nutmeg, cinnamon, cassia and allspice for rapid clonal multiplication of spices. The optimum spacing, nutrient and water requirements for black pepper, cardamom, ginger and turmeric were standardized for different soils. Mixed cropping systems were developed in black pepper and cardamom for increasing the productivity from unit area of land. Organic farming systems were developed in ginger and turmeric. High production technologies were developed in black pepper and cardamom, which resulted in substantial increase in yield.

Eco-friendly integrated strategies involving cultural methods, biocontrol agents, plant products and resistant varieties were developed for the management of pests and diseases of spice crops that resulted in substantial increase in yield and pesticide-free produce. Integrated management schedules for *Phytophthora* foot rot disease was well adopted by farmers resulting in significant increase in production of black pepper. A repository of biocontrol agents of bacteria, fungi and nematodes affecting spice crops was established to conserve, characterize and document the variability and potential of biocontrol agents.

Post harvest technologies for processing of black pepper, cardamom, ginger, turmeric, nutmeg, mace, clove, cinnamon and cassia were developed. Technologies for preparation of value added products such as salted ginger and white pepper were also standardized.

The improved varieties and technologies developed on propagation, cropping systems, nutrient and water requirements, pest and disease management and post harvest processing techniques were disseminated to farmers and other agencies through publications, training programmes and demonstrations. The institute also served as a nodal agency for dissemination of information on all aspects of spice research and development.

Research Achievements

Crop Improvement and Biotechnology

Gen. I (813)

Collection, conservation, cataloguing and evaluation of black pepper germplasm

(K. V. Saji, B. Sasikumar, Johnson K. George, K. Nirmal Babu, D. Prasath and B. Chempakam)

Collection of germplasm

Five explorations were conducted in forests of Western Ghats and farmers fields in Kerala, Karnataka and Tamil Nadu for collection of germplasm. A monoecious type of *Piper nigrum* from Nelliampathy forests and a *P. nigrum* (wild) with bold berries and with heavy setting collected at an altitude of about 1900 m above MSL from Silent Valley forests are some of the important collections made during the year (Table 4). At present, the germplasm conservatory has 3211 accessions including wild accessions, cultivars, hybrids and open pollinated progenies.

A list of existing germplasm was prepared and IC numbers for the collections were obtained from National Bureau of Plant Genetic Resources, New Delhi. One hundred and fifty accessions were characterized, documented and evaluated based on International Plant Genetic Resource Institute (IPGRI) descriptor. A CD entitled 'Spice Genes' containing passport details of germplasm accessions, corresponding pictures and evaluation data of selected accessions was prepared.

Gen. VII.1 (813)

Breeding black pepper for high yield, quality, drought and resistance to pests

(B. Sasikumar, Johnson K. George, K. V. Saji, T. John Zachariah, K. S. Krishnamurthy, S. Devasahayam and Santhosh J. Eapen)

Evaluation of new lines

Coll. 1041, a clone of black pepper cv. Thevanmundi, continued to exhibit tolerance to *Phytophthora* foot rot disease at Valparai (Tamil Nadu), a hot spot area of the disease, besides yielding high. HP-34, HP-105, HP-738 and HP-813, the hybrids suited to high altitude areas of Valparai, continued to maintain their superiority (Table 5).

Coll. 1041, OPKm, HP-34, HP-780, HP-813 and HP-1411 were identified as promising lines for the plains. These lines are characterized by high yield, high quality and tolerance to stress (Coll. 1041 and HP-780 are tolerant to biotic stress and OPKm tolerant to abiotic stress). Among the lines, HP-813 recorded high oleoresin, piperine and essential oil contents, comparable with cv. Kottanadan (Table 6).

Seventeen clonal progenies and 7 OP lines of cv. Neelamundi were evaluated for yield

Table 4. Collection of germplasm of black pepper and related species

Trip No	Place	Areas surveyed	No. of accessions collected	Accessions collected
1	Attappadi, Palakkad District (Kerala)	Siruvani, Varadimalai, Sholayur, Anakkatti	21	*P. nigrum* (2) *P. longum* (1) *P. hymenophyllum* (2) *P. galeatum* (2) *P. sugandhi* (2) *P. trichostachyon* (1) Cultivated black pepper (11)
2	Kudremukh forests, Dakshina Kannada District (Karnataka)	Kudremukh, Samse forests, Dakshina Kannada, Agumbe forests	18	*P. nigrum* (9) *P. galeatum* (1) *P. bababudani* (3) Cultivated black pepper (5)
3	Nilgiris, Nilgiris District (Tamil Nadu)	Gudalur, Naduvattom, Paikara	8	*P. schmidtii* (2) *P. wightii* (2) *P. mullesua* (3) *Piper* spp. (1)
4	Silent Valley, Nelliampathy, Palakkad District (Kerala)	Sairandri, Arukanpara, Kummatanthodu, Punnamala, Panthenthode, Kozhipara, Nelliampathy, Pothumudi	53	*P. nigrum* (22) *P. longum* (1) *P. galeatum* (6) *P. sugandhi* (21) *P. bababudani* (1) *P. mullesua* (2)
5	Idukki, Idukki District (Kerala)	Kattappana, Irattayar, Valiyathovala, Udumbanchola, Chemmannur, Thadiampad, Chelachuvadu, Painavu	53	Neelamundi (19) Vattamundi (8) Jeerakamundi (7) Vellanamban (2) Vellamundi (2) Malamundi (2) Marampadathi (1) Kuthiravaly (1) Thulamundi (1) Arakulammunda (1) Karimunda (1) Thevanmundi (1) Kottanadan (1) Chengannurkodi (1) Kaniyakadan (1) Local type (1)

Table 5. Evaluation of promising black pepper lines at Valparai

Line	Fresh yield (kg/ vine)	Height of bearing column (m)	Spikes /sq m	Spike length (cm)	Berries /spike	Dry recovery (%)	Litre weight (g)	Bulk density (g)	Piperine (%)	Oleoresin (%)	Essential oil (%)
HP-34	1.62	4.10	275	10.0	46	30	610	641	1.4	7.6	2.0
HP-105	8.40	4.50	248	8.0	46	32	610	582	1.4	8.5	3.2
HP-728	2.13	4.30	200	11.0	48	31	610	-	-	-	-
HP-778	4.47	4.50	185	12.0	48	32	600	-	-	-	-
HP-813	2.90	3.36	191	10.0	46	34	610	612	2.4	11.7	2.8
Coll.1041	7.70	4.75	240	13.0	48	35	605	582	1.4	8.5	3.2
Panniyur-1	4.94	2.32	176	13.0	50	30	580	512	3.0	9.4	2.0
Sreekara (Control)	0.90	-	-	-	-	-	-	-	-	-	-

Table 6. Evaluation of promising black pepper lines at Peruvannamuzhi

Line	Yield (kg (fresh) /vine)	Dry recovery (%)	Bulk density (g)	Oleoresin (%)	Essential oil (%)	Piperine (%)
HP-34	2.75	34.0	554.6	8.4	3.6	2.4
HP-105	2.20	32.0	454.0	10.8	3.6	2.8
HP-780	2.97	35.3	611.4	8.7	2.8	2.8
HP-813	1.80	30.6	452.2	14.6	5.4	3.5
HP-1411	2.69	29.3	473.0	10.8	3.0	3.4
Col.1041	3.15	29.0	569.0	7.8	3.0	1.9
OPKm	2.15	29.0	588.0	8.3	2.8	2.2
Sreekara (Control)	2.20	37.0	565.2	10.6	3.6	3.0

and quality and the yield of the clonal lines ranged from 0.2 kg to 2.0 kg (fresh berries)/ vine. The OP lines had more variation for yield [0.05–1.21 kg (fresh berries)/vine] when compared to the clonal progenies.

New field trials were laid out at Kasaragod, Nilgiris and Kalpetta with promising lines that were also supplied to the All India Coordinated Research Project centres at Ambalavayal and Pampadumpara (Table 7).

Table 7. Evaluation of promising black pepper lines in new locations

Location	Line
CPCRI, Kasaragod	Panniyur-1, 2, 3, 4 & 5, Sreekara, Subhakara, Kottanadan, HP-34, HP-105, HP-813, HP-780, HP-728, HP-1411, OPKm and Coll. 1041 (12 each)
Craigmore Plantations, Nilgiris	Panniyur-1, HP-34, HP-105, HP-780, HP-813, HP- 1411, Coll. 1041 and OPKm (20 each)
MSSRF, Kalpetta	HP-34, HP-105, HP-728, HP-780, HP-813, HP-1411 OPKm and Coll. 1041 (10 each)
Agronomy Section, IISR, Calicut*	HP-34, HP-105, HP-728, HP-780, HP-813, HP-1411 OPKm and Coll. 1041 (40 each)
AICRPS, Ambalavayal*	HP-34, HP-105, HP-813, HP-1411, Coll. 1041 and OPKm (46 each)
AICRPS, Pampadumpara*	HP-34, HP-105, HP-813, HP-1411, Coll. 1041 and OPKm (46 each)

*Planting material supplied

Table 8. Promising black pepper hybrids/line identified

Hybrid/Line	Parentage
HP-45	Narayakodi x Karimunda
HP-117	Cholamundi x Thommankodi
HP-127	Neelamundi x Karimunda
HP-1262	Anakampoyil x Karimunda
HP-1264	Acc. 933 x Valiakaniakadan
HP-1293	Kalluvally x Karimunda
HP-1313	Thommankodi x Karimunda
HP-1439	Thommankodi x Karimunda
OP Neelamundi	Open pollinated progeny of Neelamundi

Identification of promising hybrids

Based on single plant evaluation (third year of planting), various promising hybrids/lines which recorded an yield of 1.0–2.5 kg (fresh berries)/vine were short-listed for further multiplication and evaluation (Table 8).

Hybridization

A crossing block of 17 black pepper (bush pepper) lines namely, Karimunda 1472, HP-34, HP-780, HP-813, HP-1411, Coll. 1041, P-24, OPKm, Panniyur-1 and Vadakkan were established at Chelavoor in cement tubs under protected conditions. Forty-eight intervarietal crosses were attempted during the year, in order to raise resistant lines (biotic/abiotic stress) coupled with good yield and quality.

Screening against stress

The *Piper* accessions C-1204, HP-532 and W-254 were found resistant to *Rodopholus similis*. Acc. 816 (Neyyattinkaramundi), Acc. 841 (Veluthakaniakadan), Acc. 1084 (Chappakulammundi) and Acc. 1114 (Kumbachola) were found tolerant to *pollu* beetle infestation. Acc. 828 (Vattamundi) and Acc. 1321 (Kuthiravally) were identified as drought tolerant besides OPKm, a promising line.

Biotech. IV (813)

Biotechnological approaches for crop improvement in black pepper

(K. Nirmal Babu and K. V. Saji)

Molecular characterization

RAPD polymorphism was studied in exotic and indigenous species of *Piper* namely, *P. longum, P. hapnium, P. peepuloides, P. chaba, P. mullesua, P. silentvalleyensis, P. attenuatum, P. argyrophyllum, P. hymenophyllum, P. galeatum, P. trichostachyon, P. sugandhi, P. nigrum, P. schmidtti, P. wightii, P. cubeba, P. colubrinum, P. barberi, P. magnificum* and *P. arboreum* to assess the interrelationships between the species. Six polymorphic primers (OPA-09, OPC-13, OPD-02, OPE-11, OPF-09 and OPF-14) were selected for developing RAPD profiles between male and female of the species and also between different species of *Piper*. Comparisons were made only between the genotypes, which gave good amplification.

The preliminary studies indicated that *P. attenuatum, P. argyrophyllum* and *P. hymenophyllum* formed a group and *P. schmidtii* and *P. wightii* belonged to another group. *P. galeatum* and *P. sugandhi* were also in a similar group. *P. longum* and *P. hapnium* formed one group though two collections of *P. longum* and *P. hapnium* male and female lines were placed in distinctly separate groups. Though these observations agree with earlier findings, a few new observations could be inferred from the study. These were, grouping of *P. trichostachyon* and *P. silentvalleyensis* with *P. longum* and *P. hapnium*, and grouping of Karimunda with *P. argyrophyllum, P. hymenophyllum* and *P. attenuatum*. In general, similarities were noticed in male and female lines collected from the same location but those collected from different locations significantly differed in their RAPD profiles. The two collections of *P. colubrinum* were distinctly different from each other and *P. colubrinum*-2 was clearly different from all the other species studied. *P. silentvalleyensis*, though highly similar to *P. mullesua* male, was clearly different as one of the primer OPF-14 gave a clearly different profile. *P. schmidtii* and *P. wightii* were very close to each other. *P. peepuloides* was placed alone in a single group and hence distinctly different from all the other species studied. The study also indicated that *P. sugandhi* is closely related to *P. galeatum*, which is in agreement with the earlier findings.

Genetic transformation

The osmotin and GFP constructs received from National Research Centre for Plant Biotechnology, New Delhi, are being revived. Aseptic cultures of black pepper embryos were established for transformation. Antibiotic sensitivity of black pepper was assessed using different antibiotics and hygromysin at 50 mg/ml was most effective. Kanamycin was effective only above 100 mg/ml.

Biotech. VI (813)

Development of DNA markers for marker assisted selection in black pepper

(Johnson K. George and B. Sasikumar)

RAPD analysis

Good quality DNA was isolated from four black pepper hybrids (HP-34, HP-780, HP-1411 and HP-1775) and their parents

(Irumaniyan, Karimunda, Panniyur-1, Aimpiriyan and *Piper attenuatum*) using a modified CTAB method. All the parents could be differentiated based on RAPD profile using 12 primers. HP-34, HP-780 and HP-1411 could be confirmed as true hybrids based on male parent specific RAPD markers (OPE-18 $^{535 \& 753}$, OPE-16 ^{491} and OPE-11^{1120}, respectively) (Fig 2.).

Identification of DNA markers

RAPD analysis of individual and pooled DNA samples was done to identify specific DNA markers associated with spike length. Two putative RAPD markers (OPE-11^{2050} and OPE-17^{4268}) were found to be associated with long spike character in black pepper.

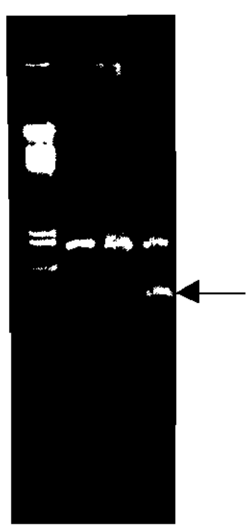

Fig. 2. RAPD profile of HP-1411 and its parents

Left to Right-Marker λ Eco RI-Hind III double digest, Aimpiriyan, HP-1411 and Panniyur-1, the male parent. Arrow mark indicates the male parent specific band

Biotech. V (813)

Large scale multiplication of released varieties of black pepper through somatic embryogenesis and genetic fidelity testing

(*R. Ramakrishnan Nair and Johnson K. George*)

Primary embryogenic cultures were established in black pepper (var. Subhakara) and scaled up through secondary-cyclic embryogenesis. The plantlets were regenerated in liquid SH medium. Sixty plantlets were established *ex vitro*.

Hort. II (813)

Utilization of *Piper colubrinum* Link. and *Piper arboreum* as rootstocks in the management of foot rot disease of black pepper

(*P. A. Mathew, J. Rema, T. John Zachariah and M. Anandaraj*)

The black pepper grafts that survived beyond 3 years in various grafting methods continued to grow satisfactorily during the year indicating that the grafts can survive up to 5 years and graft failures are observed only during first 2 years of planting in the field. However, the grafts were affected by stunt disease and the yields were negligible in the experimental plots.

The growth of graft union was assessed and during the fifth year, it was found to be overgrown due to bulging of the scion. No cracks or splits at the union and decline symptoms were observed in these grafts (Table 9). The quality of berries from grafted and non grafted varieties was analyzed (Table 10).

Table 9. Status of graft union in black pepper at fifth year

Method of grafting	Diameter of *Piper colubrinum* (cm)	Diameter of union (cm)	Diameter of *Piper nigrum* scion (cm)
Wedge	1.82	2.46	1.52
Saddle	2.06	3.20	2.00
Splice	1.72	2.26	1.58
Modified splice	2.15	2.67	2.16
Tongue	2.16	3.10	2.16
Double	2.93	3.12	2.08
Yema (budding)	2.20	3.17	2.20
Approach	2.27	3.03	2.17

Table 10. Quality of black pepper berries in grafted and non grafted vines

Variety/Cultivar	Essential oil (%)		Oleoresin (%)		Piperine (%)	
	Grafted	Non grafted	Grafted	Non grafted	Grafted	Non grafted
Subhakara	2.7	2.9	10.8	9.3	4.8	5.0
Uddakare	2.7	2.2	12.0	10.8	3.0	3.5
Pournami	2.9	2.9	7.8	8.5	4.4	5.0
Sreekara	3.0	2.9	10.5	9.8	4.7	4.0
Panniyur-1	2.7	2.0	10.5	10.0	4.7	4.8
Panniyur-2	2.4	2.5	8.2	7.3	4.2	4.3
Panniyur-3	3.1	2.5	8.7	9.1	4.4	4.4
Panniyur-4	3.3	3.7	10.7	10.8	4.7	4.3
Panniyur-5	2.1	2.5	8.4	8.0	4.0	4.4
Malligesera	3.0	2.9	9.2	9.6	4.0	4.6

Field trials of black pepper grafts in farmers fields indicated that during the fourth year, an average yield of 1.2 kg (dry)/vine could be obtained and the maximum yield was 11.0 kg (green)/vine. No decline symptoms were noticed in the grafts. Grafts were established in farmers plots in Wyanad, Idukki and Kottayam districts. However, the survival of grafts at Kainadi (Kottayam) was poor low to poor management.

Gen. IX (813)

Collection, conservation, cataloguing and evaluation of cardamom germplasm

(*D. Prasath and M. N. Venugopal*)

Collection of germplasm

Twenty-six new accessions were collected from cardamom growing areas in Idukki (15), Silent Valley (9) and Kodagu (2). The collections include a lower elevation high yielding clone, high biomass types and local types. The germplasm conservatory possesses 386 accessions including 11 related genera of Zingiberaceae.

Cataloguing of germplasm

Seventy-two accessions were evaluated for 20 yield characters (17 quantitative characters and 3 qualitative characters) based on IPGRI descriptor. The evaluation led to the selection of two high yielding accessions (APG-277 and APG-279).

Gen. X (813)

Breeding cardamom for high yield and resistance to *katte* disease

(*D. Prasath and M. N. Venugopal*)

Growth and yield parameters were recorded in 56 diallel hybrids of cardamom. Based on the *per se* performance, heterosis and specific combining ability for over 3 years, 15 hybrid combinations were short-listed for yield and susceptibility to leaf blight. The short-listed hybrid combinations were planted for clonal multiplication.

Standard heterosis for yield ranged from 23.22 to 150.33 and 25 hybrids recorded significant positive heterosis. Wherever *katte* resistant lines were used as female parents in the hybrids, there was positive relationship between seedling vigour (nursery) and yield (main field). But the same relationship did not exist in other parental combinations.

Evaluation of open pollinated progenies of 14 high yielding and *katte* resistant accessions led to the identification of 9 plants with high yield and resistance to leaf blight.

DNA was isolated from Malabar, Mysore and Vazhukka types and other accessions with distinct morphological characters. Preliminary RAPD analysis showed very little polymorphism among the collections.

Gen. II (813)

Collection, conservation, cataloguing and evaluation of germplasm of ginger and turmeric

(*B. Sasikumar, Johnson K. George, K. V. Saji and K. M. Abdulla Koya*)

Collection of germplasm

Twenty-one *Zingiber* spp. (Table 11) were collected and added to the germplasm

Table 11. Collection of germplasm of *Zingiber* spp.

Species	No. of accessions	Remarks
Z. officinale	14	Land races of Andhra Pradesh
Z. officinale	2	AG-697 and SG-698 from Himachal Pradesh
Z. officinale	1	Mahim variety from Kolhapur
Z. officinale	1	Manipur variety
Z. officinale	1	Moovattupuzha local
Z. nimmoni	1	Collected from Anamalai, Tamil Nadu
Z. wightinum	1	Collected from Mukkali, Palakkad, Kerala

conservatory. Six hundred and seventy accessions of *Zingiber* spp. and 800 accessions of *Curcuma* spp. were maintained in the germplasm conservatory.

Evaluation of germplasm

Fifty accessions of ginger were catalogued and data on yield and yield attributes were recorded (Table 12). Eight high quality ginger lines were also identified from germplasm collections (Table 13). Six ginger accessions (Accs. 26, 48, 73, 210, 217 and 232) and eight turmeric accessions (Accs. 21, 31, 35, 43, 67, 68, 78 and 91) were resistant to *Meloidogyne incognita*. Recording of shoot borer incidence in ginger germplasm collections indicated low borer incidence in 82 accessions among the 680 accessions screened.

Eleven high curcumin lines of turmeric including six Alleppey finger turmeric (AFT) selections along with Prabha and Prathibha (controls) were evaluated at Peruvannamuzhi for the fourth consecutive year. Acc. 585 (AFT Line) recorded maximum yield of fresh rhizomes of 29 kg/3m² bed (58 t/ha) with 18.6% dry recovery (Table 14). Some of these selected lines are also being evaluated through AICRPS centres at Raigarh (Chattisgarh), Chintapalli (Andhra Pradesh), Kumaraganj (Uttar Pradesh), Dholi (Bihar) and Pottangi (Orissa).

Table 12. Yield and yield attributes of ginger accessions maintained in the germplasm

Character	Range	Mean
Plant height (cm)	51.3–75.4	60.5
No. of leaves/ main shoot	17.0–30.0	26.0
No. of tillers	8.0–24.0	16.0
No. of leaves/hill	110.0–326.0	210.0
Leaf length (cm)	20.0–28.5	24.5
Leaf width (cm)	2.0–3.7	3.0
Fresh yield (kg/3m² bed)	4.0–15.0	9.0
Dry recovery (%)	14.0–26.0	-

Table 13. High quality ginger lines identified from the germplasm

Accession	Essential oil (%)	Oleoresin (%)	Fibre (%)
Acc. 11	2.0	7.2	2.2
Acc. 93	1.8	6.5	2.0
Acc. 156	2.2	6.7	2.0
Acc. 162	2.0	6.2	2.0
Acc. 197	2.5	7.0	2.8
Acc. 199	2.0	6.2	2.0
Acc. 225	2.0	6.2	2.0
Acc. 228	2.0	6.2	2.0

Dry ginger of 41 accessions were screened against infestation by the storage pest *Lasioderma serricorne* and scored for frass content 8 months after storage. The frass content varied from 0 g to 2 g and was low in Varada and few other accessions.

Release of new varieties

Based on multilocation data and trial in farmers plots, two new ginger accessions, Accs. 35 and 117, were proposed for release (State Variety Release Committee, Kerala) as IISR Rejatha and IISR Mahima, respectively (Table 15).

Multiplication of released varieties

About 800 kg seed rhizomes of Varada, 1500 kg Mahima and 100 kg Rejatha (ginger varieties) and 1000 kg Prabha, 1200 kg Prathibha and 50 kg Alleppey (turmeric

Table 14. Yield and dry recovery of high curcumin turmeric lines

Accession	Fresh yield ($kg/3m^2$ bed)	Dry recovery (%)
Acc. 126	25.7	17.8
Acc. 295	20.8	16.0
Acc. 584	24.0	22.6
Acc. 585	29.0	18.6
Acc. 591	28.0	15.3
Acc. 593	24.3	16.9
Acc. 656	15.0	15.0
Acc. 657	26.5	18.8
Acc. 691	18.3	17.2
Prabha (Control)	25.4	17.5
Prathibha (Control)	24.1	17.2
CD ($P<0.05$)	4.4	-
CV %	13.2	-

varieties) were produced under nucleus seed multiplication programme. About 8 t of Varada and Mahima and 1 t each of Prabha and Prathibha were produced and distributed through other agencies and progressive farmers. About 100 kg *kasturi* turmeric (*C. aromatica*) and 30 kg black turmeric (*C. caesia)* were also multiplied.

Gen. XIV (813)

Cytogenetics and reproductive biology of major spices

(*R. Ramakrishnan Nair and K. V. Saji*)

Cytological analysis

Cytological analysis of five open pollinated (OP) progenies of black pepper revealed variations in chromosome number (Table 16). Fifteen fast/normal growing OP progenies of cv. Vadakkan were planted in the field and some of them exhibited vigorous growth.

Table 16. Chromosome numbers in open pollinated progenies of black pepper accessions

Accession	Chromosome number (2*n*)
Acc. 4135	62
Acc. 4139	96
Acc. 4144	65
Acc. 4146	52
Acc. 4170	52

Table 15. Comparative performance new ginger varieties

Variety	Fresh yield	Dry yield (t/ha)	Dry recovery (t/ha)	Oil (%)	Oil (l/ha)	Oleoresin (%)	Oleoresin (l/ha)	Fibre (%)	Remarks
Acc. 117 (Mahima)	23.20	5.30	23.0	1.72	91.24	4.48	237.4	3.26	Resistant to nematode; bold rhizome
Acc. 35 (Rejatha)	22.40	4.25	19.0	2.36	102.70	6.24	275.9	4.00	High oil content
Control (Varada)	23.98	4.69	19.6	1.68	78.70	3.96	185.7	3.29	-

Ten germplasm accessions of ginger and 5 accessions of turmeric were cytologically analysed to determine their chromosome numbers (Table 17).

Embryo development

Fruits of *Piper colubrinum* were examined histologically at different stages to trace embryo development. Early globular and heart-shaped embryos obtained from few sections indicate that the embryo structure in *P. colubrinum* was similar to that of *P. nigrum*.

Histological analysis of fruits and seeds of *Curcuma longa* indicated that the seeds (ovules) are attached to a central column inside the fruit. Different seeds derived from the same fruit showed embryos at different developmental stages. The mature embryo showed a typical monocot structure. Persistence of the nucellus was evident even in the mature seed.

Table 17. Chromosome numbers in ginger and turmeric accessions

Accession	Chromosome number (2n)
Ginger	
Acc. 108	22
Acc. 116	24
Acc. 145	22
Acc. 147	24
Acc. 158	22
Acc. 470	22
Acc. 476	22
Acc. 477	22
Acc. 584	22
Acc. 602	22
Turmeric	
Acc. 336	42
Acc. 473	63
Acc. 514	58
Acc. 561	94
Acc. 761	64

Seed germination

Observations on seed germination in turmeric indicated that only a few seeds germinated (20%) within 1 month of sowing and a majority of seeds started germination (54%) after 5 months. The seeds also germinated *in vitro* on SH as well as E1 medium. In these media also only a small percentage of seeds germinated within 1 month.

Biotech II (813)

In vitro selection for resistance to soft rot and bacterial wilt in ginger

(*K. Nirmal Babu and A. Kumar*)

Screening of somaclones

About 300 embryoid cultures of ginger were produced for screening against soft rot and bacterial wilt diseases. An *in vitro* screening technique was developed by directly inoculating the bacterial wilt pathogen *Ralstonia solanacearum* on small plantlets (developed from somaclones) maintained aseptically in bottles. The technique is very easy to adopt and the disease reaction can be noticed in 15 days in which the susceptible plants show uniform yellow colouration.

Molecular characterization

Micropropagated and callus regenerated ginger plants were analysed for variations as expressed by RAPD polymorphism to detect the extent of variation in the DNA sequence as an index for somaclonal variation. The differences in RAPD profiles observed in some of the micropropagated plants indicated that micropropagation even without callus phase induced variations in 9 of the 13 plants tested. Among the micropropagated plants that exhibited polymorphism in RAPD profiles, only 3 genotypes showed major profile differences. Callus regenerated plants showed distinct profile differences indicating that plant regeneration through intervening callus phase induces certain amount of genetic variation. Among the plants evaluated, 12 exhibited variations in RAPD profiles. Of the callus regenerated plants found to give polymorphism in RAPD profiles, only 3 genotypes showed major profile differences. This indicates that there is high amount of variability among the selected micropropagated and callus regenerated plants of ginger and the majority of the morphological variants selected from earlier studies did show variations in RAPD profiles. Earlier studies have shown that MP-61-9, MP-61-10, CR-64 and CR-1222 are clear variants from the parent Maran and they showed considerable variations in morphology, yield and boldness of the rhizome.

Gen. VI (813)

Collection, conservation, cataloguing and evaluation of germplasm in tree spices

(*B. Krishnamoorthy, J. Rema, P. A. Mathew, D. Prasath, K. P. M. Dhamayanthi, V. S. Korikanthimath, T. John Zachariah, S. Devasahayam and S. S. Veena*)

Collection and conservation

Seven cultivated accessions of *Garcinia gummi-gutta* were collected from Kozhikode and Kannur districts of Kerala. One of the accessions had bold fruits weighing about 235 g per fruit. Ten wild accessions of *G. gummi-gutta* were collected from Siruvani, Silent Valley (Kerala) and Kidu (Karnataka) forests. Two cultivated accessions of *G. indica* were collected from Taliparamba (Kerala) and Vengurla (Maharashtra). Six accessions of *Myristica fragrans* (including a doublenut type) were collected from Vengurla and Kozhikode District. Three accessions of *M. beddomeii* were also added to the germplasm. One accession of *Syzygium cuminii* var. Gokak was collected from Vengurla. Two accessions of *Cinnamomum verum* from Vengurla and one accession of *C. cecidodaphne* from Nepal were collected and added to the germplasm. The total collections maintained in the conservatory of tree spices include 302, 482, 223 and 32 accessions of *Cinnamomum* spp., *Myristica* spp., *Syzygium* spp. and *Garcinia* spp., respectively (Fig. 3).

Fifty-seven rooted cuttings of cassia (C-1 accessions), 20 rooted cuttings of *C. perrotettii* and *C. sulphuratum*, 37 plants of *Myristica* spp., 10 plants of *Gymnocranthera canaria*, 3 Zanzibar clove grafts, 7 promising accessions of *G. gummi-gutta* and two wild species namely, *G. cowa* (?) and *G. hombroniana* were planted in the field.

Cataloguing and evaluation

Cassia

Twenty-five cassia accessions were catalogued for morphological and quality parameters based on a minimum descriptor.

In the clonal progeny evaluation of high

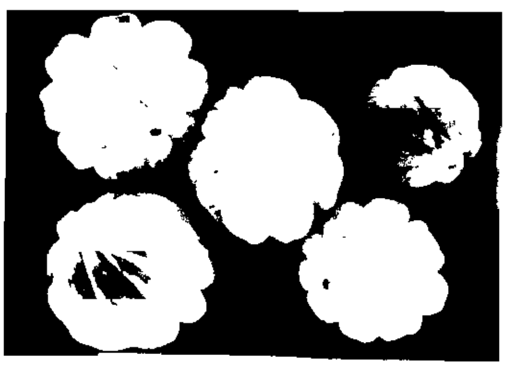

Fig. 3. A collection of garcinia from the germplasm

quality cassia selections (A-2, C-1, D-1 and D-3) planted during 1998 at Peruvannamuzhi, the first coppicing and bark extraction was carried out and morphological and yield parameters were recorded (Tables 18–20). The inter-character association of dry weight of bark, fresh weight of bark, number of branches, number of main shoots, number of harvestable (bark extractable) shoots, thickness of main shoot (1 m above the ground) and plant canopy was studied. The study indicated that there was no significant difference among the four selections for yield of bark and maximum variability was observed for almost all the characters studied. Correlation study of

Table 18. Performance of clonal progenies of elite cassia lines*

Elite line	Height (cm)	No. of main shoots	No. of branches	Canopy width (cm)	Shoot thickness (cm)
A-2	164.0	1.7	9.4	96.2	1.8
C-1	209.3	1.3	14.2	124.8	3.3
D-1	160.0	1.2	8.2	97.4	2.2
D-3	157.5	2.1	11.5	108.4	1.5
CD (P<0.05)	NS	0.49	NS	NS	1.4

*Fourth year after planting
NS = Non significant

Table 19. Performance of clonal progenies of elite cassia lines*

Elite line	No. of harvestable shoots	Fresh weight of bark (g)	Dry weight of bark (g)
A-2	4.2	137.6	37.0
C-1	5.1	409.6	109.2
D-1	5.9	462.6	123.9
D-3	3.5	240.2	71.1
CD (P<0.05)	NS	NS	NS

*Fourth year after planting
NS=Non significant

Table 20. Inter-character association in cassia

Character	Dry weight	Fresh weight	Height	No. of bran-ches	No. of main shoots	No. of shoots	Shoot thick-ness	Shoot width
Dry weight	1.00	0.97**	-0.22	-0.13	-0.03	0.83**	-0.06	0.03
Fresh weight		1.00	-0.26	-0.18	0.04	0.87**	-0.08	-0.04
Height			1.00	0.87**	-0.02	-0.30	0.84**	0.90**
No. of branches				1.00	0.13	-0.20	0.63**	0.87**
No. of main shoots					1.00	0.07	-0.36	0.17
No. of shoots						1.00	-0.12	-0.10
Shoot thickness							1.00	0.68**
Shoot width								1.00

** Significant at $P<0.01$

various characters indicated highly significant association between number of harvestable shoots and yield.

Progeny evaluation trials were also laid out at Appangala and Kalpetta with 15 and 10 elite accessions, respectively.

Nutmeg

Evaluation of quality of germplasm collections of nutmeg was carried out and is reported under the ICAR Cess Fund Project 'Characterization of nutmeg germplasm for quality'.

The proposal for release of IISR Viswashree was sent to the State Variety Release Committee, Kerala. This variety yields on an average 3122 kg nuts (dry)/ha and 480 kg mace (dry)/ha during the eighth year of planting.

Clove

Evaluation of quality of progenies of elite lines indicated that the percentage of bud oil varied from 14.8 to 20.5, with maximum bud oil (20.5%) in B-76. The oil percentage in pedicel varied from 3.3 to 7.7 with maximum (7.7%) in B-59 (Table 21).

Production of elite planting materials

Grafts of elite nutmeg selections (6700), early bearing high yielding *Garcinia* selections (2400) and rooted cuttings of Navashree and Nithyashree cinnamon varieties (1000) and elite cassia lines (600) were produced for distribution.

Hort. IV (813)

Rootstock-scion interactions in tree spices

(*J. Rema, P. A. Mathew, K. S. Krishnamurthy and B. Krishnamoorthy*)

Nutmeg

Standardization of grafting

Seeds of *Myristica malabarica*, *M. beddomeii*, *M. fragrans*, *M. prainii* and *Knema andamanica* (an allied genera of *Myristica* sp.) were collected from different parts of Kozhikode District and raised in the nursery for grafting.

Table 21. Progeny analysis in clove

Accession	Oil (%)		Eugenol (%) in oil		Eugenyl acetate (%) in oil		β-Caryophyllene (%) in oil
	Bud	Pedicel	Bud	Pedicel	Bud	Pedicel	Bud
Control	14.8	3.3	53	71	15.0	14.5	22.0
B-95	15.0	5.9	52	70	14.0	20.2	18.0
B-76	20.5	5.6	44	68	16.5	18.2	21.5
B-59	17.5	7.7	46	71	16.9	14.9	18.9
A1-Bulk	20.5	3.5	49	68	12.0	19.7	20.3
K-6	16.3	7.0	49	72	18.7	15.1	18.8

Preliminary trials on softwood grafting were carried out with two different scions namely, A9-4 and A9-69 on *M. prainii* and *K. andamanica* and no success was obtained on *M. prainii*. A success of 38% and 56% was obtained on A9-4 and A9-69 scions respectively, on *K. andamanica* after 5 months of grafting.

Softwood grafting of nutmeg with scions from rootstocks namely, *M. fragrans*, *M. malabarica* and *M. beddomeii*, was carried out and the success was highest on *M. fragrans* (88%), followed by *M. malabarica* (81%) and *M. beddomeii* (74%). Among the two scions, A9-4 and A9-69 used for grafting, the latter was more compatible with all the rootstocks.

Evaluation of grafts for productivity

The grafts of nutmeg on *M. fragrans*, *M. malabarica* and *M. beddomeii* rootstocks using two scions (A9-4 and A9-69) were planted for field evaluation at Peruvannamuzhi in a Completely Randomized Design. Morphological observations namely, height, girth and number of branches were recorded on the grafts and it was observed that growth was highest on *M. beddomeii* rootstocks for both A9-4 and A9-69 scions, followed by *M. malabarica* and *M. fragrans*. In general, it was observed that the growth of grafts with A9-69 scions was superior to that of A9-4.

Field evaluation of grafts are also in progress in farmers plots at Koli Hills and Pollachi in Tamil Nadu.

Screening rootstocks for drought tolerance

Two year old rootstocks (seedlings) of *M. fragrans*, *M. malabarica*, *M. beddomeii*, *K. andamanica* and *Gymnocranthera canaria* were screened for drought tolerance in pots by inducing stress. The pots containing the seedlings were irrigated to field capacity and observations on stress-related parameters were taken at weekly intervals till the seedlings wilted. Soil moisture was determined at field capacity and at weekly intervals. The soil moisture decreased as the stress progressed.

The number of days taken for wilting of the species was recorded and *M. malabarica*, *M. beddomeii* and *K. andamanica* took 17, 15 and 14 days for wilting respectively, and were found to withstand drought. The relative water content was higher in *M. malabarica*, *M. beddomeii* and *K. andamanica*. Membrane leakage was least in *M. malabarica, K. andamanica* and *M. beddomeii*. The total protein reduced in all the species with induction of stress. The activity of peroxidase did not show any specific trend and activity of catalase was too low to be determined. The proline content increased in all the species as the stress progressed.

Clove

The grafts of clove on *Syzygium heynianum, S. cuminii* and *S. aromaticum* were planted in the field for evaluation.

Gen. XIII (813)

Collection, conservation and improvement of vanilla

(*K. Nirmal Babu, K. V. Saji and S. S. Veena*)

Five new collections were added to the germplasm that included *Vanilla wightiana* and a putative new species resembling *V. aphylla*. Successful interspecific hybrids between *V. planifolia* and *V. tahitensis* were developed.

The variability among different species, collections and interspecific hybrids between *V. planifolia* and *V. aphylla* was estimated using RAPD markers, with three primers (OPA-10, OPB-14 and OPE-14). The paired affinity indices were estimated and cluster analysis was done using NTSYS software. The study indicated that there was very limited variability within *V. planifolia* collections from different regions of India. However, there was considerable variability in different collections of *V. andamanica*. In spite of the similarity in morphology, *V. andamanica* was not closely related to *V. planifolia* and *V. tahitensis*. *V. tahitensis* is nearest to *V. planifolia*; the similarity indices of *V. planifolia* and *V. andamanica* ranged from 11% to 57%. The putative new species resembling *V. aphylla* showed differences in RAPD patterns and hence may be a different genotype. The interspecific hybrids are true hybrids between *V. planifolia* and *V. aphylla* with VH-5 and VH-6 more closer to the female parent *V. planifolia*, while VH-1 and VH-4 were more closer to the male parent *V. aphylla*. Variations could be induced using colchicine treatment and through somaclonal variation in *V. planifolia*. The extent of variability could also be enhanced by hybridization.

Hort. III (813)

Development of paprika for warm humid tropics

(*K. P. M. Dhamayanthi, P. A. Mathew, K. N. Shiva and T. John Zachariah*)

Maintenance of germplasm

Thirty-five accessions of paprika were maintained in polybags at Chelavoor (Table 22).

Breeding

Methods were standardized for seed treatment of paprika for germination. Treatment with hydrogen peroxide 0.5% for 2 h resulted better response than control and other stimulants (GA and sodium dihydrogen orthophosphate). Seed germination was 32% higher than that of control when treated with hydrogen peroxide.

Reciprocal crosses were made with ICBD *Byadagi* lines and Papri King (a promising Zimbabian paprika variety with high colour coupled and low pungency) combination to obtain high coloured *Byadagi* type and low pungent Papri King type (hybrid) and 20%

Table 22. Germplasm accessions of paprika maintained at Chelavoor

Category	Accessions
Indigenous collections	ICBD-1, ICBD-2, ICBD-3, ICBD-4, ICBD-5, ICBD-6, ICBD-7, ICBD-8, ICBD-9, ICBD-10, ICBD-11, ICBD-12, ICBD-13, ICBD-14, ICBD-15, ICBD-16, ICBD-17, ICBD-18.
Exotic collections	PBC-171, Papri King, EC-6, EC-14, EC-18, EC-20, EC-31, EC-35, EC-38, EC-43, EC-45, EC-65, EC-71, EC-490.

fruit set was only obtained. The pods were harvested separately and the seeds were extracted and stored for further evaluation. The variations among the plant types and fruit characters were recorded.

Quality analysis

Pods of paprika accessions were subjected to analysis for estimating the colour value and pungency. Indigenous collection of *Byadagi Dabbi* (ICBD) types possessed high colour value than the exotic paprika lines. The exotic lines had low pungency than the ICBD lines. The colour value of ICBD lines ranged from 149 to 378 ASTA units (Table 23).

Table 23. Analysis of quality of paprika germplasm

Accession	Colour value (ASTA units)
ICBD-1	276.6
ICBD-3	301.7
ICBD-4	238.3
ICBD-6	378.5
ICBD-8	254.2
ICBD-9	336.8
ICBD-10	289.6
ICBD-15	259.4
ICBD-16	307.1
PBC-171	219.3
Papri King	317.4
Kt. Pl-19	333.5

Externally Funded Projects

NATP

Collection, characterization and conservation of spices genetic resources

(*Johnson K. George, K. V. Saji, B. Sasikumar and B. Krishnamoorthy*)

Exploration and collection

Four exploration trips were undertaken and 246 accessions including 93 cultivars were collected which included, a high yielding *Piper nigrum* with bold berries and good quality from Silent Valley; *Cinnamomum gracile*, a rare species from Siruvani Dam site; *Curcuma decipiense* from Bajagoli (Kudremukh); a bisexual wild *P. nigrum* from Nelliampathy forests; a wild accession of *Zingiber officinale* from Silent Valley and a high yielding, low altitude cardamom (Vandor cardamom) from Idukki District.

Characterization of germplasm

Black pepper

One hundred and fifty black pepper germplasm accessions maintained under *ex situ* conditions were characterized for qualitative and quantitative characters. High variability was observed in the accessions for yield characters namely, spike length (3.5–12.0 cm), number of fully developed berries/spike (10–82), weight of 100 fresh berries (5.5–20.5 g), volume of 100 fresh berries (6–21 ml), dry weight of 100 berries (2.0–7.5 g) and green yield/vine (0.500–2.841 kg). High variability for qualitative characters was also observed.

Ginger and turmeric

Vegetative and yield characters of 150 accessions of ginger germplasm were recorded and high variability for the characters were noticed. Yield per clump varied from 50 g to 980 g. One hundred and fifty germplasm accessions of turmeric were also evaluated for variability for vegetative and yield characters. The yield of these accessions ranged from 192 g to 1210 g with an average of 835 g per clump.

Herbarium sheets of 72 collections of spices were prepared and important ones with duplicates were deposited with NBPGR. High elevation species like *P. sugandhi*, *P. galeatum* and extra bold berried *P. nigrum* were utilized for crossing with selected cultivated black pepper cultivars as a part of genetic enhancement programme.

DBT Project

Conservation of spices genetic resources in *in vitro* gene banks

(*P. N. Ravindran and K. Nirmal Babu*)

In vitro *genebank*

Fifty accessions of spices germplasm were added to the *in vitro* genebank that included both male and female of high elevation species of *Piper* such as *P. schmidtii*, *P. wightii* and *P. mullesua* and important cultivars.

DNA bank

DNA was extracted from 100 accessions of black pepper, 100 accessions of cardamom, 50 lines of ginger, 17 accessions of cinnamon and 50 lines of vanilla and stored at −85 ^{0}C in DNA bank.

Micro rhizomes in ginger

Micro rhizomes of 5–10 g fresh weight/explant were induced in ginger tissue cultures in 2–6 months on MS basal medium supplemented with higher levels of carbon. These micro rhizomes could be directly planted in the field and established with 90–100% survival eliminating the need for hardening, thus saving cost and labour. Field trials conducted at Chelavoor indicated that the micro rhizomes gave commercially viable yields (300–500 g of fresh rhizomes/plants 12–20 kg/3 m^2 bed) comparable to normal seed rhizomes, which normally give a mean yield of 20 kg/3m^2 bed. The micro rhizomes had more tillers per plant though the tiller height was less. The seed rate requirement per bed was about 800 g/3 m^2 (@ 40 plants per bed) for normal seed rhizomes and in case of micro rhizomes it was about 400 g. The study indicated that micro rhizomes can be a good source of planting material giving reasonable yields with less of initial planting material.

DBT Project

A digitized inventory of plant resources. Part II-Other economically important species

(*P. N. Ravindran and K. Nirmal Babu*)

Data on origin, occurrence, distribution, taxonomy, utility and other details were collected and compiled in black pepper, cardamom, ginger, turmeric, large cardamom, vanilla, long pepper, nutmeg, cinnamon, cassia, bay leaf, coriander, cumin, fennel, fenugreek, dill, celery, aniseed, caraway, black cumin, ajowan, star anise, greater galangal, basil and sage.

ICAR Cess Fund Project

Organization of ginger and turmeric germplasm based on molecular characterization

(*B.Sasikumar and T. John Zachariah*)

Extraction of DNA

Among the various methods tested for extraction of DNA from ginger and turmeric, the method of Saghai-Maroof *et al.* (1984) with slight modification was most suitable. A modified Gawal and Jarret (1991) method was used for isolation of DNA from fresh, young turmeric rhizomes. In the modified method, 3% CTAB extraction buffer containing 2 M NaCl and 1% β-Mercaptoethanol was used instead of 2% CTAB buffer containing 1.4 M NaCl and 0.5% β-Mercaptoethanol. During the extraction and purification steps, 100% ethanol was used for precipitation of DNA.

PCR conditions

The amplification condition found suitable for ginger and turmeric leaf DNA was as follows : denaturation at 94°C for 5 min-1 cycle; denaturation at 94°C for 1 min-40 cycles; annealing at 35°C for 1 min-40 cycles; extension at 72°C for 2 min-40 cycles and final extension at 72°C for 10 min-1cycle.

Two amplification conditions were tried for DNA from turmeric rhizomes and both were suitable.

1. Denaturation at 93°C for 3 min-1 cycle; denaturation at 93°C for 1 min-40 cycles; annealing at 37°C for 1 min-40 cycles; extension at 72°C for 2 min-40 cycles and final extension at 72°C for 10 min-1 cycle.
2. Denaturation at 93°C for 1 min 15 sec-1 cycle; denaturation at 93°C for 45 sec-40 cycles; annealing at 37°C for 1 min 15 sec-40 cycles; extension at 72°C for 1 min 32 sec-40 cycles and final extension at 72°C for 10 min-1 cycle.

Amplification

Various concentrations of template DNA, primer, Mg, pH of buffer and amplification conditions were experimented for amplification of DNA from leaves of ginger and turmeric. A final concentration 0.15–0.25 mM dNTPs along with 2–2.5 µM $MgCl_2$, 0.5 U of Taq DNA polymerase, 10–20 ng genomic DNA and 0.2 µ M primer in 25 µl reaction volume was suitable for good amplification (Table 24).

A reaction volume of 25 µl containing 2.5 mM $MgCl_2$, 100 µM each of dNTPs, 0.2 µM primer and 1 U of Taq DNA polymerase and 2 ng genomic DNA was suitable for good amplification of DNA from turmeric rhizomes.

RAPD profiling

Species level polymorphism was high in *Zingiber* sp. and *Curcuma* sp. as compared to varietal level polymorphism.

DBT Project

Improvement of selected spice crops through biotechnological approaches

(*Y. R. Sarma, K. Nirmal Babu, Johnson K. George, M. Anandaraj, M. N. Venugopal and R. Ramakrishnan Nair*)

Table 24. Amplification of DNA from *Zingiber* and *Curcuma* species

Primer	No. of amplification products		Size of amplification products
	Zingiber spp.	*Curcuma* spp.	
OPQ-20	3.75	6.64	-
OPT-13	8.00	7.50	-
OPX-7	9.25	10.86	-
OPA-01	-	2.60	588–1477
OPA-04	-	2.85	268–1973
OPE-11	-	5.00	78–3996

Molecular characterization of cardamom

DNA was isolated from 100 lines of cardamom comprising of various species, released varieties, promising lines and genotypes collected from different regions. Fifty primers were screened and only 6 good polymorphic primers were identified. RAPD profiles were developed from 24 lines of promising lines and species with 6 primers.

Genetic transformation in black pepper

Embryogenic cultures of black pepper were established and maintained in proliferating condition through secondary embryogenesis. Regeneration into plantlets was possible, both in liquid and solid media. As the embryos originate from sporophytic tissues of the seed, the method will be helpful for transformation experiments using biolistics.

Plant transformation vector

The plasmid (*p* Cambia 1301 construct in EHA 105) for biolistic experiments was procured from Tamil Nadu Agricultural University, Coimbatore, and glycerol stocks of the cultures were maintained at –86 °C. A single colony of EHA 105 containing *p* Cambia 1301 was inoculated into 5 ml of LB broth containing 50 mg/ml of kanamycin. The plasmid isolation was carried out from this culture using two different methods namely, lysozyme method (Sambrook *et al.* 1989) and boiling method (Ausubel *et al.* 1992). Among the two methods, the former yielded plasmid of good quality.

Agrobacterium tumefaciens with osmotin gene construct was used in transformation studies. Leaf discs were used as explants for the study. The resultant calli were subjected to kanamycin resistance tests.

Isolation of disease resistant genes

Isolation of RNA

Two different methods, namely, Guanidium thiocyanate (GTC) method (Sambrook *et al.* 1989) and phenol/SDS method (Ausubel *et al.* 1992) and their modifications were tried for RNA isolation from *P. colubrinum*. Among the two methods, a modified GTC method (GTC method with addition of PVP (0.01 g/ml) and 2-Mercaptoethanol (7.5 ml/ml) in the extraction buffer yielded more RNA (65 mg/g of leaf tissue). mRNA was also successfully purified from total RNA using oligo dT cellulose.

DDRT-PCR of total RNA and mRNA

In this method, the first strand cDNA was synthesized from total RNA using random decamer primers. The first strand cDNAs were then subjected to PCR amplification using additional primers (Operon primers), which amplified sequences based on chance homology. First strand cDNA synthesis from mRNA using random hexamers and subsequent cDNA amplification using decamer Operon primers were also successful. The c DNA bands were resolved in agarose gels and visualized under UV.

Differential Display RT-PCR was carried out using RNAs isolated from *P. colubrinum* to tag genes expressed in *P. colubrinum* in response to *Phytophthora* inoculation. The cDNA bands were resolved in agarose gel and two cDNA bands corresponding to differentially expressed genes in *P. colubrinum* were eluted and reamplified for cloning and sequencing.

Isolation of RGCs in black pepper

Eighteen degenerate primers designed from NBS region of R genes were used and a product of 500 bp was found amplified in Karimunda, P-24 and *P. colubrinum*. This PCR product would be cloned and sequenced.

NATP

Molecular characterization and preparation of molecular maps in black pepper

(*K. Nirmal Babu, Johnson K. George, M. Anandaraj and P. N. Ravindran*)

Preparation of molecular maps

A mapping population of 200 progenies each was developed from selfed and crossed progenies involving two crosses, Subhakara x Panniyur-1 and Subhakara x P-24. DNA isolation is in progress.

Molecular characterization of black pepper varieties

RAPD profiles were developed using six polymorphic primers in released varieties of black pepper namely, Karimunda, Kottanadan, Kuthiravally, Thommankodi, Balankotta, Kalluvally, Poonjaranmunda, Neelamundi, Narayakodi, Perambramunda, Arakulammunda, Valiakaniakkadan, Cheriyakaniakkadan, Uthirankotta, Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4, Panniyur-5, Sreekara, Subhakara, Panchami, Pournami and Palode-2. Intra cultivar relationships were also estimated using NTSYS software. The study proved that Sreekara and Subhakara are different genotypes. Further collection of data for realistic estimation of intra cultivar differences is in progress to develop RAPD profiles/finger prints for the varieties.

DBT Project

Field evaluation of tissue cultured plants of spices and assessment of their genetic stability using molecular markers

(*K. Nirmal Babu and P. N. Ravindran*)

Genetic variability among somaclones

Molecular markers were used to estimate the extent of genetic variability of micropropagated plants of black pepper. Twenty-four operon primers were tested on Aimpiriyan and Subhakara. Morphological characters coupled with RAPD profiles indicated genetic fidelity among randomly selected micropropagated plants indicating that the micropropagation protocol, used for rapid cloning of these two genotypes can be commercially utilized. This is the first report of using RAPD polymorphism to detect genetic stability of micropropagated plants of black pepper.

Crop Production and Post Harvest Technology

Agr. XXI (813)

Efficacy of biofertilizers on nutritional management of black pepper

(C. K. Thankamani, K. S. Krishnamurthy and V. Srinivasan)

Black pepper cuttings were planted at Peruvannamuzhi with *Ailanthus* sp. as standards during 2000. The main plot treatments consist of application of *Azospirillum* and without *Azospirillum*. The sub plot treatments were: inorganic N 100% + FYM, inorganic N 75% + 10 kg FYM, inorganic N 50% + 10 kg FYM, FYM 10 kg alone, inorganic N 50% + Zn, inorganic N 50% + Zn + Bo + Mo, inorganic N 50% + Ca, inorganic N 50% + Mg, inorganic N 50% + Ca + Mg and NPK alone. The available nitrogen and phosphorus contents were higher in plots in which *Azospirillum* was applied. Maximum available nitrogen and phosphorus was observed in treatments in which NPK alone was applied. Pretreatment *Azospirillum* population was low and gradually increased and highest *Azospirillum* counts were recorded in the treatment NPK alone.

SSc. II (813)

Nutritional requirement of improved varieties of spices

(V. Srinivasan, K. S. Krishnamurthy and C. K. Thankamani)

Black pepper

Soil application of Zn at various levels significantly increased the DTPA-Zn availability over control, the levels of application behaving on par. The mean yield recorded was highest in foliar spray @ 0.25% $ZnSO_4$ applied twice with other higher levels of soil application of Zn yielding on par.

An experiment is in progress for the third year to assess the effect of Mg nutrition on black pepper and the treatments consisting of Mg @ 0, 50, 75 and 100 kg/ha were imposed. The soil availability of Mg increased with application of different doses of Mg fertilizers. The available K and Ca contents were on par among the levels of Mg fertilizers added along with uniform application of N, P and K. Highest yield was recorded in the treatment NPK + Mg @ 100 kg/ha which was on par to that of control. No clear influence on yield was observed by the application of Mg fertilizers in all the three varieties studied.

Field experiments on targeted production of black pepper were in progress at Madikeri and Kalpetta by fixing the targets for yield at three levels (5.0, 6.5 and 7.5 kg/vine). The yield recorded at Madikeri was well above (15 kg/vine) the target and that of Kalpetta was low (2.5 kg/vine) probably due to unfavourable weather conditions.

Ginger and turmeric

Integrated Plant Nutrient Management

Experiments on IPNM to scale down fertilizer use was laid out in ginger and turmeric with sources like neem cake and phosphate solubilizing bacteria to supplement the nutrients. The soil N, P, K, Ca, Mg, Mn and Cu availability significantly increased with application of neem cake, phosphobacteria (PB) and P as rock phosphate and potash. Application of neem cake increased the soil availability of N significantly, irrespective of the dosage of chemical fertilizer applied. The highest available N was recorded in beds applied with half the dose of N as urea along with neem cake @ 2 t/ha. P availability also increased significantly with application of PB along with FYM and neem cake and with increased dosage of rock phosphate. With the application of neem cake, soil availability of Mg, Fe and Zn increased significantly. Concentration of these nutrients in the leaf was also significantly high in neem cake, PB and at higher levels of P application.

Significantly high fresh rhizome yields of 18.5 and 29.4 kg/bed, were recorded in ginger and turmeric respectively, in treatments where FYM, neem cake, PB and rock phosphate were applied with half the quantity of recommended urea. Nitrogen application as urea could be reduced to half by the application of neem cake and FYM and PB. Rhizome uptake of major and micronutrients by ginger and turmeric was also studied. Uptake of P and K increased with combined application of FYM, neem cake and PB over recommended fertilizer package. The uptake of micronutrients like Fe, Zn and Cu were on par to that of control in beds where IPNM was adopted. Oleoresin content was highest (5.3%) in treatments with neem cake + PB and FYM with half the recommended urea over recommended package. The same treatment recorded highest curcumin content (8.7%) in turmeric, which was on par with recommended package (9.0% curcumin).

Effect of micronutrients

The effect of application of Zn at different levels in combination with or without coir compost was studied in ginger and turmeric. The soil availability of Zn and P were estimated at 120 days after planting (DAP) and at harvest. The available P content reduced significantly with increased levels of Zn application as compared to no Zn application. Soil Zn availability also increased significantly with levels of Zn applied. At harvest there was reduction in soil available P due to uptake by the crop. Addition of coir compost did not influence soil Zn availability. But the available P content was significantly high in beds in which coir compost was not applied indicating a temporary fixation of P by coir compost. But there was significant reduction in soil available P due to uptake after harvesting the crop. Leaf Zn level also followed the pattern of levels of Zn applied and foliar treatment recorded the highest concentration of the nutrient.

There was no trend in the yield of fresh ginger rhizomes among levels of Zn applied (Table 25). Highest yield of rhizome was recorded in the treatment where no Zn was applied followed by foliar application @ 0.25% $ZnSO_4$. The quality (oleoresin) and fresh yield of turmeric were on par among the treatments. Both soil and foliar applications were on par regarding yield (22 kg/ bed). Application of coir compost had no influence on yield of turmeric (Table 26). Curcumin content was also on par with soil and foliar application of Zn. As the soil was fertile enough no response could have been recorded. Uptake of Zn in the rhizome also increased significantly especially in turmeric with increased dose of application and in foliar treatment. In ginger, all the higher levels of Zn application were on par regarding its uptake. Rhizome concentration of P was not influenced by levels of Zn applied both in ginger and turmeric.

Phy. V (813)

Characterization of drought tolerance in black pepper

(*K. S. Krishnamurthy and S. J. Ankegowda*)

The accessions of black pepper which were found to be relatively tolerant to water stress during preliminary screening were further screened in pots using parameters such as relative water content (RWC), membrane damage, glutathione reductase (GR), catalase and peroxidase activities and gas exchange characteristics.

Relative water content

Accs. 828 and 1223 maintained higher RWC and lower membrane damage among the tolerant accessions. The tolerant and susceptible accessions had similar values for RWC and membrane damage up to 6 days after stress induction (DASI); however the difference was more at 12 DASI (Table 27).

Glutathione reductase activity

GR activity generally increased during stress and the tolerant accessions had slightly higher levels of activity, but the differences were non significant (Table 28).

Table 25. Effect of Zn on soil availability of nutrients and yield of ginger

Treatment	Soil P (mg/kg)			Soil Zn (mg/kg)			Fresh yield (kg/3m^2 bed)		
	WCC	CC	Mean	WCC	CC	Mean	WCC	CC	Mean
Zn 0	12.3	11.3	11.8	1.4	1.8	1.6	17.4	16.8	17.1
Zn 1	9.7	7.0	8.3	2.2	2.9	2.5	13.5	17.0	15.2
Zn 2	7.4	7.0	7.2	2.8	3.7	3.2	13.7	13.8	13.8
Zn 3	7.0	7.8	7.4	6.3	6.7	6.5	14.8	15.8	15.3
Zn 4	8.9	5.0	7.0	12.3	9.0	10.6	13.0	13.3	13.1
Zn Foliar	-	-	9.8	-	-	3.8	-	-	16.2
Mean	9.1	7.6	-	5.0	4.8	-	14.5	15.3	-
CD For CC			NS			NS			NS
(P<0.05) Zn			2.7			0.8			NS
CC x Zn			3.8			1.2			NS

NS=Non Significant; WCC=Without Coir Compost; CC=Coir Compost; Zn 0=0 kg Zn/ha; Zn 1=5 kg Zn/ha; Zn 2=7.5 kg Zn/ha; Zn 3=10 kg Zn/ha; Zn 4=15 kg Zn/ha

Table 26. Effect of Zn on soil availability of nutrients and yield of turmeric

Treatment	Soil P (mg/kg)			Soil Zn (mg/kg)			Fresh yield (kg/3m[2] bed)		
	WCC	CC	Mean	WCC	CC	Mean	WCC	CC	Mean
Zn 0	1.4	1.0	1.2	1.92	1.94	1.9	20.4	22.6	21.5
Zn 1	1.7	1.4	1.6	2.14	2.84	2.5	21.0	23.5	22.3
Zn 2	1.6	1.4	1.5	3.02	3.83	3.4	23.0	21.2	22.1
Zn 3	1.4	1.5	1.5	8.11	7.27	7.7	20.5	23.7	22.1
Zn 4	2.2	1.7	1.9	10.95	11.0	11.0	23.3	19.0	21.2
Zn Foliar	-	-	1.4	-	-	3.9	-	-	22.5
Mean	1.5	1.7	-	5.20	5.40	-	21.6	22.0	-
CD	For CC		NS			NS			NS
(P<0.05)	Zn		0.5			0.7			NS
	CC x Zn		0.7			1.0			NS

NS=Non Significant; CC=Coir Compost; WCC=Without Coir Compost; Zn 0=0 kg Zn/ha; Zn 1=5 kg Zn/ha; Zn 2=7.5 kg Zn/ha; Zn 3=10 kg Zn/ha; Zn 4=15 kg Zn/ha

Table 27. Relative water content and membrane leakage in black pepper accessions

Accession	Relative water content (%)			Membrane leakage (%)		
	Control	6 DASI	12 DASI	Control	6 DASI	12 DASI
Tolerant						
Acc. 1104	92.0	83.5	77.5	9.8	7.9	10.1
Acc. 1123	93.4	88.3	79.5	4.6	6.7	8.7
Acc. 1110	94.3	86.0	78.5	5.0	8.3	9.4
Acc. 1321	92.4	85.8	77.9	5.5	8.4	9.6
Acc. 1039	95.6	87.3	79.0	4.7	7.2	9.0
Acc. 828	94.3	89.1	80.4	5.2	6.3	8.0
Susceptible						
Acc. 1095	94.1	87.5	74.8	5.1	8.5	11.4
Acc. 1199	91.5	80.4	68.7	5.8	9.4	15.6
Acc. 1279	90.7	78.5	64.5	5.0	8.3	16.3
CD (P<0.05)	1.6	2.0	2.7	NS	NS	NS

DASI=Days after stress induction; NS=Non significant

Gas exchange parameters

Photosynthetic rate and transpiration rates reduced drastically under stress conditions and transpiration rate was very low (near to zero) as the leaves wilted. However, the rate of decrease in photosynthetic and transpiration rate was less in tolerant varieties than the susceptible ones. Acc. 828 maintai-ned better photosynthetic characteristics.

Phy. VI (813)

Characterisation of drought tolerance in cardamom

(S. J. Ankegowda, K. S. Krishnamurthy and D. Prasath)

Six accessions namely, APG-18, APG-34, APG-149, DR-3, DR-6 and DR-16 were screened for moisture stress tolerance in cement pots under shelter. Moisture stress was imposed by withholding irrigation and data on morphology related to drought tolerance was recorded at initiation of stress. Recording of morphological and physiological data is in progress for other stages.

Preliminary screening of 35 accessions for relative water content (RWC), specific leaf weight and stomatal count indicated significant variations. Relative water content ranged from 14.7% to 33.6% with a mean of 22.7%. Specific leaf weight ranged from 4.21 to 6.19 mg/cm^2 with a mean of 5.19 mg/cm^2. Number of stomata per microscopic field at 60 x ranged from 6.0 to 14.5 with a mean of 9.3.

The genotypes APG-228, APG-239, APG-242, APG-259, APG-260 and APG-271 recorded relatively higher RWC under stress. The genotypes APG-224, APG-246, APG-257, APG-262, APG-265 and APG-271 recorded relatively lower stomatal counts. The genotypes APG-227, APG-228, APG-239, APG-244, APG-258, APG-259 and APG-265 recorded relatively higher specific leaf weight. APG-228, APG-239 and APG-259 maintained higher RWC and specific leaf weight.

Ten accessions were collected from farmers fields in Idukki for further multiplication and evaluation.

Table 28. Glutathione reductase activity in black pepper accessions

Accession	% increase/decrease over control		
	Control	6 DASI	12 DASI
Tolerant			
Acc. 1120	4.5	15.2 ⇑	21.6 ⇑
Acc. 1104	6.6	4.5 ⇑	18.4 ⇑
Acc. 1223	5.8	7.8 ⇑	22.5 ⇑
Acc. 1110	3.9	8.4 ⇑	10.4 ⇑
Acc. 1321	2.4	5.6 ⇓	2.5 ⇑
Acc. 1039	4.7	4.7 ⇓	4.0 ⇓
Acc. 828	6.5	12.5 ⇑	19.4 ⇑
Susceptible			
Acc. 1095	5.6	3.8 ⇓	11.3 ⇑
Acc. 1090	3.2	6.4 ⇓	10.5 ⇓
Acc. 1199	4.8	14.5 ⇑	13.4 ⇑
Acc. 1279	4.1	3.2 ⇓	7.5 ⇓
CD (P<0.05)		NS	NS

DASI=Days after stress induction
NS=Non significant

Agr. XVII (813)

Vermi-composting using organic wastes available in cardamom areas

(V. S. Korikanthimath and S. J. Ankegowda)

Growth and yield parameters

Observations on plant height, number of tillers, number of bearing tillers, number of non-bearing tillers and fresh yield was recorded in plots where various treatments (Table 29) were imposed during the cropping season. There were no significant differences between treatments for growth and yield characters. However, plant height was maximum in T4 and minimum in T2. Total number of tillers per plant was maximum in T4 and minimum in T8. Fresh yield was maximum in T5.

Microclimate

No significant variation in air temperature and relative humidity was observed between treatments. Air temperature ranged from 28.13 to 28.99°C and relative humidity from 35.99 to 38.7% in different treatments during March.

Soil nutrient status

Phosphorus content was higher in T8 and T9 compared to other treatments. Very low phosphorus content was recorded in T1, T3 and T11. Potassium content was higher in T4 and T12 and lower in T1. Ca and Mg status was higher in all the treatments (Table 30).

Table 29. Details of treatments in the experiment to study the effect of vermicompost on cardamom

T1	Control
T2	NPK (50:50:100 g/plant in two splits)
T3	FYM (10 kg/plant in two splits)
T4	Neem cake (NC) (1 kg/plant in two splits)
T5	Vermicompost (VC) (3 kg/plant in two splits)
T6	NPK + FYM
T7	NPK + NC
T8	NPK + VC
T9	Half VC + Half NC
T10	Half VC + Half NC + Half NPK
T11	Half FYM + Half NC
T12	Half FYM + Half NC + Half NPK

Agr. XIV (813)

Investigation on spice based cropping system

(*V. S. Korikanthimath, C. K. Thankamani, S. J. Ankegowda and V. Srinivasan*)

Growth and yield parameters

Observations on height and number of branches in component crops and height, number of bearing tillers, non bearing tillers, total number of tillers and fresh yield per plot (0.1ha) of cardamom (main crop) in various cropping systems was recorded. Growth of nutmeg was poor whereas that of clove, cinnamon, allspice and black pepper was good. Growth parameters for cardamom were comparatively poor in all the crop combinations except nutmeg. Cinnamon and nutmeg plots yielded higher compared to other cropping systems (Table 31).

Microclimate

No significant variations in air temperature and relative humidity were observed in various crop combinations during March. Air temperature ranged from 27.4 to 28.4°C and relative humidity from 44.2 to 50.8% in different crop combinations.

Soil nutrient status

Soil samples were collected from different crop combinations from two depths and analysed for P, K, Ca and Mg (Table 32). The P content was higher in black pepper

Table 30. Effect of vermicompost and other nutrients on soil nutrient status in cardamom

Treatment	Depth	P	K (mg/kg)	Ca	Mg
T1	D1	3.4	102.7	698.7	90.5
	D2	1.7	82.3	473.7	64.5
T2	D1	13.6	159.0	496.3	91.0
	D2	8.4	111.7	368.3	65.0
T3	D1	3.3	126.7	1094.3	118.7
	D2	4.5	82.3	713.3	97.4
T4	D1	11.4	230.7	802.7	124.9
	D2	4.4	127.0	457.0	90.5
T5	D1	10.0	123.7	598.3	85.7
	D2	1.1	77.0	335.3	53.8
T6	D1	9.7	150.7	971.3	128.7
	D2	7.3	120.0	700.3	112.4
T7	D1	15.3	169.3	606.3	91.3
	D2	13.6	123.3	459.7	70.2
T8	D1	23.6	135.0	612.0	113.5
	D2	13.4	86.0	376.7	71.1
T9	D1	19.4	123.3	838.0	117.i3
	D2	17.2	92.3	526.3	95.5
T10	D1	10.2	165.7	1050.3	167.3
	D2	5.0	94.3	700.7	130.2
T11	D1	7.8	180.7	921.0	137.8
	D2	1.7	73.0	584.0	99.6
T12	D1	5.5	217.3	706.7	182.5
	D2	13.3	181.0	937.7	141.9

D1=0–15 cm; D2=15–30 cm ; Refer Table 29 for treatment details

Table 31. Yield of cardamom in various cropping systems

Treatment	No. of panicles/ plant	Wet weight (kg/plot)
Cardamom + Nutmeg	17.7	59.25
Cardamom + Clove	3.4	17.30
Cardamom + Cinnamon	25.1	75.30
Cardamom + Allspice	7.6	36.45
Cardamom + Black pepper	16.9	39.30
Cardamom + Coffee	24.4	44.05
Cardamom alone	17.7	24.25

(52.74 ppm) followed by clove (47.49 ppm) and lower in allspice (27.11 ppm) grown with cardamom. The highest content of K (407 ppm) was observed in nutmeg cultivated with cardamom followed by coffee (314 ppm) and was lowest in coffee alone (80 ppm).

The Ca and Mg contents were generally higher in all crop combinations. However, highest content of Ca (1497 ppm) was recorded in nutmeg grown with cardamom followed by coffee (988 ppm). Higher Mg content was recorded in allspice (158.2 ppm)

Table 32. Nutrient status in various cropping systems

Treatment	Depth	P	K (ppm)	Ca	Mg
Cardamom + Nutmeg	D1	39.61	407	1497	121.6
	D2	19.15	416	1267	102.4
Cardamom + Clove	D1	47.49	169	505	106.4
	D2	53.58	190	514	102.0
Cardamom + Cinnamon	D1	44.39	270	628	114.9
	D2	9.37	284	429	99.6
Cardamom + Coffee	D1	36.22	314	988	128.3
	D2	15.28	210	926	128.2
Cardamom + Black pepper	D1	52.74	133	709	135.4
	D2	21.22	110	490	101.5
Cardamom + Allspice	D1	27.11	232	804	158.2
	D2	38.33	172	388	87.2
Cardamom alone	D1	14.78	189	551	127.2
	D2	50.12	166	486	111.9
Coffee alone	D1	31.66	80	661	122.1
	D2	27.96	84	582	116.0

D1=0-15 cm; D2=15-30 cm

and lowest in clove (106.4 ppm) grown with cardamom.

Agr. XIX (813)

Management efficacy of whole farm approach in farming-A study on spices based cropping systems

(V. S. Korikanthimath and S. J. Ankegowda)

Various cropping systems such as arecanut + cardamom, coffee + cardamom, garcinia + cardamom and monkey jack + cardamom were included in the study. Growth parameters and microclimate were recorded in various crop combinations. No significant variations in air temperature and relative humidity were observed in different cropping systems (Tables 33 and 34).

Biochem. I (813)

Biogenesis of pigments in spice crops

(B. Chempakam and T. John Zachariah)

PAL activity during early germination and growth phases in turmeric

The activity of phenyl alanine lyase (PAL) was studied in turmeric during early germination and growth phase at 15-day intervals from 30 days after sowing in leaf, root and rhizome. PAL activity was maximum in leaves and rhizomes during initial stages, which declined later. However, in roots, PAL exhibited a higher activity towards the later stage (Table 35).

PAL activity in turmeric accessions

PAL activity was assayed in leaves of tur-

Table 33. Growth parameters of crops in mixed cropping systems

Crop	Height (m)	No. of branches/ leaves/tillers
Robusta coffee	1.00	9.5
Arabica coffee	1.00	10.9
Garcinia	3.00	24.8
Allspice	3.67	31.0
Arecanut	3.08	6.4
Cardamom	1.56	12.3

Table 34. Microclimatic conditions in mixed cropping systems

Crop	Air temperature (°C)	Relative humidity (%)
Robusta coffee	29.8	56.2
Arabica coffee	29.4	55.0
Garcinia	29.8	54.0
Allspice	29.8	55.2
Arecanut	30.4	55.6
Cardamom	30.4	52.0

meric accessions having low (>2%) and high (<5%) curcumin levels. The enzyme activity could be correlated with curcumin levels (Table 36) which confirmed the role of PAL as the rate-limiting enzyme during curcumin synthesis. The probable phenolic acid precursors for the biosynthesis could be identified in the leaf as coumaric, caffeic and ferulic acids.

Org. Chem. 1 (813)

Isolation and identification of naturally occurring compounds against major pests and pathogens of black pepper

(*N. K. Leela, M. Anandaraj, Santhosh. J. Eapen and S. Devasahayam*)

The antifeedant activity of hexane and methanol extracts of *Annona squamosa* seeds, *Melia composita* fruits and *Polyalthia longifolia* leaves and essential oil of *Zanthoxylum rhetsa* fruits at 1% concentration, was evaluated againist *pollu* beetle in no-choice laboratory tests. Both the hexane and methanol extracts of *A. squamosa* seeds resulted in 100% feeding deterrence at 1% concentration. Hexane extracts from *M. composita* fruits and *P. longifolia* leaves caused 51.2% and 55.8% feeding deterrence, respectively (Table 37).

The essential oil from allspice leaves completly inhibited mycelial growth of *Phytophthora capsici* at concentrations ranging from 0.5% to 2.0%. Bioassay guided fractionation of the essential oil led to the identification of the active principle as eugenol.

PHT. I (813)

Quality evaluation in spices

(*T. John Zachariah, P. Heartwin Amaladhas and B. Chempakam*)

Table 35. PAL activity in rhizome, root and leaf in turmeric

Plant part	PAL activity (µM trans-cinnamic acid released/min/mg protein x 10^{-2})				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Rhizome	42.3	20.4	21.2	14.4	14.4
Root	6.8	8.1	21.8	25.4	28.4
Leaf	30.3	22.5	17.0	21.7	12.0

DAS=Days after sowing

Table 36. PAL activity in leaves of high and low curcumin accessions

Accession	PAL activity (μM trans-cinnamic acid released/min/mg protein x 10^{-2})
Low curcumin	
Acc. 170	21.98
Acc. 216	19.83
Acc. 288	24.02
Acc. 302	25.17
Acc. 320	20.45
High curcumin	
Alleppey	45.08
Prabha	43.16
Prathibha	9.28
Suguna	30.89
Sudarshana	32.64

Quality of black pepper germplasm

Among the promising 22 black pepper accessions evaluated for quality from Peruvannamuzhi Farm, six accessions were promising (Table 38). Two hundred black pepper accessions including wild species were evaluated for oil, oleoresin and piperine and high quality lines were identified (Table 39).

Quality of ginger germplasm

Fifty-four ginger accessions were evaluated for oil, oleoresin and crude fibre and seven accessions were promising (Table 40).

Storage of ginger

Studies on evaluation of suitable containers for transportation and storage of fresh ginger rhizomes without dehydration and prevention of pest infestation in dry ginger during storage are reported under the externally aided project 'Integrated technologies for value addition and post harvest management in palms, spices and tropical tuber crops'.

PHT II. (813)

Harvesting and processing techniques in spices

(*P. Heartwin Amaladhas, T. John Zachariah and A. Kumar*)

Drying of mace

Studies were undertaken to standardize tech-

Table 37. Antifeedant activity of plant extracts against *pollu* beetle

Extract (1%)	Feeding deterrence (%)*
Annona squamosa seeds (H)	100.0
Annona squamosa seeds (M)	100.0
Melia composita fruits (H)	51.2
Melia composita fruits (M)	20.9
Polyalthia longifolia leaf (H)	55.8
Polyalthia longifolia leaf (M)	38.4
Zanthoxylum rhetsa fruits	0.0

*24 h after treatment; average of 4 replications
H=hexane extract; M=methanol extract

Table 38. High quality black pepper accessions from IISR Farm, Peruvannamuzhi

Accession	Bulk density (g/l)	Oleoresin (%)	Oil (%)	Piperine (%)
HP-1	488	11.6	3.6	3.7
HP-813	452	14.3	5.4	3.5
HP-1411	473	10.8	3.0	3.4
Acc.1365	486	10.7	2.8	3.5
OPKm	589	8.3	3.0	2.2
Sreekara	565	10.6	3.6	3.0

niques for drying of mace. Hot air drying of mace took 4 h while blanched (for 2 min in 75°C water) and dried mace required only 3.5 h for drying. The dry recovery of hot air dried and blanched mace were 37.8 and 37.1%, respectively.

Analysis of quality of dried mace showed that fresh mace had a lycopene content of 121.92 mg/100 g which after drying changed to 148.98 and 182.23 mg/100 g, respectively, for hot air dried and blanched mace. Blanched mace gave 23% more colour and more colour stability than hot air dried mace. Volatile oil and oleoresin contents of hot air dried and blanched mace were comparable.

Mace was stored in PET, polythene and polypropylene containers and the changes in quality characteristics like moisture content, volatile oil, oleoresin and lycopene contents were analysed. The moisture content increased during storage while volatile oil, oleoresin and lycopene contents decreased. After 3 months of storage, the lycopene content degraded by 68% to 86% in hot air dried mace and 66% in blanched mace (Table 41).

Table 39. High quality black pepper accessions

Accession	Volatile oil (%)	Oleoresin (%)	Piperine (%)
Acc. 5302	9.0	19.8	3.8
Acc. 5305	3.0	9.9	2.0
Acc. 983	3.2	9.0	2.3
Acc. 1216	3.6	9.3	1.5
Acc. 4081	4.0	11.0	2.9
Acc. 1382	3.0	9.9	3.2
Acc. 4021	4.3	12.0	2.7
Acc. 1633	5.8	13.0	2.8
Acc. 1622	3.0	9.3	3.0
Acc. 1058	8.8	17.0	3.0
P. II	4.9	13.3	3.4
Acc. 975	3.3	11.0	4.0
Acc. 1442	-	14.2	3.6
Acc. 1339	-	12.2	3.0
Acc. 845	3.0	11.3	2.8
Acc. 1095	5.0	11.5	2.2

Drying of Piper chaba

Drying of *Piper chaba* in hot air at 60 to 65°C at three stages of maturity indicated that it

Table 40. High quality ginger accessions

Accession	Essential oil (%)	Oleo-resin (%)	Crude fibre (%)
Acc. 11	2.0	7.2	2.5
Acc. 93	1.8	6.5	2.0
Acc. 156	2.2	6.7	2.5
Acc. 162	2.0	6.0	2.0
Acc. 197	2.5	7.0	2.8
Acc. 199	2.0	6.2	2.2
Acc. 225	2.0	6.2	2.5

took 9 h to attain a safe moisture level. The dry recovery at mature, ripe and over-ripe stages were 29.4%, 30.1% and 30.2%, respectively, compared to 71.8%, 71.6% and 71.4%, respectively in the fresh state. The moisture, oil and oleoresin contents in these stages were also estimated before and after drying (Table 42).

Drying of cassia

Sun drying and hot air drying (50°C) characteristics of cassia were studied. Sun drying was achieved in 1–2 days while hot air drying took just 3 h. The dry recovery of cassia after sun drying and hot air drying were 34.0% and 33.7%, respectively.

Aerated steam treatment of ginger

Ginger rhizomes infected with soft rot pathogens were treated using aerated steam at 46

Table 41. Quality characteristics of stored mace

Category	Moisture (%)	Volatile oil (%)	Oleoresin (%)	Lycopene (mg/100 g)
PET container + Hot air dried				
After 1 month	7.0	9.5	22.6	121.2
After 2 months	7.0	9.5	22.1	55.2
After 3 months	7.5	9.5	21.8	48.1
Blanched + Hot air dried				
After 1 month	6.0	11.0	22.1	180.6
After 2 months	6.0	11.0	21.6	119.0
After 3 months	6.5	10.0	21.6	62.1
Polythene bag + Hot air dried				
After 1 month	6.6	10.8	21.3	119.4
After 2 months	7.0	10.0	21.4	59.0
After 3 months	7.0	10.0	20.1	21.5
Blanched + Hot air dried				
After 1 month	6.0	11.0	22.1	180.4
After 2 months	6.5	11.0	21.5	139.5
After 3 months	6.5	10.0	20.6	62.8

Table 42. Quality characteristics of fresh and hot air dried *Piper chaba*

Category	Moisture (%)	Volatile oil (%)	Oleoresin (%)	Piperine (%)	Starch (%)
Fresh					
Mature	71.8	0.4	3.8	0.9	14.2
Ripe	71.6	0.4	3.5	0.8	18.1
Over-ripe	71.4	0.4	3.3	0.7	18.5
Hot air dried					
Mature	5.6	1.3	8.1	2.2	50.1
Ripe	5.7	1.3	7.1	2.2	50.3
Over-ripe	6.5	1.1	6.6	2.0	50.5

and 51°C for 15 and 30 min, for standardizing optimum conditions for treatment. After treatment, the rhizomes were treated with biocontrol agents (*Trichoderma* sp. and *Pseudomonas* sp.) and planted in the field and the plant population and yield were recorded. Aerated steam treatment at 51°C for 15 min was most effective in controlling the disease (Table 43).

Development of black pepper thresher

Two models of black pepper threshers (drum type and funnel type) were developed in collaboration with Tamil Nadu Agricultural University (TNAU), Coimbatore. The threshing capacities of drum type and funnel type threshers were 150 and 75 kg per hour, respectively with a threshing efficiency of 99.6% and 98.5%, respectively. Two commercially available models namely, Vivega hand-operated and Vivega power-operated threshers were also evaluated for their performance.

Development of black pepper cleaner cum grader

A rotary hand-operated cleaner cum grader was developed in collaboration with TNAU, Coimbatore. The thresher cleans pin heads and other small impurities and grades black pepper into three commercially available grades. The unit could clean and grade 430 kg of black pepper per hour.

Agr. XX (813)

Production of nucleus planting materials of improved varieties of spice crops

(*C. K. Thankamani, V. S. Korikanthimath, P. A. Mathew and S. J. Ankegowda*)

Black pepper rooted laterals (25,000 nos.), bush pepper (100 nos.), turmeric seed rhizomes (5 t), ginger seed rhizomes (5 t), cardamom seedlings (18,766 nos.), cardamom seed capsules (226.35 kg) and nutmeg grafts (6,000 nos.) were produced and distributed to farmers. These planting materials were produced under the Centrally Sponsored Scheme 'Integrated Programme for Development of Spices' of Department of Agriculture and Cooperation.

Table 43. Evaluation of aerated steam treatment of ginger rhizomes

Treatment	Population of ginger plants					Fresh yield
	22.7.01	22.8.01	22.9.01	22.10.01	22.11.01	(kg/3m² bed)
C	37	34	28	15	8	0.18
C + T	38	35	31	26	20	4.04
C + P	37	32	22	16	6	0.28
46°C /15 min	36	34	31	25	17	2.73
46°C /15 min + T	38	37	35	28	22	2.38
46°C /15 min + P	38	35	33	30	25	4.77
46°C /30 min	36	35	35	35	33	5.67
46°C /30 min + T	37	36	35	30	28	3.02
46°C /30 min + P	38	34	34	31	30	6.53
51°C /15 min	39	37	34	31	26	3.69
51°C /15 min + T	37	36	36	32	31	5.05
51°C /15 min + P	37	35	34	32	32	7.47
51°C /30 min	37	36	33	28	16	0.79
51°C /30 min + T	36	34	34	30	16	0.47
51°C /30 min + P	36	34	31	24	15	2.21

C=Control; T=*Trichoderma* sp.; P=*Pseudomonas* sp.

Externally Funded Projects

ICAR Cess Fund Project

Elucidation of biosynthetic pathways of curcumin in turmeric

(B. Chempakam and N. K. Leela)

Phenyl alanine lyase (PAL), the major enzyme which initiates a series of reactions leading to curcumin synthesis in turmeric was studied during early germination and growth phases. Leaves possessed highest activity among the vegetative parts analysed and least activity was observed in pseudostems. This indicates that leaves are probably the site of synthesis of curcumin precursors, which are mainly phenolic acids. An earlier study on PAL activity after 3 months up to maturity also confirmed this trend. Preliminary studies on cell fractionation of turmeric leaf and localization of PAL in each fraction indicated higher activity in the mitochondria. However, chloroplast and microsomes too had considerable amount of activity.

Studies on incorporation of $^{14}CO_2$ were continued which would give an indication of the origin of carbon atoms of curcumin. The effect of light on PAL activity was studied for manipulation under various environmental conditions.

HPLC separation of curcuminoids in turmeric root and rhizome indicated variations in the proportion of the three forms during development, with curcumin III (natural form of curcumin) having the maximum percentage. Curcumin III also showed an increase at 180–210 days after sowing (DAS) which declined at subsequent stages. However this decrease was compensated with a rise in levels of curcumin I (Bisdemethoxy curcumin) and II (Demethoxycurcumin). In roots, curcuminoids could be detected only after 90 DAS.

ICAR Emeritus Scientist Scheme

Integrated plant nutrient management strategy for breaking black pepper yield plateau and quality up gradation

(*A. K. Sadanandan*)

The effect of Integrated Plant Nutrient Management System (IPNS) in increasing nutrient availability in soil, crop uptake, yield and quality improvement in black pepper was studied in four major black pepper growing agro-ecological situations in Calicut, Wyanad (Kerala), Polibetta (Karnataka) and Pattiveeranpatti (Tamil Nadu) for two years.

Among the soil attributes, organic carbon and cation exchange capacity (CEC) were the most discriminating attributes in all the areas. Some of the soil quality factors were almost similar in Wyanad, Polibetta and Pattiveeranpatti.

The yield, spiking intensity and nutrient uptake by berries were maximum when inorganic N was applied at half the recommended dose and the balance N as organic form in conjunction with biofertilizers and micronutrients. Significant increase in leaf N status, for individual years as well as over the years, was observed due to the adoption of IPNS. Mineral fertilizer N level can therefore be economically scaled down to around 30% of the normal recommended dose in IPNS.

Bulk density of the soil decreased due to the adoption of IPNS. FYM application significantly decreased the bulk density, irrespective of the soils, indicating that bulk density of the soil is influenced by addition of organic matter. Adoption of IPNS decreased the incidence of *Phytophthora* disease over the years in all the areas.

Piperine and oleoresin contents were significantly increased due to the adoption of IPNS. In Calicut and Polibetta, maximum piperine and oleoresin contents were recorded when inorganic N was applied at half the recommended dose and the balance N as organic form supplemented with biofertilizers and micronutrients. However, in Wyanad and Pattiveeranpatti soils, maximum piperine and oleoresin contents were observed where FYM and inorganic fertilizers were supplemented with micronutrients.

NATP

Development and evaluation of soil-water conservation measures and land use systems for sustainable crop production in Western Ghats of coastal region

(*V. S. Korikanthimath and S. J. Ankegowda*)

Four field experiments namely, assessment of soil and water conservation measures in cardamom, system of planting for efficient utilization of rain water in cardamom, assessment of frequency and duration of irrigation in cardamom and assessment of soil and water conservation in coffee based multi-storeyed cropping system were initiated. The first three experiments were laid out in the Research Farm and the fourth in a farmer's field. Contour staggered trenches were opened in three experiments for soil and water conservation. Data on physical properties of soil were analysed. The pH ranged from 4.5 to 5.0 and bulk density ranged from 1.14 to 1.18. Soil nitrogen was in the range of 140–180 ppm, phosphorus 10–14 ppm, potassium 145–180 ppm, calcium 1100–1200 ppm and magnesium 85–150 ppm. Growth parameters such as plant height, number of tillers and number of leaves were also recorded. Soil moisture depletion and run off was recorded in the three experiments.

ICAR Cess Fund Project

Characterization of nutmeg germplasm for quality

(*B. Krishnamoorthy and T. John Zachariah*)

The nutmeg germplasm available in the germplasm conservatory at Peruvannamuzhi were characterized for quality. Thirty-six nutmeg accessions were evaluated for oil and its chemical profile. Essential oil in nutmeg varied from 3.9% to 16.5% and that in mace from 6% to 22%. The major components of significance in both the oils were α-pinene, sabinene, myrcene, myristicin and elemicin. Among the accessions screened, A9-71 and A9-95 were promising with high sabinene and myrcene and with low myristicin and elemicin. A9-18 contained 22.0% mace oil, 24.0% myristicin, 1.2% elemicin, 10.4% α-pinene and 21.8% sabinene in mace oil. The accessions had 16.5% nutmeg oil, 15% myristicin, 4.6% elemicin, 12.2% α-pinene and 35.6% sabinene (Tables 44 to 47).

Essential oil

Among the 36 nutmeg accessions evaluated, the essential oil content in nutmeg ranged from 3.9% to 16.5% (v/w) and was highest in A-9/18. Other accessions with high nutmeg oil were A-4/5 and A-11/12. In mace, the oil content ranged from 6.0% to 22.3% and was highest in A-9/18. The accessions A-9/18 and A-4/5 were relatively rich in both nutmeg and mace oils.

The major components of significance in both the essential oils were α-pinene, sabinene, myrcene, myristicin and elemicin. Accessions with high sabinene and myrcene coupled with low myristicin and elemicin are highly desirable for confectionery and perfume industry. Accessions which are rich in myristicin have potential application in pharmaceutical industry. A-9/18, A-9/4 and its progenies had high myristicin content in both nutmeg and mace. A-9/79 and A-9/18 had high myristicin and low elemicin in both nutmeg and mace.

NATP

Integrated technologies for value addition and post harvest management in palms, spices and tropical tuber crops

(*T. John Zachariah, P. Heartwin Amaladhas, B. Chempakam, N. K. Leela and S. Devasahayam*)

Storage of fresh ginger

A study was carried out to find out a suitable container for transportation and storage of fresh ginger rhizomes without dehydration. Fresh ginger samples were stored in polyethylene covers (with 0%, 2% and 5% ventilation), wooden box and in zero energy chamber. Zero energy chamber con-

Table 44. Nutmeg accessions with high myristicin and elemicin in nutmeg oil

Accession	Oil (%)	Myristicin (%) in oil	Elemicin (%) in oil	α-Pinene (%) in oil	Sabinene + Myrcene (%) in oil
A4-5	14.7	13.1	8.7	13.6	31.7
A4-12	8.7	4.5	12.1	9.3	34.0
A9-4	7.1	12.5	13.7	7.5	35.9
A9-4/10	7.4	12.4	12.1	6.5	38.3
A9-4/15	6.8	11.4	10.8	6.3	38.4
A9-4/16	8.2	16.4	15.5	7.6	24.0
A9-18	16.5	15.1	4.6	12.2	35.6
A9-30	5.5	1.5	15.5	15.8	32.6
A9-53	10.4	11.3	0.55	18.9	38.5
A9-66	6.9	0.6	11.8	9.3	34.0
A9-79	5.7	12.7	1.7	8.0	38.5
A9-86	8.7	6.3	11.8	9.3	37.1
A11-12	10.8	7.0	17.3	16.1	32.8

sisted of a double walled brick structure with lid, the space between the two walls being filled with sand that is frequently moistened with water.

Among the storage containers, polyethylene cover with 2% ventilation and zero energy chamber without any treatment were ideal. The samples stored in zero energy chamber retained the same dry recovery and volatile oil, oleoresin and fibre contents as that of the original sample without loss of moisture.

Storage of dry ginger

Evaluation of dried leaf powder of various plant species for prevention of infestation by cigarette beetle (*Lasioderma serricorne*) during storage of dried ginger rhizomes indicated that storage in leaf powders of *Glycosmis pentaphylla* and *Azadirachta indica* and in sealed PET containers were more effective.

NATP

Value addition and quality enhancement of selected spices

(*P. Heartwin Amaladhas, B. Chempakam and T. John Zachariah*)

Drying of black pepper

Drying characteristics of black pepper (Panniyur-1 and Karimunda and P-24) were studied by mechanical drying using 'agricultural waste fire batch type small holder's dryer' (developed by CPCRI, Kasaragod) and by sun drying. Sun drying took 4–5 days while mechanical drying took only 9 h to

Table 45. Nutmeg accessions with high myristicin and elemicin in mace oil

Accession	Oil (%)	Myristicin (%) in oil	Elemicin (%) in oil	α-Pinene (%) in oil	Sabinene + Myrcene (%) in oil
A4-11	17.9	15.9	0.5	15.6	29.4
A9-4	7.1	22.0	20.8	7.7	19.7
A9-4/10	11.5	21.4	17.3	8.5	22.0
A9-4/15	14.5	23.5	16.5	6.4	21.4
A9-4/16	13.5	19.1	16.6	9.6	21.0
A9-18	22.0	24.0	1.2	10.4	21.8
A9-28	12.0	4.1	21.0	8.4	28.4
A9-41	12.4	18.8	19.2	7.6	20.0
A9-79	7.5	20.5	1.8	6.3	28.0
A11-12	13.1	5.9	15.0	17.8	30.0

Table 46. Nutmeg accessions with low myristicin and elemicin in nutmeg oil

Accession	Oil (%)	Myristicin (%) in oil	Elemicin (%) in oil	α-Pinene (%) in oil	Sabinene + Myrcene (%) in oil
A4-11	9.9	3.30	0.69	15.0	39.4
A4-22	4.2	0.63	0.97	16.5	38.2
A9-53	10.4	11.30	0.55	18.9	38.5
A9-66	6.9	0.61	11.80	9.3	34.0
A9-71	6.3	1.90	0.80	4.1	45.0
A9-74	6.4	4.00	1.30	9.4	34.2
A9-95	8.0	3.30	1.60	8.7	45.9
A9-107	6.0	2.20	0.52	14.3	33.0

achieve complete drying. The quality in terms of volatile oil, oleoresin and piperine contents was not significantly affected by both the drying methods.

Preparation of white pepper

A refined method for preparation of white pepper by adopting the traditional pit method was evaluated. The pepper berries (green, semi-ripe and fully ripe) were placed in separate polybags and buried 60 cm below the soil and the soil surface was moistened every 3 days. At the end of 14 days, all the three categories of berries were con-

Table 47. Nutmeg accessions with low myristicin and elemicin in mace oil

Accession	Oil (%)	Myristicin (%) in oil	Elemicin (%) in oil	α-Pinene (%) in oil	Sabinene + Myrcene (%) in oil
A4-11	17.9	15.9	0.51	15.6	29.4
A9-30	11.2	1.3	12.40	15.0	29.4
A9-44	13.9	2.3	0.50	16.6	32.0
A9-69	7.5	9.4	1.10	4.7	29.4
A9-71	16.0	1.1	1.00	8.3	41.9
A9-74	12.1	2.0	0.40	15.4	37.4
A9-95	14.7	2.1	1.50	10.9	36.2
A9-150	10.3	0.8	4.00	18.4	33.5

verted to white pepper due to fermentation. The advantage of this method is complete conversion of fully ripe berries into white pepper. The quality and moisture percentage did not show any variation in comparison with the retting method.

Crop Protection

Crop Prot. I.1 (813)

Screening black pepper germplasm for reaction to diseases

(*S. S. Veena, M. N. Venugopal and K. V. Saji*)

One hundred and seventy one hybrids, 7 cultivars and 9 wild accessions were screened for their reaction to *Phytophthora capsici* through stem inoculation technique among which 4 cultivars, 2 wild accessions and 14 hybrids showed a tolerant reaction (Tables 48 and 49).

Table 48. Reaction of black pepper cultivars and wild accessions to *Phytophthora capsici*

Accession	Disease index	Lesion length (mm)
C-809	3.5	0.8
C-886	4.0	0.6
C-1204	3.5	1.3
C-1206	3.6	2.1
W-273	3.5	0.5
W-3356	3.5	1.1

Among the 4691 open pollinated seedling progenies of 3 hybrids (HP-728, HP-778 and HP-813) screened by root inoculation method, 5 seedlings remained healthy. These seedlings were replanted in fresh soil and the plants are being monitored. Fifty-four hybrids which showed tolerance to *P. capsici* in first round of screening were screened further to confirm their tolerance and 5 hybrids (HP-293, HP-400, HP-1372, HP-1375, and HP-

Table 49. Reaction of black pepper hybrids to *Phytophthora* capsici

Hybrid	Disease index	Lesion length (mm)	Hybrid	Disease index	Lesion length (mm)
HP-1751	3.8	2.9	HP-420	3.7	1.1
HP-427	4.0	1.8	HP-449	3.5	1.6
HP-421	3.6	1.0	HP-430	3.7	0.3
HP-437	3.8	0.4	HP-884	3.7	1.0
HP-840	3.8	0.4	HP-1789	3.6	4.0
HP-820	3.8	0.6	HP-1599	3.8	2.0
HP-375	3.8	1.1	HP-1654	3.6	5.0

1389) showed consistency in their reaction to *P. capsici*. Seven hybrids (HP-10, HP-34, HP-198, HP-359, HP- 664, HP-674, HP-1301 and HP-1628) were selected for third round of screening based on their reaction.

Eleven foot rot disease escape plants were collected from Gudalur (Chumala-3, Jeerakamundi-1), Idukki (Thevanmundi-1) and Kodagu (unidentified-6). Twenty-three disease escapes were screened against *P. capsici* and all succumbed to the pathogen.

Nematode tolerant lines of black pepper were screened against *P. capsici* and three accessions showed tolerant reaction (W-3299, C-204 and C-847).

Path. II.3 (813)

Disease management in *Phytophthora* foot rot affected black pepper plantations

(*S. S.Veena, M. Anandaraj, K. V. Ramana, V. Srinivasan and C. K. Thankamani*)

Sensitivity of Phytophthora capsici

The sensitivity of 29 isolates of *P. capsici* obtained from different parts of Kerala and Karnataka to potassium phosphonate was studied. The sensitivity was tested at four critical stages of the life cycle of *P. capsici*, namely, mycelial growth, sporulation, zoospore release and zoospore germination. The estimated ED_{50} and ED_{90} values for different isolates showed that there was a significant variation in the sensitivity of these isolates to the chemical (Table 50). Among the four stages of *P. capsici*, sporulation was the most sensitive stage to potassium phosphonate and mycelial growth was least affected.

Compatibility of pesticides

The *in vitro* and *in vivo* compatibility of *T. harzianum* (IISR-1369, a potential biocontrol agent) with fungicides and insecticides (Bordeaux mixture, copper oxychloride, potassium phosphonate, carbendazim, quinalphos, monocrotophos and dimethoate) used for management of pests and diseases of black pepper was studied. Potassium phosphonate did not show any deleterious effect on *T. harzianum* (*in vitro* up to 60 µg/ml and *in vivo* up to 1200 µg/ml). All the other chemicals showed adverse effect on growth and sporulation of *T. harzianum* and carbendazim and quinalphos exhibited maximum adverse effect.

Table 50. Variability in sensitivity of *Phytophthora capsici* isolates to potassium phosphonate

Stage of *P. capsici*	ED_{50} (μg/ml)	ED_{90} (μg/ml)
Mycelial growth	89.3–603.0	573.5–1635.2
Sporulation	0.3–36.3	2.1–129.3
Zoospore release	0.8–27.9	14.3–72.8
Zoospore germination	1.6–37.3	5.7–79.2

Rejuvenation of diseased gardens

The field trial consisting of 16 treatments (including effect of weeds, susceptible and tolerant lines, organic and inorganic nutrition, chemicals and biological control) was in progress. In general, the establishment, health and yield of vines were better in plots under clean cultivation compared to plots with weeds (Table 51). However, the population of *Trichoderma* sp. was higher in plots where weeds were retained (0.44×10^3–5.50×10^3 cfu/g soil) than plots under clean cultivation (0.27×10^3–13.00×10^3 cfu/g soil).

A new field experiment was initiated with the following treatments to study the efficacy of copper oxychloride applied alternating with *Trichoderma* sp.: 1. Copper oxychloride (COC) twice, 2. COC (first round) + Biocontrol agent (BCA) (second round), and 3. BCA twice. After first round of application, highest population of *Trichoderma* sp. was observed in the treatment BCA twice and after second round application, there was no significant difference in population of *Trichoderma* sp. between COC + BCA and BCA twice (Table 52).

A new observational trial was initiated to study the effect of solarization in the spread of foot rot disease. The growth of vines and number of leaves produced were highest in the plot where weeding and solarization was done (124.2 cm and 45.1, respectively) followed by clean cultivation (64.9 cm and 23.6) and the least was where the weeds were retained (51.1 cm and 20.4). The proliferation of *Trichoderma* spp. was more in solarized plots followed by plots with weeds and the least multiplication was observed in plots with weeding alone.

Effect of varietal mixtures

The establishment of vines ranged from 88.8% to 100.0% in the plot where *Piper colubrinum* and Karimunda were planted with *Phytophthora* tolerant lines. The population of *Trichoderma* ranged from 1.3×10^3 to 6.3×10^3 cfu/g soil. The establishment of vines ranged from 86.1% to 100.0% in the plot where biocontrol and chemical control were superimposed with different proportions of Karimunda and the plants exhibited yellowing.

Path. XII (813)

Investigations on stunted and phyllody diseases of black pepper

(*M. Anandaraj, S. Devasahayam, M. N. Venugopal and K. M. Abdulla Koya*)

Black pepper gardens in Kodenchery Village in Kozhikode District were surveyed for the incidence of phyllody disease. The disease ranged from 0% to 93% with an average of 23% (Table 53) (Fig. 4). The incidence of the disease was severe in areas adjacent to forests. Among the 12 species of insects recorded from diseased vines, two types of plant hoppers were consistently associated with diseased plants. A set of

Table 51. Rejuvenation of black pepper in diseased garden

Treatment	Establishment of vines (%)	Healthy vines (%)	Average fresh yield (g/vine)
With weeds			
SIC	94.4	94.5	266.9
SIB	80.5	97.3	278.9
SOC	86.1	97.3	177.8
SOB	80.5	91.7	330.3
TIC	91.6	94.5	123.1
TIB	91.6	88.9	64.3
TOC	97.2	88.9	150.9
TOB	88.8	94.5	107.2
Without weeds			
SIC	97.2	97.3	316.1
SIB	91.6	91.7	319.6
SOC	100.0	100.0	669.5
SOB	97.2	97.3	405.1
TIC	97.2	97.3	352.6
TIB	97.2	97.3	288.2
TOC	97.2	97.3	226.0
TOB	100.0	100.0	173.0

S=KS-27; T=P-24; I=Inorganic nutrition; O=Organic nutrition; C=Chemical control; B=Biological control

Fig. 4. Phyllody disease of black pepper

Phytoplasma specific primers were obtained and tested with phyllody affected samples. The bands obtained were faint and needs to be confirmed with fresh samples.

Path. X (813)

Investigations on vein clearing virus of small cardamom

(*M. N. Vengopal*)

Purification of virus

In order to identify propagation and indica-

Table 52. Effect of copper oxychloride applied alternating with *Trichoderma harzianum* for the management of foot rot of black pepper

Treatment	*Trichoderma* population (log cfu/g soil)		
	Before application	After I round of application	After II round of application
COC twice	3.303	3.487	3.870
COC + BCA	3.317	3.667	4.757
BCA twice	3.363	4.387	4.967
CD (P<0.05)	NS	0.275	0.328

COC=Copper oxychloride; BCA=Biocontrol agent

tor hosts of *kokke kandu* disease, both mechanical and vector transmission was tried using two isolates (Sirsi and Hongadahalla). Mechanical transmission was tried with borate buffer (pH 8.0) and potassium phosphate buffer (pH 7.5) using combination of antioxidants and abrasive. Six hosts namely, *Nicotiana tobacum* var. Harrison Special, *N. tobacum* var. Samson, *N. tobacum* var. Whiteburley, *N. glutinosa*, *Physalis* sp. and *Elettaria cardamomum* (var. CCS-1) were evaluated and no mechanical transmission was observed in any of the tested hosts. Vector transmission was tried with *Pentalonia nigronervosa* f. *caladii*, *P nigronervosa* f. *typica*, *Myzus persicae*, *Aphis* spp. and *Toxoptera* sp. Different periods of acquisition and transmission feeding was given on virus source and inoculants, respectively. However, no transmission was

Table 53. Incidence of phyllody disease black pepper in Kozhikode District

Village	Incidence (%) in various clusters			Mean
	a	b	c	incidence (%)
Nellipoyil-Meemutty	73.3	26.6	93.3	64.4
Nellipoyil-Mundoor	66.6	40.0	60.0	55.3
Kodenchery-Chembukadavu	93.3	13.3	73.3	59.9
Nellipoyil-Pathippara	-	-	-	-
Meemutty	20.0	-	-	8.8
Vattachira	33.3	60.0	86.6	59.8
Muttithode	40.0	-	-	13.3
Thiruvambady	-	-	-	-
Valanthode	-	-	-	-
Muthappanpuzha	-	-	-	-
Anakampoyil	-	-	-	-
Thiruvambady	46.6	-	-	15.5
Mean				23.0

observed in any of the inoculants other than main host even after 45 days of transmission. Two more protocols standardized for banana bract mosaic virus and badna virus were tried with two isolates of *kokke kandu* disease. No virus particles were observed in the protocol tried for potty virus and few isometric particles were observed in the purified preparations of leaf sheath of infected cardamom (Sirsi isolate).

Screening of germplasm

The third individual inoculation with Sirsi isolate of *kokke kandu* disease was undertaken and 11 accessions did not take infection through vector transmission. These 11 accessions, 11 *katte* resistant lines (APG-300, APG-303, APG-305, APG-306, APG-307, APG-308, APG-309, APG-310, APG-328, APG-331 and APG-333), 5 hybrids (APG-336, APG-340) and 9 open pollinated selections are under clonal multiplication for next phase of screening trials.

Path. XI (813)

Studies on bacterial wilt of ginger

(*A. Kumar and M. Anandaraj*)

Disinfection of seed rhizome

Solarization

A simple method was developed for disinfecting seed rhizomes of ginger infested with *Ralstonia solanacearum* by heating the rhizomes to 47°C using solar energy. Various trials were conducted to standardize the heating process, without affecting germination, by exposing the rhizomes to sunlight after packing them air tight in polythene bags. When these rhizomes were solarized during May a temperature of 60°C was recorded inside the seed rhizome at 1.00 pm, whereas the air temperature in the polythene bag was 51°C. Solarization for 2 h from 9.00 to 11.00 am, did not affect germination of sprouts. When artificially inoculated rhizomes were solarized for 2 and 4 h, the developing ginger plants were free from bacterial wilt disease, indicating the effectiveness of rhizome solarization as a method of disinfecting seed rhizomes of ginger (Table 54). When such rhizomes were tested for bacterium using NCM-ELISA, none of the treated rhizomes yielded positive reaction with Rs specific antibodies. This is the first report of disinfection of ginger from bacterial wilt pathogen using solar energy.

Table 54. Effect of rhizome solarization on germination and bacterial wilt incidence of ginger

Treatment	Germination (%)	Days to express wilting symptom	Disease incidence 4 months after planting (%)
No solarization	93.0 (76.0)a	80	33.8 (32.1)a
2 h of rhizome solarization from 9 to11 am	85.4 (69.0)b	110	0.93 (6.1)b
2 h of rhizome solarization from 10 am to 12 noon	82.0 (67.1)b	-	0 (4.5)b

Figures in parenthesis are angular transformed values

Figures followed by the same letter in a column are not significantly different in DMRT ($P < 0.05$).

Table 55. Effect of discontinuous microwaving of rhizomes on bacterial wilt incidence in ginger

Microwave treatment (sec)	Temperature (°C)	Disease incidence* after 120 DAP (%)
Unexposed	26	0.0
0	27	57.0
1 x 10 s	30	26.7
2 x 10 s	35	13.2
3 x 10 s	42	19.1
4 x 10 s	45	0.0
5 x 10 s	47	0.0

*Disease noticed after 45 days; DAP=Days after planting

Microwaving

Ginger rhizomes subjected to pulse microwaving involving 4–5 cycles of 10 s, with a pause time of 5 s between cycles confirmed the effectiveness of microwave disinfection in checking bacterial wilt incidence in ginger (Table 55).

Detection of pathogen in ginger

Studies were undertaken to develop a method for detection for *R. solanacearum* in ginger exploiting the poly-beta-hydroxybutyric acid (PBH) granules located in cytoplasm of bacterial cells. Nile blue is reported to selectively stain these granules, which in turn excites at 460 nm in epifluroscence microscope. In order to know the effect of nile blue on multiplication of bacterium, assays were done and the growth was determined spectrophotometrically. The constant absorbance value obtained for 0.001% to 0.006% nile blue amendments clearly indicated the non-toxic nature of nile blue at these concentrations. The cell thus multiplied in nile blue added medium was inoculated in plants to know its effect on pathogenicity of the cells. The inoculated plants succumbed to the disease after 8 days indicating the retention of virulence after nile blue labeling.

Thin sections made from inoculated plants were subjected to epifluorescence microscopy in order to know the retention of fluorescence in the labeled bacterial cells. It was observed that none of cells emitted orange fluorescence indicating the partitioning of nile blue concentration upon cell multiplication in xylem vessels. Experiments were also conducted to detect the movement of bacterial cells in the plant. Nile blue staining was performed on sections made from different plant parts. There was greater accumulation of cells in the base and middle of the pseudostem than the upper part of the plant indicating the effectiveness of this staining procedure in tracking the movement of bacterial cells in plant tissues.

Characterization of pathogen

Twenty-five strains of *R. solanacearum* were characterized using random and specific primers including Rep primers. RFLP-PCR technique was standardized to identify the bacterial wilt pathogen *R. solanacearum*.

Detection of pathogen in soil

In order to develop an assay system for detection of bacterial inoculum in soil, a simple technique based on staining of PHB granules of *R. solanacearum* was developed. It was observed that there was reduction in the population of cells in unsterile soil as compared to sterile soil where the cell number was found to be increasing, which could be due to absence of antagonism by native microflora of sterile soil. It was also noticed that small sized particles were fluorescing in the presence of nile blue. Considering the size and shape of fluorescing particles, this epifluorescence microscopy based detection assay can be adopted as a routine method in laboratories. When the wavelength of light was reduced to 330 nm, the *R. solanacearum* cells emited an unique fluorescence. The differential fluorescence can be exploited as a marker for the presence of bacterial wilt pathogen in soil.

Isolation of antagonists

The selectivity of nile blue staining and development of assay system for identification of antagonists against *R. solanacearum* was studied. Though the PHB granules are universal in prokaryotes, they are not likely to be stained by nile blue. In the present investigation, two of the candidate bacteria representing two genera, *Bacillus* and *Pseudomonas*, did not emit fluorescence after staining with nile blue. This information was exploited to study the antagonism between these bacterial genera and *R. solanacearum*. In the presence of these bacteria, the multiplication of *R. solanacearum* was significantly reduced indicating the antagonistic nature of *Bacillus* and *Pseudomonas* on *R. solanacearum*. This novel assay system could be exploited for large scale screening of antagonists against *R. solanacearum*.

Biocontrol I. 1 (813)

Biological control of diseases of spices

(*M. Anandaraj, A. Kumar and S. S. Veena*)

Field experiments to study the effect of biocontrol agents on *Phytophthora capsici* were continued and the populations of the biocontrol agent and the pathogen were monitored before and after application of biocontrol agents. The population of *Trichoderma* spp. ranged from 10^3 to 10^5 cfu/g soil in various treatments (Table 56). There was positive baiting in all the treatments indicating that the pathogen was active and many vines showed slow decline symptoms and succumbed to root rot.

The biocontrol agent is generally multiplied with sorghum as the base. Since the population of *Trichoderma* spp. did not multiply beyond 10^5 cfu/g soil, the population of microfauna was estimated in greenhouse trials. The results indicated that when sorghum based *Trichoderma* formulation is used, there was increase in populations of saprophytic mites and nematodes which probably affected the population of *Trichoderma* spp.

The taxonomic identity of 99 isolates of *Trichoderma* spp. was determined based on morphological characters. The isolates belonged to two sections namely, *Trichoderma* and *Longibrachiatum* and to seven species namely, *T. koningii, T. harzianum, T. longibrachiatum, T. citrinoviride, T. reeseii, T. parceramosum* and *T. atroviride*.

The biocontrol agents (30 *Trichoderma* isolates and 35 bacterial isolates) obtained from Silent Valley Biosphere Reserve, were screened for their ability to suppress *P. capsici* and the efficient isolates were short-listed for further studies. Some of the disease suppressing isolates also enhanced growth of black pepper plants in green house studies.

Nema. III (813)

Investigations on nematodes associated with spices

(*K. V. Ramana and Santhosh J. Eapen*)

Table 56. *Trichoderma* populations* where biocontrol agents and plant mulches were applied

Isolate	*Trichoderma virens*	*Trichoderma harzianum*	*Chromolaena odorata*
Glomus sp. Is.-1	4.8**	3.0**	2.5
Gigaspora gigantea Is.-1	2.8	4.2**	1.5
Glomus sp. Is.-2	1.3	1.5	0.8**
Gigaspora gigantea Is.-2	4.3**	0.8	2.6**
Glomus sp. Is.-3	4.2**	2.3**	1.7**
Glomus sp. Is.- 4	4.6	15.9	1.7**
Control	29.2	2.5	12.8

* x 10^3 cfu/g soil; **Presence of *Phytophthora*

Screening of germplasm

In a preliminary screening six accessions each of ginger and turmeric were screened against *Meloidogyne incognita*, and among them two turmeric accessions (Accs. 1 and 8) showed reasonably good resistance against the nematode. Another seven ginger (Accs. 26. 48, 73, 117, 202, 210 and 217) and eight turmeric (Accs. 21, 31, 35, 43, 67, 68, 78 and 91) accessions, which were rated as resistant lines in the preliminary screening, were evaluated under simulated field conditions; all the accessions continued to show their resistance to root knot nematodes.

Effect of organic amendments

Studies on effect of organic amnendments for nematode management were concluded. Incorporation of *Piper colubrinum* and *Strychnos nux-vomica* leaves in black pepper basins controlled nematodes and improved the yield of plants.

Genetic diversity in nematodes

Morphometrics of three root knot nematode cultures were carried out.

Crop Prot. I.3 (813)

Screening black pepper germplasm for reaction to nematodes

(*K. V. Ramana, Santhosh J. Eapen and K. V. Saji*)

Sixty black pepper germplasm accessions (cultivars-8, wild-17 and hybrids-35) were screened against *Radopholus similis* and six accessions (C-1204, W-254, W-348, HP-39, HP-47 and HP-532) showed resistance in the preliminary screening. Sixty-two black pepper hybrids were multiplied for screening against nematodes. Carrot cultures of *R. similis* and *Meloidogyne incognita* were maintained on their respective hosts as well as on coleus. Cultures of *Pratylenchus* spp. infesting ginger were also established.

Biocontrol I.3 (813)

Biological control of nematodes of spices

(*Santhosh J. Eapen, K. V. Ramana and A. Kumar*)

Screening of metabolities

Culture filtrates of 77 bacterial isolates were studied for their nematotoxic activity, among which 22 isolates caused >90% mortality while 40 isolates caused >50% mortality to root knot nematodes. Metabolites (volatile and non volatile) of 67 bacterial isolates were also tested for their nematicidal activities and the production of HCN and H_2S by these bacteria were monitored. Among the 98 isolates screened, only 6 isolates produced HCN. H_2S production was observed in another 6 isolates among the 50 tested.

Studies on PGPRs

Sixteen *Pseudomonas* spp. and 20 *Bacillus* spp. were isolated from the rhizosphere of nematode antagonistic plants and 4 unidentified bacteria were obtained from black pepper. Twenty and 52 rhizobacteria were screened under *in vitro* conditions against *R. similis* and *M. incognita*, respectively. Several isolates were highly effective against *M. incognita*, but very few showed promising results against *R. simlis*. Among the 84 isolates evaluated in a greenhouse trial, 21 caused 100% mortality to root knot nematodes. Another set of 15 promising rhizobacteria were tested for their antagonism on both *R. similis* and *M. incognita* in a greenhouse trial using black pepper cuttings.

Chitin based formulations of five promising rhizobacteria were tested against *R. similis* and *M. incognita* in a greenhouse trial. LS-255 and LS-260 caused maximum suppression of *M. incognita* and LS-255 and LS-256 were the best in controlling *R. similis*.

Scaling up of promising isolates

Among the four solid substrates evaluated for multiplication of *V. chlamydosporium*, sorghum was the best while starch water and coconut water were best among the liquid substrates. The optimum pH and temperature conditions for this fungus were 5 and 26°C, respectively.

Field trials with biocontrol agents

In the ongoing field trial at Pulpally (Wyanad District), *V. chlamydosporium* performed the best in improving the growth and yield of black pepper vines. Phorate treatment too caused a significant reduction in yellowing and improvement in the yield of black pepper vines. Another field trial was initiated at Peruvannamuzhi using four promising fungal biocontrol agents.

Inducing variability in* Verticillium *isolates

A laboratory study was conducted to understand the effect of various C and N sources on growth of *Verticillium* isolates. The results of the study showed that the most preferred C and N source were fructose and sodium nitrate, respectively. Copper oxychloride even at 2000 ppm did not inhibit the growth of one of the *V. chlamydosporium* isolates.

Ent. XI (813)

Bioecology and management of mealybugs infesting black pepper

(K. M. Abdulla Koya, S. Devasahayam and M. Anandaraj)

Distribution

Surveys were conducted in farmers fields in north eastern Kozhikode District, where black pepper is cultivated to a large extent, to study the distribution of root mealybug *Planococcus* sp. on the crop. The areas covered included Nellipoyil, Chembukadavu, Pathipara, Meemutty, Vattachira, Muthappanpuzha, Koorottupara, Thusharagiri, Nooranthode, Kakkadompoyil, Pannikuzhi and Poomaramthode. However, the pest infestation was not observed in any of the areas surveyed.

Life history

Studies on life history of root mealybug are under progress. The total life cycle from egg to adult took 21-25 days. The duration of various stages is being determined.

Management

Field trials were laid out in a farmer's field at Wyanad to evaluate the efficacy of four insecticides (quinalphos 0.075%, chlorpyriphos 0.075%, prophenphos 0.075% and malathion 0.075%) for the management of root mealybug on black pepper. The insecticide application was done during May and August and observations of incidence of root mealybug were carried out 30 days after second application of insecticide.

The trials revealed that all insecticides were effective in reducing the population of root mealybug on black pepper when compared to control. Among the various treatments, chlorpyriphos was the most effective and was on par with quinalphos. Combined analysis of data collected for 2 years also showed that all the insecticides were effective in reducing the population of root mealybug when compared to control. Chlorpyriphos was most effective and was found to be on par with quinalphos and prophenphos. The addition of wetting agent (Sandovit) did not increase the efficacy of insecticides.

Crop Prot. 1.2 (813)

Screening black pepper germplasm for reaction to insect pests

(K. M. Abdulla Koya and S. Devasahayam)

The germplasm collections of black pepper maintained at Peruvannamuzhi and black pepper somaclones at Chelavoor were screened for their reaction to *pollu* beetle (*Longitarsus nigripennis*) to identify sources of resistance against the pest.

Among the 187 cultivars and 34 hybrids screened at Peruvannamuzhi, none were found free of pest infestation, the range of infestation varying from 1.2% to 34.8% in cultivars and 3.7% to 10.4% in hybrids. All the somaclones were also infested, the pest infestation ranging from 41.0% to 54.5%.

Biocontrol I.2 (813)

Biological control of insect pests of spices

(S. Devasahayam, K. M. Abdulla Koya and T. John Zachariah)

Evaluation of plant products

The efficacy of capsicum extract that was found to possess appreciable antifeedant activity against *pollu* beetle (*Longitarsus nigripennis*) in laboratory bioassays was evaluated in the field at Peruvannamuzhi for the management of the pest. The extract was sprayed at 1% concentration at fortnightly intervals during July to October along with a wetting agent (Sandovit 0.1%). The present recommendation of spraying endosulfan 0.05% during July and October was also carried out. The trials indicated that capsicum extract was not effective in reducing the damage caused by *pollu* beetle to black pepper berries and the incidence of infested berries was on par with that of control.

Evaluation of entomopathogens

Seven isolates of fungi belonging to the genera *Penicillium*, *Fusarium*, *Aspergillus* and *Scopulariopsis* collected from spice ecosystems were evaluated for their pathogenicity in laboratory bioassays against root mealybug (*Planococcus* sp.) raised on pumpkins. The trials indicated that among the isolates, *P. citrinum* and *P. fumiculosum* were more promising resulting in 41.1% and 37.5% reduction in population of root mealybug, 21 days after treatment, when compared to control.

Management of shoot borer

A commercial formulation of neem product (Nimbicidine) was evaluated in the field at Peruvannamuzhi at 0.5 and 0.3% concentrations for the management of shoot borer (*Conogethes punctiferalis*) on ginger and turmeric. The neem product was sprayed at 15-day intervals during July to October along with a wetting agent (Sandovit 0.1%). The present recommendation of spraying malathion 0.1% during July to October at monthly intervals was also carried out. The trials indicated that on both ginger and turmeric, spraying of the neem product at 0.5% concentration was significantly superior in reducing the damage on the shoots when compared to control. However, the present recommendation of spraying malathion was the best treatment.

Pesticide residues in ginger

The pesticide residues in which the recommended package of practices for the management of shoot borer on ginger involving spraying of malathion 0.1% and monocrotophos 0.05% during July–October (4 sprays) and September–October (2 sprays) (along with pruning of infested shoots during July–August) was determined. The residues of malathion and monocrotophos were below detectable limits (<0.001 ppm) in dried ginger rhizomes at harvest under both the schedules of spraying.

Evaluation of repellent plants

Curcuma zeodaria (a related species resistant to shoot borer) was planted along with ginger in the border of the beds in the field at Chelavoor to evaluate its efficacy as a repellent crop for the prevention of infestation by shoot borer on ginger. However, the trials indicated that *C. zeodaria* was not effective in preventing the infestation of shoot borer on ginger.

Management of rhizome scale

Dried leaves of *Chromoleana odorata*, *Glycosmis cochinchinensis*, *Melia composita* and *Strychnos nux-vomica* were evaluated as storage material for the management of rhizome scale (*Aspidiella hartii*) on ginger during storage. The trials indicated that dipping of seed rhizomes in quinalphos 0.075% and storing in dried leaves of *S. nux-vomica* was more effective for obtaining higher recovery of rhizomes, higher number of sprouts and lesser incidence of rhizome scale.

Tritrophic interactions

Studies on host plant-insect pest-natural enemy interactions in ginger and turmeric indicated that the incidence of shoot borer was not significantly different on ginger and turmeric when these crops were grown individually and as mixed crops. The incidence of parasitism by hymenopterous parasitoids on shoot borer was also not significantly different in these crops.

Crop Prot. II (813)

Mechanisms of resistance to pests and pathogens in spice crops

(*M. Anandaraj, B. Chempakam, S. Devasahayam, Santhosh J. Eapen and T. John Zachariah*)

Resistance to Phytophthora capsici

Open pollinated progenies of black pepper varieties P-24 and KS-27 were screened for their reaction to *Phytophthora capsici*. The reaction ranged from hypersensitive to highly susceptible. The seedlings showing both the extremes were selected and are being multiplied to study the molecular basis of such reactions. For RAPD studies, 40 primers were screened and some of the primers showed differential amplifications and these are being utilized for RAPD work.

Resistance to pollu *beetle*

Pollu resistant lines were analysed for their biochemical characters. Phenols, total carbohydrates, reducing sugars and free amino acid content were significantly higher in *pollu* resistant lines (Tables 57 and 58).

The epicuticular wax content of susceptible and resistant black pepper lines were estimated and it was significantly higher in all the *pollu* resistant lines (Table 59).

Externally Funded Projects

ICAR Cess Fund Project

National Network Project on *Phytophthora* Diseases of Horticultural Crops

(*Y. R. Sarma and M. Anandaraj*)

Characterization of Phytophthora

Four hundred and seventy-two isolates of *Phytophthora* from different hosts were maintained in the National Repository of

Table 57. Biochemical constituents in leaves of *pollu* resistant and susceptible black pepper cultivars and wild *Piper* spp.

Category	Total carbohydrate (mg/100 g)	Reducing sugars (mg/100 g)	Phenols (mg/100 g)	Free amino acids (mg/100 g)
Susceptible (Cultivars)				
Panniyur-1	1.74	0.288	0.293	0.203
Karimunda	1.20	0.178	0.210	0.159
Resistant (Cultivars)				
Acc. 816	2.64	1.420	0.917	0.725
Acc. 841	5.08	1.610	0.979	0.268
Acc. 1114	4.76	0.839	0.625	0.274
Acc. 2070	3.15	0.744	0.670	0.241
Resistant (Wild Piper *spp.)*				
Acc. 1811	4.15	1.282	0.553	0.272
Acc. 1755	3.99	1.203	0.925	0.289
P. barberi	3.30	0.998	0.881	0.285

Table 58. HPLC analysis of free amino acids in *pollu* resistant and susceptible black pepper cultivars and wild *Piper* sp.

Amino acid (mg/100 g)	Panniyur-1 (Susceptible)	Acc. 841 (Resistant)	*Piper colubrinum* (Resistant)
Asp	99.67	54.71	Tr
Thr	360.50	380.90	51.39
Ser	179.80	141.80	64.16
Glu	19.87	30.75	Tr
Gly	28.35	Tr	16.60
Ala	Tr	Tr	349.50
Val	71.17	31.71	23.50
Met	22.58	44.92	Tr
Isoleu	38.57	21.04	15.80
Leu	27.75	32.70	12.10
Tyr	42.15	30.80	6.72
Phe	198.90	194.30	97.60
His	5.55	26.86	4.17
Lys	50.72	44.86	52.66
Arg	Tr	7.39	Tr

Tr=trace

Table 59. Epicuticular wax in *pollu* resistant and susceptible black pepper cultivars and wild *Piper* sp.

Category	Epicuticular wax (mg/100 g)
Susceptible (Cultivars)	
Panniyur-1	161.5
Karimunda	149.6
Resistant (Cultivars)	
Acc. 816	281.2
Acc. 841	338.3
Resistant (Wild Piper *spp.)*	
Acc. 1811	284.0
Acc. 1755	410.5
P. barberi	300.2
P. colubrinum	333.4
P. chaba	417.8

Phytophthora. *Phytophthora* isolates stored in sterile distilled water were viable up to 6 months. *Phytophthora* was isolated from new hosts (nutmeg, *Bauhinia* sp., *Vanilla* sp., tapioca and *Piper chaba*) for the first time. One hundred and seventy isolates of *Phytophthora* infecting black pepper were characterized morphologically. Among these, 159 isolates were *P. capsici*, 5 were *P. palmivora*, 3 were *P. parasitica* and another 3 were atypical isolates.

Fifty-two isolates of *Phytophthora* from betelvine were characterized morphologically. Among these, 39 belonged to *P. parasitica* and 13 to *P. capsici*. *P. capsici* and *P. parasitica* isolated from betelvine were characterized biochemically for their variability in isozyme (catalase, superoxide dismutase, esterase, malate dehydrogenase, malic enzyme and diaphorase) patterns. However, the banding patterns in catalase and esterase were inconsistent and were not included in the final analysis. Twenty-eight *electrophoretic types were isolated for 9 loci* across 4 enzyme system studied for 40 isolates. The West Bengal isolates formed a separate group and Jabalpur isolate 98.119 formed a distinct cluster from the other *P. parasitica* isolates.

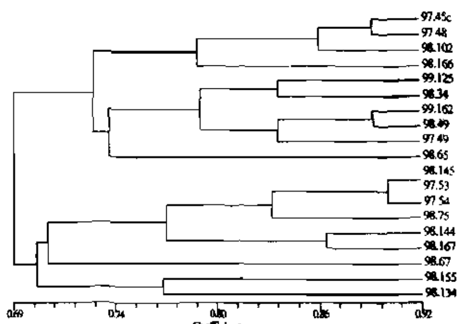

Fig. 5. UPGMA cluster analysis of *Phytophthora capsici* from black pepper

The variability among 19 black pepper isolates for 4 enzymes (superoxide dismutase, catalase, malic enzyme and glucose 6 phosphate dehydrogenase) was studied. The results indicated the presence of two groups, but there was no correlation between these groups and geographical distribution (Fig 5).

Protocols were standardized for DNA isolation and RAPD analysis of *Phytophthora* isolates from black pepper and cardamom. Among the 20 random primers tested, primer OPA-09 amplified a DNA (872 – 1353 bp) in foot rot tolerant cultivars of black pepper that was screened for RAPD analysis. Forty random primers were screened for *Phytophthora*. Among these, OPABA-3, OPAA-7, OPAB-4, OPAB-5, OPAB-7 and OPAB-8 showed multiple banding. In addition to this, ITS primers ITS6 and ITS4 were used to identify different species of *Phytophthora*. The primer sequence for ITS-6- 5 'GAA GG TGAA GTC GTAACAAGG3' and ITS 4-5 'TCC TCCG CTTATT-GATATGC3' were obtained from internet and the primers were synthesised by Bangalore Genei and PCR protocols were standardized. There was an amplified product of 862 bp which when digested with restriction enzymes such as MSP 1 revealed the presence of species banding pattern. The DNA from about 100 isolates have been isolated and stored for this study.

Evaluation of antagonists

Four hundred and seventy-three isolates of *Trichoderma* and other antagonists of *Phytophthora* were maintained in the Repository of Biocontrol Agents. Four *Trichoderma* species mainly, *T. harzianum* P-26 (TH), *T. virens* P-12 (TV), *T. aureoviride* P-25 (TAV) and *T. pseudokoningii* 4 (TPK) were applied alone and in various combinations in order to study their synergistic effect on growth promotion of black pepper plants and control of foot rot. The treatments, TH + TV, TAV + TPK, TH + TAV + TPK and TV + TAV + TPK promoted plant growth significantly. When challenge inoculated with *P. capsici*, significant reduction in mortality was observed with treatments of TAV, TH+TAV, TH+TPK, TH+TV+TAV and TH+TAV+TPK.

Protocols were standardized for isolation of protoplasts from *Trichoderma* sp. and their regeneration. Protoplasts of *T. harzianum, T. virens* and *T. aureoviride* were streaked on PDA amended with copper oxychloride and Ridomil MZ at 300, 500, 800, 1000 and 2000 ppm concentrations. Colonies that were able to grow at higher concentrations of fungicides were isolated. *T. virens* P-12 protoplasts tolerant to 300 ppm of copper oxychloride, and *T. aureoviride* protoplasts tolerant to 800 ppm of Ridomil and *T. harzianum* P-26 protoplasts tolerant to 500 ppm of Ridomil were obtained.

ICAR Cess Fund Project

Compatibility, stability and potential of biocontrol consortium on suppression of *Phytophthora* foot rot of black pepper and their conservation

(Y. R. Sarma, M. Anandaraj and A. Kumar)

Evaluation of biocontrol agents

Isolations of biocontrol agents were made from rhizosphere of black pepper and ginger and added to the biocontrol repository to make up a present strength of 789 isolates of PGPRs and 567 isolates of *Trichoderma*. These isolates were screened *in vitro* for antagonism against *P. capsici. Bacillus* spp. (IISR-398) and *Pseudomonas fluorescens* (IISR-51) could inhibit the growth of *P. capsici* up to 68%. The efficient isolates were tested in the greenhouse and *P. fluorescens* (IISR-396) and *Bacillus* sp. (IISR-398) protected black pepper plants from root rot up to 74.5% and 78.44%, respectively, after challenge inoculation with *P. capsici*. These strains could also reduce the pathogen population in the soil as indicated by decrease in disease potential index (DPI) from 32 to 8. The PGPR strains were tested for rejuvenation of infected black pepper cuttings and soil drenching followed by aerial spray with the bacterial strain was more effective in protecting the plants and *P. fluorescens* (IISR-52) rejuvenated infected black pepper cuttings by 68.5% over control. Two strains of *P. fluorescens* (IISR-51 and IISR-396) could also enhance the growth of black pepper significantly.

Basic studies on biocontrol agents

Antibiotic resistance markers in the PGPR strains facilitated studies on population dynamics and rhizosphere competence. *P. fluorescens* (IISR-51) was resistant to kanamycin (50 ppm), rifamycin (100 ppm) and nalidixic acid (40 ppm). The efficient strains were tested for phosphate solubilization potency and *P. fluorescens* (IISR-51 and IISR-396) could release 0.6 ppm of phosphate to the culture media from tricalcium phosphate. These efficient bacteria were also rhizosphere competent and colonized black pepper rhizosphere. The population of the introduced bacteria did not come down below 10^5 cfu/g of the rhizosphere soil and 10^6cfu/g of the root tissue, over a period of 30 days. In addition, they were found to be endophytic in black pepper and could be detected not only in the root system, but also in the shoot and leaf of the plant.

The biocontrol agents, fluorescent pseudomonads and *Trichoderma* spp. were compatible and induced *Phytophthora* wall degrading enzymes such as lipases, β-1,3 glucanases and β-1,4 glucanases in culture.

DBT Project

Immunological approaches for pathogen detection and use of defence proteins in disease management in plantation crops: ginger and cardamom

(*Y. R. Sarma, A. Kumar, B. Sasikumar and M. N. Venugopal*)

Development of immunokits

Polyclonal antibodies were developed against membrane protein (42.3 kDa) specific for biovar III of *Ralstonia solanacearum* (bacterial wilt pathogen of ginger) as well as heat and glutaraldehyde-treated *R. solanacearum* cells and their dilution end point was determined to be 1: 50000.

Survival of Ralstonia solanacearum

Serological studies on survival of *R. solanacearum* in seed rhizomes of ginger and the status of rhizomes upon storage at different temperatures revealed multiplication of the bacterial cells resulting in complete rotting of rhizomes when stored at 28–30°C (room temperature) and 37°C for 30 days of storage. At temperatures of 4°C and below there was no multiplication of *R. solana-cearum* when compared to high temperatures (15°C and above) as revealed by the absorbance value at 405 nm. However, throughout the study period, minimum number of bacterial cells were recorded in rhizomes stored at -80°C, -30°C and -20°C. The study confirms that storage at 4°C may not be useful to eliminate the pathogen from planting material like rhizomes. However, storage temperatures of 0°C and 4°C can be exploited for maintaining the viability of infected rhizomes without any further spoilage.

Enrichment of Ralstonia solanacearum

In order to design a selective medium for enrichment of *R. solanacearum*, the intrinsic antibiotic resistance of the bacterium was determined and it was observed to grow in a mixture of antibiotics such as Ampicillin, Chloramphenicol, Penicillin, Polymixin B - sulphate, Bacitracin and Cycloheximide. Sucrose peptone medium was modified by incorporating the above antibiotics for selective isolation and enrichment of *R. solanacearum* for post enrichment ELISA.

The composition of the new selective medium for *R. solanacearum* is as follows: sucrose (20 g), peptone (10 g), K_2HPO_4 (0.5 g), Mg SO_4 $7H_2O$ (0.25 g) in 1 l of distilled water at pH 7.2. The medium is cheap and involves the following antibiotics: Ampicillin (5 µg/ml), Chloramphenicol (5 µg/ml), Penicillin (1 µg/ml), Cycloheximide (50 µg/ml), Polymyxin B-sulphate (25 µg/ml), Bacitracin (25 µg/ml), Crystal violet (5 µg/ml) and Tetrazolium chloride (10 µg/ml).

Induction of defence proteins

By pathogen

Two month old ginger plants were artificially inoculated with *R. solanacearum* and tissue samples were taken from roots, leaves, rhizomes and pseudostems at different time intervals and electophorated in SDS PAGE. Protein with molecular weight of 14 KDa was observed in root samples taken 4, 24 and 48 h after inoculation (HAI) and a protein with molecular weight of 38 KDa could be noticed in roots 4 HAI. No induction was noticed in other tissues beyond 4 h. The accumulation of protein declined beyond 4 h. This protein could probably play a role in the initial colonization of the bacterium in the roots.

By elicitors

Ginger cells in suspension cultures were exposed to varying concentrations (50, 100, 150, 200 and 250 µg/ml) of two plant elicitors namely, BD and CASRIP (courtesy: Prof. H. N. Verma , Lucknow University). The extracted total proteins is being analysed.

Development of transgenic plants

Transformation of ginger and cardamom for constitutive expression of glucanase and chitinase was performed using vector pBZ100, driven by CaMV 35 S promoter. The infected calli is under the first round of selection for obtaining possible disease tolerant plants of ginger and cardamom.

The selected cardamom callus (infected with osmotin construct pGV 2260) failed to regenerate during the subsequent stage. None of the ginger calli infected with this construct could survive in the first round of selection.

ICAR Cess Fund Project (Final Report)

Biological control of plant parasitic nematodes of major spice crops

(*K. V. Ramana and Santhosh J. Eapen*)

Identification of biocontrol agents

Soil and root samples (121 numbers) were collected from rhizospheres of black pepper, cardamom, ginger and turmeric through random surveys undertaken in seven districts of Kerala and six turmeric samples were collected from Andhra Pradesh. Bacteria (251 isolates) and fungi (79 isolates) were isolated from these samples using standard methods. The rhizosphere of black pepper, ginger and turmeric yielded 172, 42 and 37 isolates of bacteria, respectively. The rhizosphere of black pepper, cardamom, ginger and turmeric yielded 20, 3, 49 and 23 fungal isolates, respectively.

Forty-five of the fungal isolates were identified based on morphological characteristics in consultation with Centre for Advanced Studies in Botany, University of Madras, Chennai. The isolates belonged to *Trichoderma* spp., *Aspergillus* spp., *Verticillium* spp., *Paecilomyces* spp., *Fusarium* spp., *Scopulariopsis* spp. and *Humicola* spp. The bacterial isolates were maintained at –80°C in 20% glycerol for long-term storage. The fungal cultures were stored in potato carrot agar medium or liquid paraffin.

Screening for nematicidal activity

The initial screening of fungal isolates was done *in vitro* by standard protocols namely, hatching suppression and egg parasitization. Among the 79 isolates tested, 19 isolates caused more than 80% hatching suppression while 24 isolates showed good parasitization of nematode eggs. Seven isolates (*F. oxysporum* (Is. 11), *Scopulariopsis* sp. (Is. 14), *V. chlamydosporium* (Is. 31, 32 and 34), *V. lecanii* (Is. 35) and *P. lilacinus* (Is. 36) had a very high inhibitory effect (>90%) on egg hatching while another 10 isolates suppressed egg hatching by more than 80%. *Aspergillus* spp. (Is. 2, 7, 10 and 49), *Fusarium* spp. (Is. 11 and 13), *Scopulariopsis* sp. (Is. 14), *Scolicobasidium* (Is.15), *Trichoderma* spp. (Is. 16, 25, 33 and 56), *V. chlamydosporium* (Is. 31, 32, 34 and 57), *V. lecanii* (Is. 35), *Paecilomyces* spp. (Is. 20, 27 and 36), *Gliocladium* sp. (Is. 40 & 41) and *Drechleria* sp. (Is. 44), showed good parasitization of root knot nematode eggs. Thermostable toxic metabolites in culture filtrates of *V. chlamydosporium* (four isolates), *V. lecanii* and *P. lilacinus* (one isolate) showed significant effects on egg hatching and mortality of juveniles of root knot nematodes.

The bacterial isolates (99 numbers) were screened initially by employing the buffer method to assess their nematode suppressing ability. Most of the bacterial isolates caused very less mortality of nematodes. Based on their efficacy, 30 bacterial isolates were selected for further *in vitro* evaluation using different methods like culture filtrate assay, direct assay of bacterial suspension and assay of volatile and non-volatile metabolites, and promising isolates were identified.

Evaluation of nematode antagonists

P. lilacinus (Is. 36), *F. oxysporum* (Is. 11) and *A. tamarii* (Is. 2) were studied separately in three different experiments using tomato as the test plant. All the fungal isolates significantly suppressed nematode population in both soil and roots and hence can be used as potential biocontrol agents. However, among the three fungi tested, *P. lilacinus* was noteworthy as it had profound effect on the growth of tomato plants (Table 60).

In another greenhouse trial using four fungal biocontrol agents (*F. oxysporum* - Is. 11, *A. tamarii* - Is. 2, *V. chlamydosporium* - Is. 32 and *Trichoderma harzianum* - Is. 33), none of the isolates had any significant positive or negative effects on growth and yield of root knot nematode infested ginger. However, *V. chlamydosporium* caused a slight improvement in growth of ginger plants even in the presence of root knot nematodes.

Seventy-five bacteria were tested in four different experiments for their ability to control nematodes. In Experiment-1, among the 12 bacterial isolates used, 8 isolates caused significant increase in height of plants over control and Is. 13 resulted in maximum height. Seven isolates caused significant increase in shoot weight. All the tested isolates resulted in significant nematode suppression and maximum suppression was obtained with Is. 13. This isolate was very effective, both in promoting the growth of tomato plants and in nematode suppression. In Experiment-2, where 18 isolates were used, three isolates were effective in increas-

Table 60. Effect of *Paecilomyces lilacinus* on growth and nematode multiplication in tomato plants

Treatment	Fresh weight (g/plant)		Shoot length (cm)	No. of egg masses	No. of galls	Gall index	Re-isolation of Pl
	Shoot	Root					
Control	29.56c	5.26c	24.00a	0.00c	0.00c	0.00d	-
RKN	31.19c	17.05a	23.33a	77.95a	67.46ab	4.00a	-
Pl	44.11a	10.07b	26.00a	00.00c	00.00c	0.00d	9.2×10^6
RKN + Pl	40.38abc	8.96b	24.33a	47.18ab	91.49a	3.00b	8.7×10^6
RKN > Pl	32.60bc	7.16bc	20.31a	31.46abc	35.39abc	1.67c	2.2×10^6
Pl > RKN	42.34ab	9.96b	28.00a	10.66bc	6.44bc	1.00c	6.6×10^6

Values indicate means of 3 replicates
Figures followed by the same letter in a column are not significantly different in DMRT ($P<0.05$)
RKN=Root knot nematode; Pl=*Paecilomyces lilacinus*

ing the height of the plants significantly over control and none except Is. 84 could induce significant increase in total biomass.

In Experiments 3 and 4, where 9 and 21 isolates were used, respectively, none of them caused any improvement in plant growth characters. However, all the isolates caused significant reduction in nematode development and 100% nematode suppression was obtained with three isolates (Is. 113, 117 and 123). Therefore, it can be summarized that rhizobacteria belong to different categories like growth promoters, nematode antagonists and some have both the capabilities.

Evaluation of biocontrol agents

Isolates of *V. chlamydosporium* (Is. 31 and 32), *Trichoderma* spp. (Is. 25 and 56), *Penicillium* sp. (Is. 4), *V. lecanii* (Is. 35), *P. lilacinus* (Is. 36), *F. oxysporum* (Is. 11), *Scopulariopsis* sp. (Is. 14) and *Aspergillus* spp. (Is. 10) were selected based on their *in vitro* performance and evaluated in three field experiments on ginger and turmeric. None of the treatments resulted in significant change in the number of tillers of turmeric and ginger whereas the height of the plant increased significantly compared to control on treating with the biocontrol agents (Table 61). Though the fungal inoculation had resulted in increase in yield of ginger and turmeric, a significant change could only be observed in turmeric with the inoculation of *F. oxysporum*. All the fungal biocontrol agents evaluated except *Penicillium* sp., *Scopulariopsis* sp., *Aspergillus* sp. and one isolate of *Trichoderma* sp., proved their efficiency significantly in suppressing root knot nematode population. However, complete suppression of root knot nematodes could be achieved only by application of *F. oxysporum*.

Mass multiplication of biocontrol agents

Among the four synthetic chemical media evaluated for culturing *V. chlamydosporium*, Czapek Dox Agar (CDA) was the best for sporulation of the fungus. Evaluation of solid substrates for mass multiplying promising fungi showed that both rice and ginger shoot powder supported very good sporulation and multiplication of *P. lilacinus* and *A. tamarii*. *A. tamarii* multiplied well on tea waste too. Ginger shoot powder is an ideal carrier substance as it is light in weight and easily available as an agricultural waste in ginger fields. Among the various liquid substrates evaluated for mass multiplication of *V. chlamydosporium*, the highest mycelial production was observed on starch medium followed by coconut water. Very little mycelial mass was produced in media containing molasses and there was no mycelial yield from media containing vermi-wash. Large scale multiplication of the above fungus was done by liquid fermentation using PDB broth as the substrate. The yield of the fungus correspondingly increased with increase in incubation period.

Ecology of biocontrol agents

Studies were also conducted to determine optimum pH and temperature conditions for growth of promising fungal biocontrol agents. Maximum growth of *Trichoderma* sp. (Is. 33) was at pH 4 and another isolate of *Trichoderma* sp. (Is. 56) was at pH 5. Is. 33 showed adaptation to a wide range of pH (4–7) while Is. 56 showed adaptability to pH ranging from 4 to 6. *Fusarium* sp. showed more adaptability to higher pH (>6). Similarly, growth of *Fusarium* sp. (Is. 11) was maximum at pH 6. pH 5 can be considered as the optimum pH for the growth of *V.*

Table 61. Evaluation of fungal biocontrol agents against root knot nematodes in the field

Ginger-Chelavoor

Treatment	No. of tillers	Height of plant (cm)	Fresh yield (kg/bed)	Nematode population (per g root)			
				Eggs	Juveniles	Females	Total
T (Is. 25)	7.47a	50.17a	2.01a	0.00b	0.00b	0.00a	0.00b
P (Is. 4)	7.98a	48.01a	2.08a	10.06ab	6.00ab	0.46a	16.52 ab
V (Is. 35)	7.70a	49.71a	2.14a	0.46b	0.00b	0.00a	0.46b
T (Is. 56)	7.13a	48.89a	2.49a	4.24ab	4.75ab	0.46a	9.45ab
Vc (Is. 31)-bed	7.44a	47.94a	2.37a	0.67b	0.00b	0.00a	0.67b
Vc (Is. 31)-seed	8.94a	47.70a	2.48a	2.97ab	3.02ab	1.32a	7.31ab
Control	6.56a	46.83a	1.71a	51.48a	24.64a	0.00a	76.12a

Ginger-Peruvannamuzhi

Treatment	No. of tillers	Height of plant (cm)	Fresh yield (kg/bed)	Nematode population (per g root)			
				Eggs	Juveniles	Females	Total
Pl (Is. 36)	6.01a	73.42b	5.50a	0.46b	1.33c	0.00a	1.79b
Fo (Is. 11)	6.07a	70.45c	7.25a	3.03b	2.13bc	0.00a	5.16b
S (Is. 14)	6.84a	75.76a	7.75a	10.11ab	26.93ab	0.46a	37.50ab
A (Is. 10)	6.06a	74.37ab	6.50a	7.33 ab	2.13bc	0.46a	9.92b
Vc (Is. 32)	6.15a	70.19c	5.00a	3.58b	1.14c	0.00a	3.72b
Control	5.94a	71.57c	6.50a	66.92a	126.93a	0.46a	194.31a

Turmeric-Peruvannamuzhi

Treatment	No. of tillers	Height of plant (cm)	Fresh yield (kg/bed)	Nematode population (per g root)			
				Eggs	Juveniles	Females	Total
Pl (Is. 36)	2.24a	129.13c	12.76ab	5.54b	0.00b	0.46b	6.00b
Fo (Is. 11)	2.14a	134.43a	15.73a	0.00b	0.00b	0.00b	0.00b
S (Is. 14)	2.06a	133.04b	12.55ab	8.20ab	1.45b	1.60ab	11.25ab
A (Is. 10)	2.06a	134.49a	13.55ab	10.02ab	6.07ab	0.00b	16.09ab
Vc (Is. 32)	2.35a	134.64a	13.24ab	3.23b	8.09ab	0.00b	11.32ab
Control	2.38a	118.35d	11.16b	158.59a	61.66a	6.93a	227.18a

Figures followed by the same letter in a column are not significantly different in DMRT ($P<0.05$)
T=*Trichoderma* sp.; P=*Penicillium* sp.; A=*Aspergillus* sp.; S=*Scopulariopsis* sp.; Fo=*Fusarium oxysporum*; Vc=*Verticillium chlamydosporium*; Pl=*Pacilomyces lilacinus*

chlamydosporium. The optimum temperatures for growth and multiplication of *T. harzianum* (Is. 33) and *P. lilacinus* (Is. 36) were between 25°C and 30°C while that of *V. chlamydosporium* (Is. 34) was 25°C. Further studies revealed the exact temperature requirement of *V. chlamydosporium* (Is. 34) as 26°C.

The compatibility of the fungal biocontrol agents *Trichoderma* sp. (Is. 33), *Verticillium* sp. (Is. 34) and *Paecilomyces* sp. (Is.36) with metalaxyl mancozeb, potassium phosphonate, phorate and chlorpyriphos was studied by poisoned food technique. Potassium phosphonate and insecticides like phorate and chlorpyriphos at recommended levels did have adverse effect on these biocontrol agents. However, metalaxyl at all concentrations reduced growth and sporulation of all the fungi.

Social Sciences

Econ. I (813)

Economics of spices production and marketing

(*M. S. Madan*)

Economics of cultivation

Surveys conducted in Kerala and Karnataka indicated marked increase in cost of production of major spice commodities. Production of black pepper was profitable with a benefit-cost ratio of 1.9. However, both ginger and turmeric growers faced benefit- cost ratio of <1 because of drastic price fall. Surveys in spice nurseries indicated poor demand for black pepper, ginger and turmeric planting materials, while there was an increased interest among farmers for vanilla cultivation. The status of spices production in Andhra Pradesh and Kerala were analysed and policy implications brought out.

Data on production and marketing

Data on various aspects of production, productivity, markets, market prices, arrivals, auction prices, wholesale and retail prices in the domestic market and spot prices for spices in international markets were collected and tabulated for preparation of a database.

Digitized database

A 'Spice Database', that was developed was integrated with NATP on 'Integrated National Agricultural Resources Information System (INARIS)'. The data from the database were tabulated and analysed to bring out useful interpretations. The strengths and weaknesses of Indian spice industry in general and black pepper and cardamom in particular were analysed in the context of free trade in the world market.

The present scenario of spice production and marketing and price behaviour were analysed to know the opportunities in the light of WTO impact. The trend in area and production, change in productivity due to change in technological inputs and developmental activities, price trends and impact of international prices on domestic price were worked out using time series data.

Economic evaluation of technologies

The cost of production of rooted black

pepper cuttings following the bamboo and pit methods were worked out to know the economic viability of the technologies. The cost of black pepper cuttings produced through bamboo method was much costlier than the pit method, which is more suitable for small and medium farmers. The improved technologies being popularized under Pepper Technology Mission were evaluated for their economic viability.

Ext. IV (813)

Training of research and extension workers

(P. Rajeev and M. S. Madan)

Two regular institute training programmes one each on 'Spices Production Technology' and 'On-farm Processing of Spices' were organised. Four on-demand training programmes on 'Spice Production Technology' were also conducted in which 59 trainees participated.

Externally Funded Projects

NATP

Integrated Agricultural Resources Information System

(M. S. Madan)

A requirement analysis workshop was carried out to identify the relevant parameters to be included in the Geographical Indexing System (GIS) database that is being created under the project. A brain storming session on 'Digitization of Database on Plant Protection for Spice Crops' was conducted to identify the requirements to create a sub-database on plant protection. A national level workshop on 'Codification of Crop Resources' was conducted to decide the code numbers to be used for the parameters to be included in the 'National Data Warehouse'. A database software 'Spice Database' was created to store product and market statistics components of the proposed database for spices. Relevant statistical information for the database is being collected and tabulated. Primary bench mark surveys (one each in Kerala and Karnataka) were conducted to validate secondary data in the database.

NATP

Agricultural Technology Information Centre

(P. Rajeev)

Information dissemination

The queries of farmers through post or as personal visits to Agricultural Technology Information Centre (ATIC) were monitored and recorded in coordination with other divisions of the institute. The publications of ATIC including a technical bulletin on 'Spices Production Technology', pamphlets on crop management of seven major spices and four folders on specific technologies were distributed to farmers. The sale of all institute publications was also monitored through ATIC. Publications worth Rs. 21,440/- were sold during the year. The Centre organised two exhibitions in connection with the Silver Jubilee celebrations of the institute during October 2001.

Input delivery

A demonstration nursery of black pepper with an annual production target of 20,000 single nodded rooted cuttings using rapid multiplication method is being maintained at the ATIC. Rooted cuttings worth of Rs. 50,000/- were distributed to farmers.

Audio-visual aid support

A video film highlighting the achievements of the institute on completion of 25 years of service was released in connection with the Silver Jubilee celebrations of the institute during October 2001. Filming of two more short documentaries on cultivation of black pepper and ginger is in progress. An exhibition hall (Technology Park) depicting the research and development activities of the institute has been set up in the ATIC building.

DBT Project

Distributed Information Sub-Centre

(*Santhosh J. Eapen*)

Infrastructure

The Bioinformatics Centre was shifted to the main building of the institute during October 2001. New facilities like 64 kbps leased line connection were established for uninterrupted internet connectivity.

Institute web site

A new web site (www.iisr.org) of the institute was developed and launched during October 2001.

Databases and softwares

Spice Genes Part I, a database on germplasm resources of black pepper was brought out in CDs. An online version of the database is available on the net. Other databases like 'Spice Prop' and 'Spice Bibliography' are also available online.

Training

The Centre organized a 3 day training programme on 'Internet and Web Designing' during 21–23 November 2001 in which 13 participants participated. A 3 day training programme on 'Internet in Biological Research' was held during 16–18 January 2002 that was attended by 11 participants.

Government of Kerala Project

Technology Mission on Black Pepper

(*Y. R. Sarma, V. Srinivasan, B. Sasikumar, C. K. Thankamani and S. S. Veena*)

The research programmes under Technology Mission on Black Pepper were initiated during 1999 with seven multidisciplinary research projects. All the projects are being implemented in farmers fields located in the four northern districts of Kerala namely, Kozhikode, Wyanad, Kannur and Kasaragod.

In all the districts surveyed, Karimunda (44%) followed by Panniyur-1 (17.9%) was the most popular cultivar/variety grown. Only 2% of the surveyed areas were occupied by other released varieties. Various released varieties, local varieties and eight new promising lines are being evaluated in farmers fields (at least three farmers fields in a district) to study location x genotype interactions. In order to study the low input responsive varieties, separate trials involving elite lines/released varieties with half the recommended dose of package of practices (½ POP) and no fertilizers were also laid out in at least one farmer's field in each of the four selected districts.

Survey of fertilizer application for black pepper revealed that 32% of the farmers apply fertilizers. Trials on organic farming and low input technology for black pepper were also laid out in all the districts. Analysis of pre experimental soil samples for major, secondary and micronutrient status revealed that soils of Kannur and Kasaragod districts showed low levels of phosphorus and the Zn level was at critical concentration in all the districts. The available trend from the first year results indicated that providing black pepper vines with 50% N as FYM + 50% N as inorganic + phosphobacteria or biofertilizers have yielded better and under low input technology treatments, ½ POP + $ZnSO_4$ application was ideal for obtaining higher yields.

Experiments were laid out in all the districts for the management of *Phytophthora* in the nursery and field. The treatment comprising of soil solarization + biocontrol agents + systemic fungicides was compared with the existing management practice of application of copper fungicide. The initial results indicated that the integrated strategy gave better protection of black pepper vines against *Phytophthora* infections in the field.

Technology Assessed and Transferred

Management of root mealybug of black pepper

The root mealybug (*Planococcus* sp.) is a serious insect pest of black pepper especially in Wyanad District of Kerala. The pest infests the basal portions of stems and roots of black pepper vines in the field and rooted cuttings in the nursery causing yellowing and wilting of leaves, drying of lateral branches and mortality of young vines. The pest infestation can be controlled by drenching the affected vines during initial stages of infestation with chlorpyriphos 0.075%. The drenching has to be repeated after 30 days if the infestation persists.

Management of nematodes of black pepper

Root knot nematodes (*Meloidogyne* spp.) cause significant damage to black pepper vines in South India and are currently being managed through application of nematicides like phorate and carbofuran. *Verticillium chlamydosporium*, a facultative nematode parasite, parasitizes egg masses and sedentary females of root knot nematodes. Application of *V. chlamydosporium* with a spore load of around x 10^6 (@ 50 g/vine) to the rhizosphere soil twice a year (pre and post monsoon) is effective for the management of root knot nematodes when integrated with other methods. The fungus multiplies well on rice and sorghum grains and starch/ coconut water amended solid substrates. Pesticides like phorate, chlorpyriphos and potassium phosphonate are compatible with the fungus.

Education and Training

Training programmes

Isotope Techniques for Water Management, Centre for Water Resources Development and Management, Calicut, 12–16 February 2001 (C. K. Thankamani).

MS Office I and II, Indian Agricultural Statistical Research Institute, New Delhi, 11–23 June 2001 (C. K. Thankamani).

IPR and WTO Awareness Training, Hyderabad, 10–12 July 2001 (B. Sasikumar).

Micropropagation of Horticultural and Forestry Species, Regional Plant Resources Centre, Bhubaneswar, 3–23 September 2001 (D. Prasath).

Advanced Training in Gas Chromatography, Perkin Elmer, Mumbai, 17–19 October 2001 (T. John Zachariah).

IX Refresher Course in Chemistry, University of Calicut, Calicut, 15 November–15 December 2001 (N. K. Leela).

Internet and Web Designing, Indian Institute of Spices Research, Calicut, 21–23 November 2001 (J. Rema).

Water Quality Monitoring Technique, Centre for Water Resources Development and Management, Calicut, 11–14 December 2001 (S. Hamza).

Trainers Training Programme on Plant Genetic Resources Management, New Delhi, 8–31 January 2002 (J. Rema).

Application of Internet in Biological Research, Calicut, 16–18 January 2002 (S. Devasahayam, C. K. Thankamani).

Management Development Programme on Values, Ethics and Organisational Responsibility, Calicut, 15–16 February 2002 (B. Krishnamoorthy).

Linkages and Collaboration

Agency	Linkage
National Bureau of Plant Genetic Resources, New Delhi	Collection and conservation of germplasm
Central Tuber Crops Research Institute, Thiruvananthapuram	Research collaboration in post harvest technology
Central Plantation Crops Research Institute, Kasaragod	Research collaboration in post harvest technology
Centre for Water Resources Development and Management, Calicut	Research collaboration in biosynthesis of pigments and translocation of pesticides
Rajeev Gandhi Centre for Biotechnology, Thiruvananthapuram	Research collaboration in molecular markers
Craigmore Plantations, Nilgiris	Evaluating black pepper lines for high altitudes
Tata Tea Ltd., Valparai	Evaluating black pepper lines for high altitudes
Kerala Agricultural University, Thrissur	Research collaboration in biotechnological approaches for improvement of spices and evaluation of tissue cultured plants; PG Centre for Post Graduate studies
University of Calicut, Calicut	PG Centre for Post Graduate studies; MOU for teaching M.Sc. Biotechnology and M.Sc. Plantation Development courses
Bharathiyar University, Coimbatore	PG Centre for Post Graduate studies
Spices Board, Kochi	Evaluation of improved varieties; training programmes
Directorate of Arecanut and Spices Development, Calicut	Planting material production; implementation of developmental schemes
Department of Agriculture/ Horticulture of States	Transfer of technology

All India Coordinated Research Project on Spices

The mandate of All India Coordinated Research Project on Spices (AICRPS) is to conduct and coordinate spice research being carried out at 19 centres and 8 voluntary centres in 12 spice crops in the country. New programmes were formulated during the year giving emphasis on integrated pest and disease management and organic farming in spices.

Crop improvement

The AICRPS centres strengthened the genetic resources of various spice crops and at present the germplasm holdings consist of 421 black pepper, 330 cardamom, 443 ginger, 1134 turmeric, 117 tree spices and 3681 seed spices accessions that are being maintained at different centres. Based on evaluation of germplasm, 5 black pepper accessions [Karimunda-II and III, PRS-17, Cult. 5489 and Cult. 5308 (Panniyur)], 9 cardamom accessions [PS-44, PS-27, S-1 (Pampadumpara), CL-692, CL-730 (Mudigere), MCC-13, MCC-18, MCC-200 and MCC-347 (Myladumpara)]; 2 ginger accessions [V_1C_8 and V_1S_1-2 (Pottangi)] and 11 turmeric accessions [TCP-1 (Pundibari), PTS-55, TU. No-1, PTS-11, PTS-15, PTS-52, PTS-59 (Pottangi), JTS-6, JTC-313 (Jagtial) and RH-5 (Dholi)] were identified for the new Comparitive Yield Trials. Promising genotypes in OP seedling progenies (D-237, CC-730 and CL-692) and other superior clones (Acc. 8-4-D11 and 7-24-D11) were identified in cardamom. Drought tolerant lines were also identified in cardamom (CL-668, P-6, D-237 and 2-2-D11). Acc. 239 was identified as a promising black pepper line at Sirsi. V_3S_1-8 and V_1E_8-2 in ginger and PTS-59, PTS-43 and PTS-55 in turmeric were identified as promising lines at Pottangi and are in an advanced stage for release.

Seven new promising varieties (PV-2 in cardamom; TCP-2 in turmeric; Hisar Sugandh and UD-446 in coriander; and Hisar Mukta, Hisar Madhavi and Hisar Suvarna in fenugreek) were proposed/recommended during the XVI National Workshop of AICRPS for state/central release. The exotic line of coriander EC-232666 was identified as the best leafy type for commercial growing.

Three turmeric accessions (PCT-1, GL Puram and PTS-16) and one turmeric accession (CL-67) with 6.4% curcumin were identified to be high curcumin types by Solan and Coimbatore centres, respectively. The turmeric varieties Alleppey and BDJR-1260 were high yielding types with high curcumin. Acc. BDJ-105 and Acc. 360 had high dry recovery and ST-IM and ST-7M had high essential oil and oleoresin, respectively. The turmeric accession SG-685 was identified for high dry recovery at Solan. In coriander, Jco-331 had high oil (0.45%). The highest volatile oil content in cumin was recorded in EC-232684 (4.4%) and JC-147 (3.9%) and in fennel for UF-144.

Crop production

The fertilizer and irrigation requirements for black pepper-arecanut mixed cropping system were standardized. Micronutrients such as boron and molybdenum influenced capsule yield of cardamom. A fertilizer dose of 100:100:175 kg NPK/ha was recommended in integrated nutrient management using organic and inorganic manures in cardamom. The package of practices for ginger and turmeric production were also standardized for Chintapalli region. A fertilizer package including application of biofertilizers was standardized for clove and nutmeg in Yercaud region. Yield and quality of coriander and fennel increased by the application of Zn, Fe, Mn and Cu. In Gujarat, sowing of cumin on 15 th October was most appropriate to obtain high yield with less blight incidence. A closer spacing of 15 cm x 10 cm and sowing during first week of October gave highest yield at Coimbatore and during 31 st October in Jobner for fenugreek. Sowing of fenugreek variety RMt-1 by the last week of October and UM-305 up to 15 th November at 25–30 cm row spacing was recommended to obtain higher seed yield under semi-arid conditions.

Studies confirmed that micronutrient application increased the yield in coriander and fennel. Foliar application (at pre-flowering stage) of $MnSO_4$, $ZnSO_4$ and $CuSO_4$ each @ 0.5% and soil application of $FeSO_4$ @ 5 kg/ha or foliar application @ 0.125% was recommended to obtain higher seed yield of coriander under micronutrient deficient sandy loam soils. Application of $ZnSO_4$ as foliar application (at pre-flowering stage) @ 0.5% or soil + foliar application @ 10 kg/ha + 0.25%, $FeSO_4$ as foliar application @ 0.25% or soil + foliar application @ 5 kg/ha + 0.125%, $MnSO_4$ as foliar application @ 0.5% or soil + foliar application @ 12.5 kg/ha + 0.25% and $CuSO_4$ as foliar application @ 0.5% was recommended to obtain higher seed yield of fennel under micronutrient deficient sandy loam soils.

Crop protection

A package of plant protection practices was recommended for the management of *Phytophthora* foot rot in black pepper. A low-cost technology for mass multiplication of *Trichoderma* sp. for field application was developed. Rhizome rot under storage can be managed by storing in sand layered pits mixed with Dithane M-45 + Bavistin (5 g + 3 g/kg of seed). Surveys conducted in Bihar established the severity of stem gall disease in coriander. The coriander varieties RCr-441, RCr-435, RCr-436, UD-446 and UD-684 were resistant to root knot nematodes. Sowing cumin on 10 th November was best to minimize wilt incidence with maximum green yield (3.63 q/ha). Sowing of cumin on 20 th December was recommended for higher seed yield and lesser incidence of wilt in Jobner region. Guj. Cum. 3, Acc. 1136, Acc. 1145 and Acc. 1165 were moderately resistant to *Furarium* wilt. Kasuri methi (fenugreek) was resistant to powdery mildew. Two sprayings of either monocrotophos (0.05%) or dimethoate (0.05%) at fortnightly intervals after harvest of berries was effective for the management of mussel scale (*Lepidosaphes piperis*) of black pepper at high ranges of Idukki District.

Krishi Vigyan Kendra

The Krishi Vigyan Kendra (KVK) was established under the institute in 1992 at Peruvannamuzhi.

Training programmes

The KVK imparted 66 vocational training programmes of 1 to 5 days duration in agriculture and allied fields (Table 62).

Front line demonstration programme

The main objective of the front line demonstration (FLD) programme is to demonstrate newly released technologies in farmers fields under various agro-climatic regions and farming situations.

Introduction of improved variety of tapioca

Tapioca is the most important tuber crop of Kerala grown throughout the year. The farmers generally cultivate local types with poor cooking quality of tuber and 10–11 months duration. In this programme it was envisaged to introduce a short duration tapioca variety of 6–7 months with excellent cooking quality namely, Sree Vijaya, from Central Tuber Crops Research Institute, Thiruvananthapuram. Three demonstrations of 0.08 acre each were carried out and the crop was raised following the package of practices of Kerala Agricultural University.

In one of the demonstration plots, two spacing were adopted namely, one at the recommended spacing (90 cm x 90 cm) and another at an increased spacing (1.2 m x 1.2 m) but well below the farmers practice of 2 m x 2 m. The yield and income obtained were higher in the demonstration plot where a higher spacing (1.2 m x 1.2 m) was followed than the recommended spacing (Table 63).

Even though the variety demonstrated was characterized as short-duration type, in the actual field situation, it took almost 9 months for harvesting. The cooked tuber was also

Table 62. Training programmes conducted by KVK during 2001–02

Category	No. of courses	No. of participants			No. of SC/ST participants
		Male	Female	Total	
Practising farmers	59	1010	630	1640	89
Rural youth	6	78	44	122	6
Extension functionaries	1	40	22	62	0
Total	66	1194	1824	1824	95

Table 63. Demonstration of cultivation of improved variety of tapioca

Character	Demonstration plot		Control plot
	I	II	
Variety	Sree Vijaya	Sree Vijaya	Salykappa (Local)
Duration	9 months	9 months	10–11 months
Spacing	1.2 m x 1.2 m	0.9 m x 0.9 m	2 m x 2 m
Yield/plant	9.9 kg	5 kg	15 kg
Yield/ha	68.75 t	61.73 t	37.5 t
Gross income/ha	Rs. 3,43,750	Rs. 3,08,650	Rs. 1,87,500

slightly bitter especially in a plot where more of FYM was applied compared to chemical fertilizers. The skin of the tuber of this variety also peeled easily making it unsuitable for long distance transport. However, even with these shortcomings, the high yield of this variety makes it superior to the local variety (Salykappa), which is highly susceptible to mosaic disease.

On-farm testing programmes

The on-farm testing (OFT) programme aims at testing the new technologies developed at the research institute in the field to ensure their suitability and sustainability to specific locations and to suggest or modify or refine the technology.

Effectiveness of pheromone traps

The red palm weevil and rhinoceros beetle are serious pests of coconut in Poozhithode and surrounding hills in Kozhikode District bordering Wyanad District. Most of the farmers in this area loose 2–3 coconut palms every year due to the attack of these pests. The effectiveness of pheromone traps in trapping these pests was tested in about 25 acres of coconut gardens with the farmers practice as control.

Evaluation of ferrolure pheromone trap against red palm weevil

The performance of ferrolure pheromone trap was evaluated against red palm weevil. The ferrolure traps were examined every fourth day and replacement of bait was done at 10 days intervals. The farmers were trained to identify male and female weevils based on the presence of pubescence on the snout in males and its absence in the female. The ferrolure pheromone trap was very effective in attracting both sexes of red palm weevil. The total catch of adult weevil from 10 ha was 2833 in 4½ months. The

Table 64. Observations on catch of adult red palm weevil in ferrolure pheromone trap

Plot	No. of weevils trapped from December to May		
	Male	Female	Total
1	445	352	797
2	346	348	694
3	276	413	689
4	102	132	234
5	206	213	419
Total	1375	1458	2833

average monthly catch of weevils in the traps was 126. Summer months (December–May) resulted in better catches suggesting that the best time to use the traps was during summer (Table 64). The pheromone trap was safer to the environment and poultry in the homesteads compared to poison baited stump traps.

Evaluation of stump trap against red palm weevil

Stump traps were prepared in two farmers fields by cutting the palm 1.2 m above the ground and making a transverse slit on top of the stump and a bait of toddy, yeast and sugar mixture was pasted with a pinch of phorate. The bait mixture was replaced everyday. A total of 84 adults only could be collected during 4 months from both the traps. The average monthly catch was only 10 per trap. Both sexes of the beetle were collected in almost equal proportion. The stump trap required daily collection and killing of trapped weevils. It was also risky to the poultry in the homesteads, which fed on the poisoned weevils fallen from the trap (Table 65).

Evaluation of rhinoceros beetle pheromone traps

The rhinoceros beetle pheromone traps were inspected for adult beetles once in 4 days. The farmers were trained to identify male and female beetles based on the presence of long horn head in males and short horn in females. The traps were very effective in attracting both sexes of the beetle. The total catch of adult beetles from 10 ha was 602 in an average time span of 4 months indicating an average monthly catch of 27 beetles per trap. Both male and female beetles were equally attracted to the traps. The height of trap recommended (8') was not effective for hilly tracts as the catch was best at 6' height from the ground.

Control of yellow leaf disease of arecanut

The trial was in progress in an area of 0.5 acres with South Kanara variety of arecanut. The arecanut palms which were treated with *Trichoderma* sp. 100 g + 1 kg neem cake + Ridomil @ 1.25 g/l x 5 per palm during the previous year were monitored. However, the palms did not show any improvement and it was concluded that the treatment is not effective against yellow leaf disease of arecanut.

Efficacy of glyricidia extract against ecto-parasites

Leaf extracts of *Glyricidia* sp. were evaluated for their efficacy in controlling ecto-parasites of farm animals. Various age groups of farm animals consisting of both

Table 65. Comparison of ferrolure pheromone trap and stump trap

Particulars	Pheromone trap	Stump trap
Average catch efficiency per month	126	10
Frequency of trap servicing and change of feed/bait	10 days	3 days
Average longevity of trap	4 months	1 week
Safety to environment and poultry	Safe	Risky
Easiness in setting and operation	Easy	Requires frequent inspection

sexes having heavy tick infestations were selected for the experiments. In group I, 92 cases were taken for the experiment. About 500 g of *Glyricidia* sp. leaves mixed with sufficient quantity of water + 30 ml of neem oil was boiled in a container and the mixture was applied on the body of the animals. In heavily infested cases only 50% of ticks were removed by first application and all the ticks were killed during second application, done after a week. There was no allergic or photosensitization effect on the animals and the technique was economical and easy to adopt.

In group II, 62 affected animals were tested by external spraying of deltamethrine and cyamo-methyl cistrans 2-methyl cyclopropane carboxylate (5 ml of 2% solution in 1 l water); however, the chemicals had no effect on ticks at this concentration. At higher concentration (15 ml of 2% solution in 1 litre water), all the ticks were killed when applied at an interval of 7 days. The tested animals were not exposed to sunshine and were washed with cold water after half an hour. Even though these chemicals controlled ectoparasites at higher concentrations, glyricidia extract with neem oil not only control ectroparasites but had no harmful effects and also had antiseptic and antidermatitic properties. These chemicals at higher concentrations may produce residual toxins, which may affect public health through milk and meat.

Revolving Fund Programme

Under this programme, quality planting materials of various crops were produced and sold at moderate rates (Table 66). The KVK operates a plant and animal clinic to cater various services to the farmers. An artificial insemination facility is also provided under the centre to upgrade the genetic stock of livestock. The centre offers consultation, treatment and door services at a nominal fee. The centre also provides vaccination facility and organises animal health camps in association with the state animal husbandry department. Rs. 2.68 lakhs was realised by sale of planting materials and also through the Plant and Animal Health Centre as contributions to the revolving fund during the year.

Extension activities

Exhibitions

The KVK participated in three exhibitions during the year.

- Silver Jubilee celebration of IISR, Calicut, 8–9 October 2001.
- Golden Jubilee celebration of St. Thomas High School, Thottumukkam, 16–18 November 2001.
- District Agricultural Seminar and Exhibition, Peruvayal, 22 November 2001.
- Swadeshi Vigyana Mela 2002, Kochi, 12–19 January 2002
- Calicut Agri-Horti Promotion Council-Vasatham 2002, Calicut, 20 January–27 February 2002
- Calicut Flower Show 2002, Calicut, 7-12 February 2002

Radio talks and popular articles

The scientists of KVK gave two radio talks and also contributed two popular articles on various aspects of agriculture and allied fields.

Table 66. Planting materials produced by KVK

Crop	Variety	No. of plants produced	No. of plants sold
Arecanut seedlings	Mohitnagar, SAS-1	-	2636*
Allspice seedlings	Elite lines	400	553*
Anthurium plants	20 varieties	100	64*
Bush pepper plants	Sreekara, Subhakara, Panchami, Pournami, Panniyur-1	700	765*
Garcinia grafts	Elite lines	1840	945
Nutmeg grafts	Elite lines	13,500	12,854
Mango grafts	Bennet Alphonso, Kalepady	180	111
Guava layers	Allahabad Safeda	110	194*
Watery rose apple rooted cuttings	Seedless type	100	134*

* Includes previous years stock also

Demonstration units

Medicinal plant unit

About 100 species of medicinal plants collected from Kottakkal Arya Vaidyasala and other places were maintained in pots with labels to motivate visitors and trainees. A herbal garden in an area of 0.5 acre is being established.

Model homestead garden

A coconut garden of 0.3 ha area was developed into a model homestead garden with banana, pineapple, mango, papaya, minor fruits and spices like black pepper, ginger, turmeric, allspice, clove, nutmeg, cinnamon, tubers and fodder grasses.

Improved black pepper varieties

A demonstration unit of released black pepper varieties and promising lines of black pepper including high yielding local cultivars was established in an area of 0.5 acre.

Model arecanut seed garden

A seed garden cum demonstration plot of Mohitnagar variety of arecanut was planted in about 1 acre area along with clove.

Anthurium cultivation

Five hundred pots of 20 varieties of anthuriums are maintained for production of planting materials and training purposes.

Cashew scion bank

An area of 0.2 ha is maintained as cashew scion bank with the varieties, Selection 1 and 2, Ullal–3, Priyanka, UN–50, Mrudula and Sulabha.

Collaborative activities

The KVK collaborated with other NGOs such as Centre for Overall Development, Vikas Volunteer Vahini Club, INFAM, Womens Cell and Self Help Groups, functioning in Kozhikode District in conducting training programmes in agriculture and allied fields.

The KVK also maintained functional linkages with All India Radio, Krishi Bhavans under the State Department of Agriculture, Department of Animal Husbandry, Department of Fisheries, Matsyafed, Agri-Horti Society, Gramin Banks, National Agricultural Bank for Rural Development, Kerala Agricultural University, Central Plantation Crops Research Institute, Central Marine Fisheries Research Institute and Central Tuber Crops Research Institute in organizing various training programmes and other extension activities like animal health camps, seminars and exhibitions.

The training programmes imparted from the KVK have assisted some of the beneficiaries to begin small-scale employment units with follow up assistance from KVK, such as nurseries, vermi-compost units, goatary units and contract production of planting materials. The self-employment units helped the beneficiaries to obtain adequate income from these units.

Documentation of indigenous knowledge

The following indigenous technical knowledge utilized by local farmers were documented.

- Swabbing juice from leaves and berries of *mullilliam* (*Zanthoxylum limonella*) is effective for control of pseudostem borer of banana (*Odoiporos longicollis*) and nematodes by mulching.
- Use of catfish as a biological agitator in manure tanks for agitation and thorough mixing of sediment and other manures.
- Use of *Manihot glaziovii* as a source of nectar and pollen for honeybees during rainy season.

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On-going Research Projects

Institute Projects

Crop Improvement and Biotechnology

1. Gen. I (813): Collection, conservation, cataloguing and evaluation of black pepper germplasm
2. Gen. VII. 1 (813): Breeding black pepper for high yield, quality, drought and resistance to pests
3. Biotech. IV (813): Biotechnological approaches for crop improvement in black pepper
4. Biotech. VI (813): Development of DNA markers for marker assisted selection in black pepper
5. Biotech. V (813): Large scale multiplication of released varieties of black pepper through somatic embryogenesis and genetic fidelity testing
6. Hort. II (813): Utilization of *Piper colubrinum* Link. and *Piper arboreum* as rootstocks in the management of foot rot disease of black pepper
7. Gen. IX (813): Collection, conservation, cataloguing and evaluation of cardamom germplasm
8. Gen. X (813): Breeding cardamom for high yield and resistance to 'katte' disease
9. Gen. II (813): Collection, conservation, cataloguing and evaluation of germplasm of ginger and turmeric
10. Gen. XIV (813): Cytogenetics and reproductive biology of major spices
11. Biotech. II (813): *In vitro* selection for resistance to soft rot and bacterial wilt in ginger
12. Gen. VI (813): Collection, conservation, cataloguing and evaluation of germplasm of tree spices
13. Hort. IV (813): Rootstock-scion interactions in tree spices
14. Gen. XIII (813): Collection, conservation and improvement of vanilla
15. Hort. III (813): Development of paprika for warm humid tropics

Crop Production and Post Harvest Technology

1. Agr. XXI (813): Efficacy of biofertilizers on nutritional management of black pepper
2. SSc. II (813): Nutritional requirement of improved varieties of spices
3. Phy. V (813): Characterization of drought tolerance in black pepper
4. Phy. VI (813): Characterisation of drought tolerance in cardamom
5. Agr. XVII (813): Vermi-composting using organic wastes available in cardamom areas

6. Agr. XIV (813): Investigation on spice based cropping systems
7. Agr. XIX (813): Management efficacy of whole farm approach in farming -A study on spices based farming systems
8. Biochem. I (813): Biogenesis of pigments in spice crops
9. Org. Chem. I (813): Isolation and identification of naturally occurring compounds against major pests and pathogens of black pepper
10. PHT. I (813): Quality evaluation in spices
11. PHT. II (813): Harvesting and processing techniques in spices
12. Agr. XX (813): Production of nucleus planting materials of improved varieties of spice crops

Crop Protection

1. Crop Prot. I. 1 (813): Screening black pepper germplasm for reaction to diseases
2. Path. II. 3 (813): Disease management in *Phytophthora* foot rot affected black pepper plantations
3. Path. XII (813): Investigations on stunted and phyllody diseases of black pepper
4. Path. X (813): Investigations on vein clearing virus of small cardamom
5. Path. XI (813): Studies on bacterial wilt of ginger
6. Biocontrol I. 1 (813): Biological control of diseases of spices
7. Nema. III (813): Investigations on nematodes associated with spices
8. Crop Prot. I. 3 (813): Screening black pepper germplasm for reaction to nematodes
9. Biocontrol. I. 3 (813): Biological control of nematodes of spices
10. Ent. XI (813): Bioecology and management of mealybugs infesting black pepper
11. Crop Prot. I. 2 (813): Screening black pepper germplasm for reaction to insect pests
12. Biocontrol. I. 2 (813): Biological control of insect pests of spices
13. Crop Prot. II (813): Mechanisms of resistance to pests and pathogens in spice crops

Social Sciences

1. Econ. I (813): Economics of spices production and marketing
2. Ext. IV (813): Training of research and extension workers

Externally Funded Projects

ICAR Cess Fund

1. Organization of ginger and turmeric germplasm based on molecular characterization
2. Characterization of nutmeg germplasm for quality
3. Elucidation of biosynthetic pathways of curcumin in turmeric
4. National Network Project on *Phytophthora* Diseases of Horticultural Crops
5. Biological control of plant parasitic nematodes of major spice crops

Department of Biotechnology

1. Conservation of spices genetic resources in *in vitro* gene banks
2. A digitized inventory of plant resources. Part II. Other economically important spices
3. Improvement of selected spice crops through biotechnological approaches
4. Field evaluation of tissue cultured plants of spices and assessment of their genetic stability using molecular markers
5. Immunoserological approaches to pathogen detection and use of defence proteins in disease management in plantation crops-ginger and cardamom
6. Compatibility, stability and potential of biocontrol consortium on suppression of *Phytophthora* foot rot of black pepper and their conservation
7. Distributed Information Sub-Centre

National Agricultural Technology Project

1. Collection, characterization and conservation of spices genetic resources
2. Molecular characterization and preparation of molecular maps in black pepper
3. Development and evaluation of soil-water conservation measures and land use systems for sustainable crop production in Western Ghats of Coastal Region
4. Integrated technologies for value addition and post harvest management in palms, spices and tropical tuber crops
5. Value addition and quality enhancement of selected spices
6. Integrated National Agricultural Resources Information System
7. Agricultural Technology Information Centre

Department of Agriculture and Cooperation

1. Centrally Sponsored Scheme-Integrated Programme for Development of Spices

Government of Kerala

1. Technology mission on black pepper

Emeritus Scientist Scheme

1. Plant nutrient management strategy for breaking black pepper yield plateau and quality upgradation

Consultancy and Commercialization of Technology

The Consultancy Processing Cell (CPC) of the institute offers consultancy services, contract research and services and training programmes to individuals and the corporate in spice research and development. The technology for large-scale multiplication of *Trichoderma harzianum* was much sought after by entrepreneurs and a sum of Rs. 70,000 was obtained through its sale. Consultancy in management of ginger diseases was another major service undertaken by the institute under the Indo Swiss Project at Sikkim. The CPC also offered short term training and project work programmes to post graduate students of various universities. Rs. 2.5 lakhs was collected this year though consultancy services and sale of technologies.

Institute Management Committee

Director, Indian Institute of Spices Research, Calicut.	Chairman
Assistant Director General (Plantation Crops), Indian Council of Agricultural Research, New Delhi	Member
Dr. E. V. Nybe, Associate Professor and Head, Kerala Agricultural University, Thrissur.	Member
Dr. M. N. Venugopal, Head in Charge, Cardamom Research Centre, Indian Institute of Spices Research, Appangala.	Member
Dr. B. Chempakam, Head in Charge, Division of Crop Production and Post Harvest Technology, Indian Institute of Spices Research, Calicut.	Member
Dr. M. Anandaraj, Principal Scientist, Indian Institute of Spices Research, Calicut.	Member
Dr. B. Sasikumar, Senior Scientist, Indian Institute of Spices Research, Calicut.	Member
Director of Horticulture, Karnataka.	Member
Director of Agriculture, Kerala.	Member
Senior Finance and Accounts Officer, Central Marine Fisheries Research Institute, Kochi.	Member
Assistant Administrative Officer, Indian Institute of Spices Research, Calicut.	Member Secretary

Research Advisory Committee

Members

Prof. V. L. Chopra	: Chairman
Prof. T. N. Ananthakrishnan	: Member
Mr. C. V. Jacob	: Member
Dr. Man Singh Manohar	: Member
Dr. K. R. Maurya	: Member
Dr. A. M. Michael	: Member
Dr. P. N. Ravindran	: Member Secretary

Recommendations

The RAC meeting was held during 16–17 March 2001 and the following recommendations were made.

General

1. In addition to research support for increasing spices production at national level, IISR should also strive to standardize technologies for production of quality spices to meet growing international standards.
2. Brain storming sessions may be organized to identify future needs of spice production.
3. Multidisciplinary approach should be given more importance in all future research programmes.
4. Prioritization of research programmes, based on existing manpower and facilities may be made.
5. The institute should analyse critically the global/national demand-supply position and advice ICAR and other agencies to bring out proactive measures to help the growers.
6. Action taken reports should be supported with facts and figures.

Crop Improvement and Biotechnology

1. Work on breeding for resistance to biotic and abiotic stresses in black pepper and cardamom should be continued as a high priority item.
2. Genetics of resistance to *Phytophthora* foot rot of black pepper must be studied.
3. More number of ginger accessions with low fibre content may be identified. Role of environment in development of fibre in ginger may be studied.
4. Work on paprika improvement may be discontinued at the institute level and may be taken up through All India Coordinated Research Project on Spices.

Crop Production and Post Harvest Technology

1. The effect of root exudates on soil micro flora/fauna dynamics needs investigation.
2. Cost-benefit ratio has to be worked out for the recommendations made in agronomic studies.

3. Soil temperature, soil moisture regime and stage of the crop are to be considered scheduling irrigation in cropping systems.

4. Specific tools employed in planting, harvesting and processing of spices are to be identified and improved upon.

5. Collaboration with CFTRI may be sought for developing post harvest technology including product development.

Crop Protection

1. Induced systematic resistance against fungal, bacterial and viral pathogens of black pepper, ginger and cardamom should be given priority in future programmes.

2. Diagnostics for viral diseases should be given priority to ensure production of disease-free planting material.

3. Biocontrol agents with multiple mode of action and consortia need to be developed for disease suppression and growth promotion.

4. Population dynamics of nematodes in soil in response to various agricultural inputs should be studied.

5. Studies on the effect of plant volatiles on infestation of insect pests and their natural enemies on spices may be initiated in collaboration with biochemists.

6. The effect of neem extracts on reducing the population of mealybugs on black pepper may be studied.

7. Chemical analysis of root exudates of resistant and susceptible species may be carried out and the role of various components in chemoattraction of insect pests may be studied.

Social Sciences

1. Periodic meetings of Social Sciences Section should be convened to plan, take stock and assess transfer of technology projects.

2. Database on total population employed in spices production sector should be prepared.

3. The database on spice production statistics already prepared should be commercialized and made accessible to prospective users on payment.

4. Village adoption programmes should be followed up and strengthened.

5. Audiovisual aids like technology specific video films, user-friendly computer demos and internet web sites should be designed and produced.

Staff Research Council

The XVI Annual Staff Research Council Meeting of the institute was held during 4–6 June 2001 at Calicut. The Inaugural Session of the meeting was held during the forenoon of 4 June 2001. Dr. Y. R. Sarma, Director, delivered the inaugural address and highlighted the significant achievements of the institute during the past year. He also exhorted the scientists to rededicate themselves to the cause of spice research and development in view of the changing economic scenario of the country.

The progress of work in 39 institute projects was presented and discussed in four technical sessions and the technical programme for the ensuing year was approved in these sessions. Two new project proposals were also presented and were approved.

The Plenary Session was held during the afternoon of 6 June 2001 and was chaired by Dr. Y. R. Sarma. The publication 'Research Highlights 2000-01' was released during the session. The significant achievements and future thrust areas of research were presented by the heads of divisions/ section. Five improved varieties, three in cardamom and two in ginger were proposed for release. Recommendations for management of rhizome scale of ginger and turmeric and shoot borer of ginger, for extension agencies, were presented and approved.

Participation of Scientists in Meetings

Brain Storming Session on Intellectual Property Rights with Particular Reference to Plantation Crops, Kasaragod, 9 January 2001 (K. V. Ramana, B. Krishnamoorthy, B. Sasikumar, J. Rema).

National Symposium on Pest management - Current Trends and Future Prospects, Chennai, 1–2 February 2001 (S. Devasahayam).

National Symposium on Relevance of Plant Biochemistry and Biotechnology-Modern Trends, Madurai, 1–3 March 2001 (K. P. M. Dhamayanthi).

National Seminar on Kokum, Vengurla, 12–13 May 2001 (P. A. Mathew).

National Seminar on Statistical Methods for Plantation Crops Research, Kayamkulam, 18–19 June 2001 (M. S. Madan).

Workshop on Requirement Analysis for INARIS, Kasaragod, 27–29 June 2001 (M. S. Madan, V. Srinivasan).

Workshop on Requirement Analysis for INARIS, Calicut, 30 June–2 July 2001 (M. S. Madan).

Seminar on Molecular Modalities in the Manipulation of Insect Natural Enemies, Chennai, 14 July 2001 (S. Devasahayam).

Symposium on Plant Genetic Resources Management: Advances and Challenges, New Delhi, 1–4 August 2001 (D. Prasath).

Annual Review Workshop on Development and Evaluation of Soil and Water Conservation Measures on Land Use Systems for Sustainable Crop Production in Western Ghats of Coastal Region, Kasaragod, 6–7 September 2001 (S. J. Ankegowda).

Workshop on Alternate Crops, Karnataka, 13 September 2001 (S. J. Ankegowda).

National Review Workshop of Agriculture Technology Information Centre, Dharward, 25–26 September 2001 (P. Rajeev).

Interface-Spice Exporters, Farmers and Scientists, Calicut, 9 October 2001 (All scientists).

Annual Review Workshop of Transfer of Technology Centres of Kerala and Lakshadweep, Ambalavayal, 11–12 October 2001 (P. Rajeev).

National Seminar on WTO and its impact on Indian Agriculture, Hyderabad, 11–12 October 2001 (B. Sasikumar).

National Group Meeting of Research Workers of AICRP on Spices, Thrissur, 1–3 November 2001 (P. N. Ravindran, M. N. Venugopal, S. Devasahayam, B. Krishnamoorthy, T. John Zachariah, B. Sasikumar, K. S. Krishnamurthy, C. K. Thankamani, K. V. Saji, V. Srinivasan, K. N. Shiva, D. Prasath, Johny A. Kallupurackal).

Diamond Jubilee Symposium on Hundred Years of Post Mendelian Genetics and Plant Breeding-Retrospect and Prospect, New Delhi, 6–9 November 2001 (B. Sasikumar).

Meeting on Spice Exports and Pesticide Residues, Kochi, 22 November 2001 (S. Devasahayam).

Seminar on Spices, Nagercoil, 23 November 2001 (B. Krishnamoorthy).

Symposium on Post Harvest Technologies for Agricultural Produce and Prospects for the Food Processing Industry in Konkan Region, Goa, 23–24 November 2001 (P. A. Mathew).

National Workshop on NATP-PB, New Delhi, 23–24 November 2001 (K. V. Saji).

Policy Makers Workshop on Farmers Rights: From Legislation to Action and Kerala's Bioresources Conservation, Kalpetta, 24 November 2001 (Y. R. Sarma, B. Krishnamoorthy, B. Sasikumar, J. Rema, C. K. Thankamani).

National Symposium on Plant Physiology and Biochemistry in Transgenic Era and Beyond, Kolkata, 1–3 December 2001 (S. J. Ankegowda).

International Symposium on Importance of Potassium in Nutrient Management for Sustainable Crop Production in India, New Delhi, 3–5 December 2001 (V. Srinivasan).

Awareness Seminar on Implementation of New Geographical Indication (Registration and Protection) Act 1999, Kochi, 10 December 2001 (B. Sasikumar).

Southern Zone Meeting, Indian Phytopathological Society, Calicut, 10–12 December 2001 (All scientists).

Meeting on Spices Production Technology, Bhopal, 4–5 January 2002 (P. Heartwin Amaladhas).

Annual Workshop of KVKs, Ambalavayal, 10 January 2002 (P. A. Mathew).

Implementing Farmers' Rights for Conservation and Utilization of Plant Genetic Resources in Asia Pacific Regions-From Legislation to Action, Chennai, 21–22 January 2002 (B. Sasikumar).

National Symposium on Crop Protection and WTO-an Indian Perspective, Kasaragod, 22–25 January 2002 (M. Anandaraj, S. S. Veena).

International Conference on Biodiversity and Conservation, Calicut, 24 January 2002 (B. Sasikumar).

Annual BTIS Coordinators Meeting, Pune, 29–30 January 2002 (Santhosh J. Eapen).

Brain storming session on Stimulation Models in Perennial Crops, Kasaragod, 29–30 January 2002 (C. K. Thankamani).

Monitoring Committee Meeting, Review of IPM/INM Programmes, Calicut, 30–31 January 2002 (M. Anandaraj, S. Devasahayam and S. S. Veena).

National Seminar on Indigenous Nutrient Management Practices and Brain Storming Session on Organic Farming, Bhopal, 30–31 January 2002 (V. Srinivasan).

Workshop on Codification of Crop Resources, Calicut, 5–6 February 2002 (All Scientists).

National Symposium on Biological Control of Insect Pests, Chennai, 7–8 February 2002 (S. Devasahayam).

Seminar on Black Pepper, Kalpetta, 12 February 2002 (S. J. Eapen, C. K. Thankamani)

Fourth Indian Agricultural Scientists and Farmers Congress, Meerut, 16–17 February 2002 (K. V. Saji).

Nematode Diseases of Black Pepper-'Nema 100 Kerala', Kayamkulam, 21–22 February 2002 (K. V. Ramana and Santhosh J. Eapen).

National Workshop on Germplasm Management of Horticultural and Agro Forestry Crops for Sustainable Utilization, New Delhi, 27–28 February 2002 (K. N. Shiva).

III Zonal Workshop of NATP, Kasaragod, 6–7 March 2002 (K. V. Saji).

NATP Annual Workshop, Kasaragod, 26 March 2002 (T. John Zachariah).

Seminar on Trends in Applied Biology 2002, Kannur, 27 March 2002 (B. Sasikumar).

Meetings Organized by the Institute

Interface-Spice Exporters, Farmers and Scientists, Calicut, 9 October 2001.

National Group Meeting of Research Workers of All India Coordinated Research Project on Spices, Thrissur, 1–3 November 2001.

Kisan Mela, Peruvannamuzhi, 9 November 2001

Southern Zone Meeting, Indian Phytopathological Society, Calicut, 10–12 December 2001.

Department of Biotechnology, Monitoring Committee Meeting, Review of IPM/INM Programmes, Calicut, 30–31 January 2002.

Workshop on Codification of Crop Resources, Calicut, 5–6 February 2002.

Radio Talks

Harvesting and processing of turmeric, All India Radio, Calicut, 6 May 2001 (B. Chempakam).

Diseases of ginger and turmeric, All India Radio, Calicut, 31 May 2001 (S. S. Veena).

Cropping systems, harvesting and processing of cardamom, All India Radio, Madikeri, 28 June 2001 (S. J. Ankegowda).

Nursery management and cultivation practices of cardamom, All India Radio, Madikeri, 14 July 2001 (S. J. Ankegowda).

Processing of pepper, All India Radio, Madikeri, 19 July 2001 (S. J. Ankegowda).

Viral diseases of black pepper, All India Radio, Calicut, 8 August 2001 (S. S. Veena).

Spices varieties released from IISR and other agencies, All India Radio, Calicut, 15 August 2001 (B. Sasikumar).

Tissue culture and genetic engineering. Will it come to the help of our farmers?, All India Radio, Thiruvananthapuram, 4 September 2001 (B. Sasikumar).

Management of pests and diseases of cardamom, All India Radio, Madikeri, 16 September 2001 (M. N. Venugopal).

Varieties of pepper and their productivity, All India Radio, Madikeri, 30 September 2001 (M. N. Venugopal).

Management of pests and diseases of pepper, All India Radio, Madikeri, 7 October 2001 (M. N. Venugopal).

Improved practices for ginger cultivation, All India Radio, Madikeri, 4 November 2001 (M. N. Venugopal).

Improved practices for turmeric cultivation, All India Radio, Madikeri, 25 November 2001 (M. N. Venugopal).

Clean spice production and organic spice products for globalized market, All India Radio, Calicut, 10 December 2001 (C. K. Thankamani).

Patenting procedure, All India Radio, Calicut, 15 December 2001 (B. Sasikumar).

Spice cultivation for better income, All India Radio, Thrissur, 12 February 2002 (B. Sasikumar).

The rhizosphere, All India Radio, Calicut, 22 February 2002 (Santhosh J. Eapen).

Lectures Delivered by Scientists

Post harvest processing of spices, Central Plantation Crops Research Institute, Kasaragod, 4 May 2001 (T. John Zachariah).

Modern technologies and trends in food processing with special reference to spices, Workshop on Food Processing, Calicut, 24 May 2001 (T. John Zachariah).

Black pepper varieties, Planters Seminar on From Lab to Land, Kalpetta, 27 June 2001 (B. Sasikumar).

Management of insect pests of black pepper, Planters Seminar on From Lab to Land, Kalpetta, 27 June 2001 (S. Devasahayam).

Black pepper and vanilla varieties and their cultivation, Pepper Seminar, Malappuram, 17 July 2001 (B. Sasikumar).

Potential of spices based food products in Kerala, Workshop on Initiatives in Development of Food Processing Industries in Kerala, Calicut, 18 August 2001 (T. John Zachariah).

Equipments in spice processing and its importance, Kisan Mela of Kerala Agricultural University, Pilicode, 31 October 2001 (P. Heartwin Amaladhas).

Value addition in spices, Kisan Mela of Kerala Agricultural University, Pilicode, 31 October 2001 (T. John Zachariah).

Black pepper cultivation and processing, Karshaka Seminar, Malappuram, 22 December 2001 (S. Hamza).

Machinery and post harvest up gradation in spices, Indian Institute of Plantation Management, Bangalore, 1 January 2002 (P. Heartwin Amaladhas)

Spices extracts with reference to market potential and manufacturing aspects of spices, Indian Institute of Plantation Management, Bangalore, 1 January 2002 (T. John Zachariah)

Introducing Bioinformatics, ECIL-BDPS Computer Education, Calicut, 9 February 2002 (Santhosh J. Eapen)

Pests and diseases of black pepper, Pepper Seminar, Kalpetta, 12 February 2002 (Santhosh J. Eapen)

Agronomy of black pepper, Pepper Seminar, Kalpetta, 12 February 2002 (C.K. Thankamani)

Bioinformatics, Nest-Atlanta Computer Exhibition, Calicut, 15 February 2002 (Santhosh J. Eapen)

Distinguished Visitors

Dr. M. Balasubramaniam, Advisor, Department of Biotechnology, New Delhi.

Dr. K. V. A. Bavappa, FAO Consultant and Former Director, Central Plantation Crops Research Institute, Kasaragod.

Dr. E. V. V. Bhaskara Rao, Director, National Research Centre for Cashew, Puttur.

Dr. Bhushan Jalal , Director (Research), Harayana Agricultural University, Hisar.

Dr. S. Edison, Director, Central Tuber Crops Research Institute, Thiruvananthapuram.

Mr. R. C. Gupta, Additional Director General (QA), Directorate of Supplies and Disposals, New Delhi.

Mr. C. J. Jose, Chairman, Spices Board, Kochi.

Dr. G. Kalloo, Deputy Director General (Horticulture), Indian Council of Agricultural Research, New Delhi.

Mr. Koshy John, Director (Development), Spices Board, Kochi.

Dr. S. Lingappa, Director of Research, University of Agricultural Sciences, Dharwad.

Dr. T. Madhan Mohan, Director, Department of Biotechnology, New Delhi.

Dr. R. Naidu, Director (Research), Coffee Board, Bangalore.

Dr. Y. L. Nene, Chairman, Asian Agri-History Foundation, Secunderabad.

Dr. R. N. Pal, Additional Director General (PC), Indian Council of Agricultural Research, New Delhi.

Dr. P. Parvatha Reddy, Director, Indian Institute of Horticultural Research, Bangalore.

Dr. Paul Khurana, Project Co-ordinator, Central Potato Research Institute, Shimla.

Dr. K. V. Peter, Vice Chancellor, Kerala Agricultural University, Trichur.

Dr. V. Rajagopal, Director, Central Plantation Crops Research Institute, Kasaragod.

Dr. M. S. Reddy, Coordinator, Biocontrol Laboratory, Alabama University, USA.

Dr. P. Rethinam, Chairman, Coconut Development Board, Kochi.

Mr. A. K. Sangma, Minister (Conservation), Government of Meghalaya.

Dr. Seema Wahab, Director, Department of Biotechnology, New Delhi

Dr. S. D. Shikhamany, Director, National Research Centre for Grapes, Pune.

Dr. A. N. Shukla, Additional Director General (Extension), Indian Council of Agricultural Research, New Delhi.

Dr. M. S. Swaminathan, Chairman, M. S. Swaminathan Research Foundation, Chennai.

Dr. O. P. Vijay, Director, National Research Centre for Seed Spices, Ajmer.

Personnel

Headquarters, Calicut

Managerial

Dr. Y. R. Sarma, Director

Scientific

Dr. P. N. Ravindran, Project Coordinator, All India Coordinated Research Project on Spices

Dr. K. V. Ramana, Head, Division of Crop Protection

Dr. V. S. Korikanthimath, Head, Division of Crop Production and Post Harvest Technology

Mr. K. Narayana Kurup, Principal Scientist (Agricultural Statistics) and Head in Charge, Section of Social Sciences (Joined on 27 August 2001)

Dr. M. Anandaraj, Principal Scientist (Plant Pathology)

Dr. B. Chempakam, Principal Scientist (Biochemistry)

Dr. S. Devasahayam, Principal Scientist (Agricultural Entomology)

Mr. B. Krishnamoorthy, Principal Scientist (Plant Breeding) and Head in Charge, Division of Crop Improvement and Biotechnology

Mr. K. M. Abdulla Koya, Scientist (Selection Grade) (Agricultural Entomology)

Dr. K. Nirmal Babu, Senior Scientist (Plant Breeding)

Dr. M. S. Madan, Senior Scientist (Agricultural Economics)

Dr. T. John Zachariah, Senior Scientist (Biochemistry)

Dr. B. Sasikumar, Senior Scientist (Plant Breeding)

R. Suseela Bhai, Senior Scientist (Plant Pathology) (Joined on 1 February 2002)

A. Ishwara Bhat, Senior Scientist (Plant Pathology) (Joined on 18 February 2002)

Dr. J. Rema, Scientist (Senior Scale) (Horticulture)

Dr. Johnson K. George, Scientist (Senior Scale) (Genetics and Cytogenetics)

Mr. Santhosh J. Eapen, Scientist (Senior Scale) (Nematology)

Ms. N. K. Leela, Scientist (Senior Scale) (Organic Chemistry)

Ms. K. P. M. Dhamayanthi, Scientist (Senior Scale) (Genetics and Cytogenetics)

Mr. R. Ramakrishnan Nair, Scientist (Senior Scale) (Genetics and Cytogenetics)

Dr. K. S. Krishnamoorthy, Scientist (Senior Scale) (Plant Physiology)

Dr. P. Rajeev, Scientist (Senior Scale) (Agricultural Extension)

Dr. C. K. Thankamani, Scientist (Agronomy)

Mr. K. Kandiannan, Scientist (Agronomy) (On Study Leave)

Dr. S. S. Veena, Scientist (Plant Pathology)

Dr. A. Kumar, Scientist (Plant Pathology)

Dr. V. Srinivasan, Scientist (Soil Science)

Dr. K. N. Shiva, Scientist (Horticulture)

Technical

Dr. Johny A. Kallupurackal, Technical Information Officer (T-7)

Mr. P. Azgar Sheriff, Technical Officer (T-6)

Dr. P. Hamza Srambikkal, Technical Officer (T-6)

Mr. V. Balakrishnan, Technical Officer (T-5) (Retired on 31 May 2001)

Mr. M. M. Augusthy, Technical Officer (T-5)

Administrative

Ms. K. Usha, Assistant Administrative Officer (Transferred on 18 September 2001)

Mr. T. Gopinathan, Assistant Finance and Accounts Officer (Retired on 30 September 2001)

Mr. M. K. Sachidanandan, Assistant Finance and Accounts Officer

Mr. V. L. Jacob, Assistant Finance and Accounts Officer

Mr. A. P. Sankaran, Assistant Administrative Officer

Mr. S. M. Chettiar Private Secretary

Krishi Vigyan Kendra

Dr. Femeena Hassan, Technical Officer (T-6) (Transferred on 21 November 2001)

Ms. V. Radha, Junior Accounts Officer (From 4 December 2001)

Experimental Farm, Peruvannamuzhi

Scientific

Mr. P. A. Mathew, Principal Scientist (Horticulture) and Head in Charge

Mr. K. V. Saji, Scientist (Economic Botany)

Mr. P. Heartwin Amaladhas, Scientist (Agricultural Engineering)

Technical

Mr. V. K. Abubacker Koya, Farm Superintendent (T-7)

Krishi Vigyan Kendra

Mr. P. S. Manoj, Technical Officer (T-6)

Dr. S. Shanmugavel, Technical Officer (T-6)

Mr. K. M. Prakash, Technical Officer (T-6)

Cardamom Research Centre, Appangala

Scientific

Dr. M. N. Venugopal, Principal Scientist (Plant Pathology) and Head in Charge

Dr. S. J. Ankegowda, Scientist (Senior Scale) (Plant Physiology)

Mr. D. Prasath, Scientist (Horticulture)

Administrative

Ms. Enid Savitha, Assistant Administrative Officer

Silver Jubilee Celebrations

The Indian Institute of Spices Research, Calicut, which had its beginning as the erstwhile Regional Station of Central Plantation Crops Research Institute, Kasaragod, in 1976, has completed 25 years of service to the cause of spice research and development, and the Silver Jubilee celebrations were held during 8–9 October 2001. Prof. M. S. Swaminathan, the renowned agricultural scientist, was the Chief Guest during the function and the main laboratory buildings of the institute was dedicated to the nation by him (Fig. 6). A Silver Jubilee Hall was inaugurated by Dr. G. Kalloo, Deputy Director General (Horticulture), ICAR, New Delhi, during the occasion. A Greenhouse Facility was inaugurated by Dr. R. N. Pal, Assistant Director General (Plantation Crops), ICAR and a Local Area Network and Leased Line Connection of the instittue were inaugurated by Dr. T. Madhan Mohan, Director, Department of Biotechnology, New Delhi. An exhibition depicting the achievements of the institute during the past 25 years was organized and various publications on research achievements and technologies developed by the institute were released. Two interfaces, one between scientists and exporters of spices and another between scientists and farmers were held as part of the Silver Jubilee celebration. The retired staff of the institute were honoured in recognition of their services to the institute.

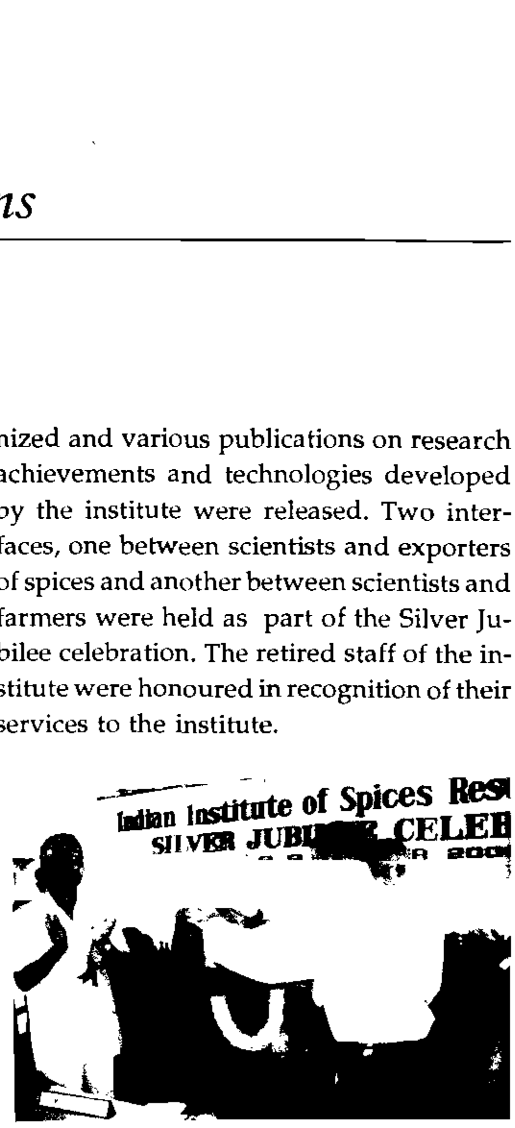

Fig. 6. Prof. M. S. Swaminathan, being felicitated during the Silver Jubilee celebrations of the institute

Weather

Weather data for 2001 (Peruvannamuzhi)

Month	Rainfall (mm)	No. of rainy days
January	0	0
February	43	2
March	0	0
April	247	12
May	349	14
June	1048	26
July	927	27
August	632	28
September	204	12
October	333	18
November	285	13
December	10	1
Total	4078	153

Weather data for 2001 (Appangala)

Month	Temperature		Rainfall (mm)	No. of rainy days
	Max. (°C)	Min. (°C)		
January	28.1	13.1	32	1
February	31.1	16.9	0	0
March	32.2	16.9	0	0
April	31.1	19.2	107	8
May	28.9	18.8	82	8
June	24.8	18.1	494	21
July	23.2	17.7	825	31
August	22.3	18.2	417	26
September	27.2	18.0	211	8
October	27.0	17.1	203	11
November	27.6	16.2	114	4
December	26.9	13.5	6	2
Total	-	-	2491	120

मुख्य सारांश

जर्मप्लाज्म का समाहरण तथा संरक्षण

मसाले फसलों के हर क्षेत्र से अनुसंधान एवं विकास ही *भारतीय मसाले फसल अनुसंधान संथान* Calicut का लक्ष्य है। यह संस्थान पहले सी पी सी आर ऐ (क्षेत्रीय स्टेशंन) के नाम से जाना जाता था । ये अनुसंधान इस संस्थान के विभिन्न कार्यक्रमों के अंतर्गत समय निर्बद्रित रूप में चलाया जा रहा है। वर्ष 2001 मे हुए मुख्य सफलताओं के बारे मे नीचे विवरण है।

रजत जूबीली कार्यक्रम

मसाले फसल अनुसंधान एवं विकास में इस संस्थान का पच्चीस वर्ष का यागदान रहा है। इसके उपलक्ष्य में ण्ड्ढ 8-9 2001 में 25 वाँ वर्षगाठ मनाया गया। प्रसिद्ध कृषि वैज्ञानिक प्रो एम एस स्वामिनाथन (Prof. M. S. Swaminathan) इस कार्यक्रम के मुख्याथिति थे। अन्होने इस अवसर पर नई प्रयोगशालाओं को राष्ट्र के लिए समर्पित किया Dr. D. G. Kalloo उपाध्यक्ष (भागवानी) ध्क्त्न्ङ ने जूबीली मंदिन का उदघाटन किया। एक प्रदर्शनी का आयोजन किया गया जिसमे इस संस्थान के उन्नति को दर्शाया गया। वैज्ञानिकों एवं मसाले फसल निर्यातकों को संपर्क मे लाने के लिए एक मंच तैयार किया गया।

सिरुवानी, आनाकाटी ,शोलयार, अटटप्पाढी, सैलन्ट वाली, नेल्लियाम्पति इडुक्की (केरल) कुद्रीमुख (कर्नाटक) और नीलगिरी (तमिल नाडु) में की गई खोजों के फलस्वरूप पैपर स्पीशीस एवं कालीमिर्च कल्टिवार के 153 अधिमिलनों का समाहरण किया गया। नेल्लियाम्पति जंगलों से *पी . नैग्रम* (जंगली) का विरल द्विलिंगी प्रकार इकटठा किया गया। संरक्षिका में अब उपलब्ध कुल जर्मप्लाज्म में काली मिर्च कल्टिवार के 2299 अधिमिलन और *पैपर* स्पीशीस के 932 अधिमिलन शामिल हैं। *कालिमिर्च जर्मप्लाज्म के डाटाबेस एक सी डी में रखा* गया है।

इलायची और इसके संबद्ध स्पीषीसों का छब्बीस अधिमिलनों का समाहरण इडुक्की (15) सैलन्टवाली (9) और कुडागु (2) से किया गया। जिन्जिबेरेसिए के 11 *संबदध जेनेरा के सहित अब संरक्षिका में तीन सौ* पचासी अधिमिलनें उपलब्ध है। ऐ पी जी आर आई डिस्क्रिप्टा के आधार पर 14 गुणों के लिए इनमें से बहत्तर अधिमिलनों का मूल्यांकन किया गया।

जिन्जिबर स्पीशीस के इक्कीस अधिमिलनों का समाहरण किया *गया* ओर इसके 645 अधिमिलनों *तथा* करक्यूमा स्पीशीस के 800 अधिमिलनों संरक्षिका में रखा गया है। अदरक के 50 अधिमिलनों को आकृतिविज्ञान संबन्धी तथा उपज गुणों का अभिलेखन किया गया है।

केरल के कालिकट तथा और कण्णूर जिलों से *गर्सीनिया गम्मी -गटटा* के सात खेती किए गए अधिमिलनों को समाहरण किया गया है। *जी. गम्मी गटटा* के दस जंगली अधिमिलनें सिरुवानी ,सैलन्ट वाली (केरल) और किडु (कर्नाटक)जंगलों से समाहरण

किया गया। तलिव्परम्बा(केरल) और वेन्गुरला (महाराष्ट्र) से *जी. इन्डिका* के खेती किए गए दो अधिमिलनों का समाहरण किया गया। वेन्गुरला और कालिकट से *मिरिस्टिका* फ्राग्रन्स के छ अधिमिलनों का समाहरण किया गया। *एम बेडडोमी* के तीन अधिमिलनों को भी जर्मप्लाज्म में मिला दिया। वेन्गुरला से *साइसिजियम क्युमिनि* प्रजाति गोकक का एक अधिमिलन का समाहरण किया गया। वेन्गुरला से *सिन्नमोमम वीरम* के दो अधिमिलनों तथा नेपाल से सी सेसिडोडाफने का एक अधिमिलन का समाहरण किया गया। संरक्षिका में रखे गए कुल अधिमिलनों में क्रमश *सिन्नमोम* स्पीशीस, *मिरिस्टिका स्पी. साइसिजियम* स्पी और गार्जोनिय स्पी. के 302, 482, 223 और 32 अधिमिलनों शामिल है।

वनिला वाकेरिए, वी टाहिटेन्सिस और वी. प्लानीक्षेनफोलिया के एक एक अधिमिलन जर्मप्लाजम में मिला दिया है। संरक्षिका में वनिला स्पी. के तीस अधिमिलनें रखे गए है।

काली मिर्च (20) इलायची (1) अदरक (9) हल्दी (18) वनिला (85) क्याप्सिकम (12) और अन्य मसाले (81) के अधिमिलनें जीनबैंक में मिला दिया है। जीन बैक में अब विभिन्न मसाले फसलों के तीन सौ नवासी अधिमिलनें उपलब्ध है।

जर्मप्लाज्म के कोशिकात्मक ओर आणिवक लक्षणें

अदरक के 10 अधिमिलनों के कोशिकात्मक विश्लेषण से यह विदित हो गया है कि अधिमिलन 147 और 116 की क्रोमसोम संख्या साधारण 2n=22 है। जबकी अन्य अधिमिलनों की क्रोमसोम संख्या साधारण 2n=22 है। हल्दी के पाँच पौध सन्ततियों के विश्लेषण में विभिन्न क्रोमसोम संख्यायें दिखाई गई। (2n=42–94).

काली मिर्च के जर्मप्लाज्म के 70 अधिमिलनों से डी एन ए (DNA) का पृथक्करण किया गया और 13 पैपर स्पीशीस में रेन्डम प्रैमर के प्रयोग करते हुए आर ए पी डी प्रोफाइल विकसित किया गया। *जिन्जिबर* के चार स्पीशीस के आर ए पी डी प्रोफाइल और *करकूमा* के 12 कल्टिवार तथा 6 स्पीशीस भी पाँच प्राइमर के साथ विकसित किया गया। स्पीशीस स्तर से ही अपेक्षाकृत अच्छी बहुरूपता दिखाई पडी। दालचीनी में डी एन ए के पृथक्करण केलिए एक नयाभार का मानकीकरण किया गया है। आण्विक लक्षणें के लिए दालचीनी के 100 अधिमिलने, वनिला के 50 अधिमिलनें तथा 10 *सिन्नमोमम* स्पी. से डी एन ए का पृथक्करण किया गया है।

काली मिर्च में सच्चे संकरों का पहचानने के लिए आर ए पी डी पर आधारित अण्विक मर्कर तकनीक विकसित किया गया है। आर ए पी डी विशेष पितृ वृक्ष के पैतृक के आधार पर एच पी 34 एच पी७ 80 और एच पी 1411 संकरों की संकरता सुनिश्चित की गई।

फसल सुधार

रोपाई के चौले वर्ष के दौरान कालीमिर्च के समाहरण 1041 ओ पी के एम, एच पी 780 एच पी 1411 और एच पी 813 , 2–3 कि. ग्राम औसत उपज प्रति बेल (नाजे बेरियाँ) के साथ उनकी तर्जीह बनी रखी। काली मिर्च के संकरों के प्रारंभिक उपज मूल्यांकन से पाया गया कि रोपाई के तीसरे वर्ष में संकर एच पी 1313 2.1 कि, ग्राम (ताजे बेरियाँ) प्रति बेल की औसत उपज तथा 41.2% सूखी उपज देने की क्षमता रखती है।

काली मिर्च के प्रथम कायिक भ्रूणों (सी. वी. करिमुण्डा) को प्रेरित करके काली मिर्च के तुरंत क्लोनल गुणन के लिए द्वितीय भ्रूण-रचन से विकसित किया गया।

इलायची के 15 संकर संकलनों को उनकी क्षमता, हेटरोसिस, संकलन क्षमता, क्याप्सूल के आकार, आकृति तथा रंग और मोजाइक रोग की प्रतिरोधन क्षमता आदि के आधार पर पहचान लिया गया है। जीव द्रव्य, उपज, क्याप्सूल गुणों और पत्र - दाग तथा प्रकन्द सड़न रोग से प्रतिक्रिया के आधार पर जर्मप्लाज्म से तिरपन अधिमिलनों (4 मैसूर, 8 वाषुक्का, 29 मलबार और 12 संकुक्त पुष्पक्रम वर्ग) का समारहण किया गया। विशिष्ट वर्गीय काष्या के तीन वर्ष की क्लोनल संततियों के मूल्यांकन से ऐसा पाया गया कि उनके चारों प्रकारों (A2, C1, D1, D3) में महत्वपूर्ण विभिन्नताएँ नहीं होती है और इनकी उपज 137.6-462.7 ग्राम प्रति पौधे पर विभिन्न होती है।

लौंग में कलम बाँधने के लिए प्रयोग करनेवाले *साइसीजियम* स्पी. के मूलकांड के मूल्यांकन से पाया गया कि तीन वर्ष के बाद भी *एस. हेनियानम और एस अरोमाटिकम* के खेत के कलमों की बढ़ती संतोषजनक थी।

वी. टाहिटेन्सिस (मादा) और *वी. प्लानिफोलिया*(नर) और *वी. अफिल्ला* (नर) के द्वारा किए गए जात्यंतर संकरण से फूल-विकास में सफलता प्राप्त की।

निम्नताप में परिरक्षित वी. अफिल्ला के पराग से किए गए परागण भी फल- विकास में परिणत हुए।

उच्च उपजवाली प्रजातियाँ

अदरक की दो प्रजातियों यानी, ऐ ऐ एस आर महिमा तथा ऐ ऐ एस आर रजता जो क्रमश 23.2 टन/हे और 22.4 टन/हे उपजवाली है, को नर्मोचन करने का प्रस्ताव राज्य प्रजाति निर्मोचन समिति, केरल को प्रस्तुत किया गया है। मोटे प्रकन्दों इन प्रजातियों के प्रमुख लक्षण है। जायफल की एक उपजवाली प्रजाति, 3122 कि. ग्राम सूखे फल/हे और 480 कि ग्राम जावित्री (सूखा) /हे. के औसत उपजवाली ऐऐ एस आर विश्वश्री भी राज्य प्रजाति निर्मोचन समिति, केरल को प्रस्तुत किया गया है।

सूखा से सहिष्णुता के लिए मूल्यांकन

काली मिर्च के 150 अधिमिलनों को विभिन्न सूखा प्राचलों के लिए (आपेक्षिक जलांश, कोशिका-झिल्ली के टपकन, पत्तों से जलांश नष्ट, कटालेस और पेरोक्साइड गतिविधियाँ और प्रोटीन के इलक्ट्रो-फोरेटिक प्रकार) किए गए प्रारंभिक परीक्षणों से विदित हो गया कि अधिमिलन 828 अपेक्षाकृत सहिष्णुतावाला है। सूखा से बचाव के लिए ग्राफ्टिंग के लिए प्रयोग करने वाले मूलकांड के लिए मूल्यांकन किए गए *मिरिस्टिका* के विभिन्न स्पीशीसों में *एम. मलबारिका* सर्वोच्च पाया गया।

गुणता के लिए मूल्यांकन

गुणता के लिए काली मिर्च के दो सौ जर्मप्लाज्म अधिमिलनों का मूल्यांकन किया गया उनमें अधिमिलन 5302 में 8.0% तेल, 19.0% तेलीयराल और 3.7% पिपेरिन निहित है।

गुणता केलिए अदरक के 54 जर्मप्लाज्म अधिमिलनों का मूल्यांकन किया गया और अधिमि 197 सबसे गुणवत्ता वाला पाया गया जिसमें 2.5% तेल, 7.0% तेलीय राल और 2.8% रेशा निहित है

हल्दी के उच्च करक्युमिनवाले वर्ग जिसमें छ एएफटी (आलप्पी फिन्गर हल्दी) और प्रतिभा तथा प्रभा प्रजातियों भी शामिल है, स्पष्ट किया जाता है कि 18.6% सूरवी उपज के साथ अधि 585 (ए एफ टी

लाइन) सबसे अधिक उपज प्रदान किया (29 कि ग्राम ताज़ा) प्रति 3 वर्ग मीटर क्यारि) उच्च तथा निम्न करक्यूमिन अधिमिलनों में करक्युमिन के पुरोवर्तियों के रूपीकरण में सहायक होने वाले प्रमुख एनजाइम फीनाइनल अलनिन अमोनिया लयेस की प्रतिक्रिया करक्युमिन तल से पॉलिटिवली संबद्ध है। कोशिका प्रभाजन अध्ययन से देखा गया कि इस एनजाइम की उच्चतर प्रतिक्रिया माइटोकोन्ड्रिया मे है।

गुणता प्राचलों के लिए परीक्षित जायफल के 37 अधिमिलनों में गिरीदार फलों में सुगन्धित तेल 2.4% से 16.5% तक तथा जावित्री में 6.0% से 26.1% तक पाया गया। अधिमिलन A 9/18 के गिरीदार फल तथा जावित्री दोनों के सबसे ज्यादा तेल पाया गया। दोनों के सुन्धित तेल में पिनीन,सबीनिन मिरसीन मिरिस्टिसिन और एलिमिसिन प्रमुख घटक है। B 9/71 और ए 9/95 उच्च उपजवाले है, जिसमे सबीनिन तथा मिरसीन ज्यादा और मिरिस्टिन तथा एलिमिसिन कम रूप सेक पाया जाता है।

उच्च वर्गीय लौंग प्रजातियों में कलिका तेल की प्रतिशतता 12.9% से 20.5% तक भिन्न होती है और बी 76 में अधिकतम कलिका तेल पाई जाती है। पैडिसिल तेल की प्रतिशतता में 2.8 से 7.7 तक की भिन्नता पाई जाती है ओर बी 59 मे अधिकतम पैडिसिल तेल निहित है।

संयोजित पोषाहार प्रबंधन

काली मिर्च में पोषाहार प्रबंधन के अध्ययन से विदित हो गया है कि मिटटी में जिन्क के प्रयोग से जिन्के की मात्रा में ज्यादा वृद्धि हुई। जिन्क के प्रयोग से इसमें उपलब्ध फोसफोरस की मात्रा कम हो गई। संयोजित पोषाहार प्रबंधन को स्वीकार करने से मिटटी में पोषकों की उपलब्धता में वृद्धि हो गई और उपमें में 30%(वयनाड) से 40% (कोडगु) संयोजित वनस्पति पोषाहार प्रबंधन को स्वीकार करने से फाइटोफतोरा पादगलन रोग में कमी हुई और तेलीय राल एवं बेरी में पिपेरिन की मात्रा जैसे गुणता प्राचलों में वृद्धि हुई। अदरक में 0.25% (दो बार) की दर से पत्तियों में जिन्क के प्रयोग करने से मिटटी में प्रयोग करने की अपेक्षा प्रकन्दों की उपज में वृद्धि हुई। नीमखली के प्रयोग से नत्रजन की उपलब्धता में ज्यादा वृद्धि हुई और जिन क्यारियों में नत्रजन की आधी मात्रा यूरिया के रूप में 2 टन प्रति हेक्टायर की दर से नीम खली के साथ प्रयोग किया, उनमें सबसे ज्यादा नत्रजन की उपलब्धता अंकित की गई। नीमखली फॉस्फोबैक्टीरिया और फॅस्फेट मिटटी के रूप में फोस्फोरस, कैल्सियम, मग्निशियम जिन्क और मैनगनीम की उपलब्धता में काफी मात्रा में वृद्धि हुई।

फसलोत्तर प्रबंधन

पैपर छाबा के पकी शूकियों को नौ घंटे तक 60–65 सेल्शियस में सुखाना चाहिए ताकि इसके जलांश 5.5% के सुरक्षित स्तर तक हो जाए और तेलीयराल 8.1% में हो जाए।

50 सेल्सियस में जायफल के जावित्री को गर्म हवा में सुखाने के लिए चार घंटे चाहिए जहाँ विवर्ण करने तथा सुखाने के लिए 3.5 घंटे मात्र लगता है। जावित्री को 75 सेल्सियस गर्म पानी में सुखाने से पहले दो मिनट तक विवर्ण कटाने से गर्म हवा में सूखे हुए जावित्री से 23% अधिक रंग तथा रंग स्थिरता मिलती है। गर्म हवा में सूखे हुए और विवण किए गए जावित्री की सूखी उपज तथा बाष्पशील तेल तुलनीय है।

काष्या के शुष्कन तकनीकी के मूल्यांकन से विदित हो गया कि इसको गर्म हवा में सुखाने के लिए 50 °C में 3 घंटे चाहिए जहाँ धूप में सुखाने के लिए 1–2

दिन लगते हैं। गर्म हवा में सूखी हुई और धूप में सूखी हुई काष्या की सूखी उपज क्रमश 34.0% तथा 33.7% थे।

ताजे अदरक को 2% वायुसंचार वाले पोलिएतिलिन बैगों में भण्डारण करने से इसमें न्यूनतम निर्जलीकरण होता है जो कोर्डबोर्ड बक्स और अन्य खुले बर्तनों में रखने से बेहतर है। शून्य एनर्जी चेम्बर में भण्डारण करने से भी निर्जलीकरण नही होता है। चार महानों के भण्डारण के बाद सूखी उपज में 40% वृद्धि तथा रासायनिक गुणता में 20% कमी थी। चार महीनों तक भण्डारण करने के बाद उच्च उपजवाली प्रजाति वरदा से 19.8% सूखी उपज, 1.6% तेल, 4.9% तेलीय राल तथा 3.9% क्रूड फैबर प्राप्त हुए।

सोंठ के भण्डारण के दौरान सिगेरेट बीटल (लसिलोडेमी सेरीकोर्नी) के संक्रमण को रोकने के लिए विभिन्न स्पीशीस के पौधों के सूखे पत्तों के चूर्ण के मूल्याकन से पाया गया कि ग्लाइकोस्मिस पेन्टाफिल्ला और *असाडिराक्टा* इन्डिका के पत्ते चूर्ण में मुद्रित पीईटी बर्तनों में भण्डारण करने से बेहतर फल मिला था ।

जायफल के जावित्री का भण्डारण पी ई टी बर्तनों और पोलिएतिलीन बैगों में करने से इसमें ज्यादा जलांश पाया गया जबकि वाष्पशील तेल तेलीयराल तथा लाइकोपीन कम पाया गया।

काली मिर्च के चार गाहने की मशीनों (थ्रेशर) को गाहपे की क्षमता के लिए मूल्यांकन किया गया और टी एन ए यु ड्रम वाले थ्रेशर सबसे क्षमतावाला पाया गया जिसकी क्षमता 99.6% है और इसमें 150 कि. ग्राम गुच्छों प्रति घंटे गाहने की क्षमता होती है।

रोग प्रबंधन

फाइटोफतोरा पाद गलन

विभिन्न पोषदों से *फाइटोफतोरा* के चार सौ बहत्तर प्रकारों को *फाइटोफतोरा* के राष्ट्रीय संग्रह में रखा गया है। काली मिर्च पर संक्रमण् करने वाले *फाइटोफतोरा* के सत्तर प्रकारों को रूपवैज्ञानिक रूप से पहचान लिया गया जिसमें से 159 प्रकारें पी क्याप्सिका में ओर बाकी *पी पाल्मीवोरा* तथा *पी. पारासिटिका* में आता है।

काली मिच्र से ऐसोसाइम विश्लेषण के द्वारा *पी क्याप्सिकी* के जैवरासायनिक लक्षणवर्णनों से पाया गया कि इस स्पीशीस में दो उपप्रजातियाँ होती है। *काली मिर्च तथा इलायची से फाइटोफतोरा* प्रकारों के आर ए पी डी विश्लेषण के लिए नयाचार का मानकीकरण किया गया है।

पोषद प्रतिरोध

काली मिर्च के 343 संकरों, 7 कल्टिवारों तथा 9 जंगली अधिमिलनों के पी क्याप्सिक से प्रतिक्रिया के लिए छानबीन करने से पाया गया कि 9 संकरें 4 कल्टिवारें तथा दो जंगली अधिमिलनें सहिष्णु थे। 31 संकरों को *पी काप्सिकी* से प्रतिक्रिया के लिए फिर परीक्षणं किया गया और छ संकरें (एच पी 293 एच पी 400 एच पी 674 एच पी 1372 एच पी 1375 और एच पी 1389ऋ संहिष्णु पाए गए। पी 24(प्रतिरोधी लाइन) और के एस 27 (ग्रहणशील लाइन) को पी क्याप्सिकी के प्रति क्रियाशीलता के लिए छानबीन किया गया और पी २४ के पौदों में अधिक प्रतिशतता में सहिष्णुता की प्रतिक्रिया पाई गई।

प्रबंधन

कृषण क्रियाएँ

फाइटोफतोरा पादगलन रोग संक्रमित कालिमिर्च के बागों के पुनरुज्जीवन के लिए किए गए परीक्षणों से पाया गया कि खरपतवार बाले प्लोट (88.9%) की अपेक्षा साफ प्लॉट में (97.7%) बेलों की बढती तथा

उपज ज्यादा था। फिरभी ट्रइकार्डर्मा की मात्रा खरपतवार वाले प्लोटों में अधिक पायी गई। रोगसंक्रमित प्लोटों में जहाँ सोरीकरण के बाद पुनः रोपण किया था वहाँ बेलों की बढती बेहतर थी। खरपतवारवाले तथा साफ प्लोटों की अपेक्षा सौरीकृत प्लोटों में *ट्राइकोडेर्मा* अधिक पाई गई।

पैपर कोलुब्रिनम के प्रतिरोधी मूलकांड से किए गए परीक्षणें से पाया गया कि कलम बाँधने के पाँच वर्ष बाद भी बढती में कमी नहीं थी। इनमें से औरसत उपज ११ कि. ग्राम (हरा) प्रति पौधे की दर से उपज (सी वी करिमुण्डा) प्राप्त की थी। एक वर्ष पुराने कलम बंधे पौधों के सूक्ष्मौतिक वैज्ञानिक अध्ययन से पाया कि *पी कोलुब्रीनम* तथा *पी नैग्रम* का मेल पूर्ण था।

रासायनिक नियंत्रण

केरल तथा कर्नाटक से प्राप्त पी. क्याप्सिसी के २९ पृथकरणों को पोटासियम फोस्फोनेट से संबेदन क्षमता के अध्ययन से पाया गया कि इनकी संवेदन क्षमता में महत्वपूर्ण विभिन्नता है और बीजाणु उत्पात्ति की अवस्था में सबसे अधिक संवेदनक्षमता पाई गई।

ट्राइकोडेर्मा स्पी तथा पोटासियम फास्फोनेट के 'इन विट्रो' तथा 'इन विवो' संगतता का अध्ययन किया गयाऔर इस रासायनिक का कोई क्षतिकारक प्रभाव *टी हर्ज़ीरियेनम* पर नही पाया गया (क्रमश 60 और 1200 μg/ मि. लिटर तक)! *ट्राइकोडेर्मा* स्पी के प्रोटोप्लास्ट पुनः निर्मित कलोनियों को भी विकसित किया गया, जो कोप्पर ओक्सि क्लोराइड और मेटालाक्सिल से सहिणु भी थे।

जैविक नियंत्रण

जैविक नियंत्रण एजेंटों के रिपोसिटरी में ट्राइकोडेमी तथा अन्य फइफटतोरा विरोधी 473 पृथकरणें रखा गया है। सैलेंन्ट वाली से प्राप्त ट्राइकोडेमा्र पृथक्करण को रूपवैज्ञानिक दृष्टि से दो वर्गो में बाँटा गया, यानी, ट्राइकोडेर्मा और लोजिब्राकियेटम और सात स्पीशीसों में शामिल किया गया, यानी टी. पारसेरामोसम , टी. ओरियोविरिडी, टी. सिट्रिनोविरिडी और टी. लोजीब्रकियेटम। ट्राइकोडेर्मा स्पी. के 12 रान्डम प्रैमरों के प्रयोग करके किए गये मोलिकुलार वर्गीकरण से पाया कि 22 पृथक्करणों को तीन वगों में बाँटा जा सकता है जिसमें सबसे प्रभावी टी. हार्जियेनम है।

ट्राइकोडेर्मा स्पी. के 222 पृथक्करणों के पी. क्याप्सिकी के प्रति विरोध के लिए छानबीन किया गया और पाया कि पृथक्करणों द्वारा पी. क्याप्जिकी का **अवरोध** 20% ls. 84% भिन्न है। काली मिर्च के बढती के लिए 79 प्रभावी पृथकरणों की जाँच की गई, 29 पृथक्करणों बढती को वृद्धि करने वाले थे, काली मिर्च की बढती की वृद्धि 31.6% से 184.7% तक भिन्नता रखती थी। आठ पृथक्करणों रोग दमन करने वाले थे, रोग का संक्रमण 0% से 30% तक भिन्न है, नियंत्रण 80%से 100% तक साघ्य है।

जैविक नियंत्रणं एजेंटों के प्रयोग को निश्चित करने के लिए पी काप्सिकी कके आवपन के द्वारा ट्राइकोडेमी स्पी के विभिन्न सान्द्रता में 'बयो अस्भे' का आयोजन किया गया। *टी हार्जियानम और टी वैरेन्स* 17 से किए गए 'बयो अस्से' (bioassay) में रोग संक्रमण केवल 20% था, जबकि 10 सी एफ यु/ गा्रम मिटटी के विरोधी सान्द्रता में 90% नियंत्रण हो सकता है , जहाँ *टी. ओरियोविरिडी* 25 और टी वैरेन्स पी 12 में रोग संक्रमण को कम कराने के लिए 10 सी एफ यू/ग्राम मिटटी की जरूरत थी। जैविक नियंत्रण एजेंटों के विभिन्न मिश्रणों के प्रयोग (*टी हर्ज़ीयानम, टी. वैरेन्स. टी बोरियोविरिड और टी स्यूडोकोनिगी*) से काली मिर्च

के बेलों की बढती में 107.5–132.5% वृद्धि हो गई और 75% रोग दमन 0% नियंत्रण से साध्य हो गया। अलग अलग रूप से प्रयोग करने पर रोग दमन में 50% से 75% तक फल प्राप्त हुआ 'ग्रीन हाउस' अध्ययन से पाया कि सैलन्ट वाली के पौधे बढती में वृद्धि करनेवाले राइज़ोबैक्टीरिया के कुछ स्ट्रंन(,ऐ ऐ एस आर 310 ऐ ऐ एस आर 314 और ऐ ऐ एस आर 331) काली मिर्च के कलमों में 147–228% तक बढती में वृद्धि कर सकता है। ऐ ऐ एस आर 331 ने स्ट्रेन पी क्याप्सिकी इन विट्रों में अधिकतम 82.7% दमन दिखाया। ऐ ऐ एस आर 8, ऐ ऐ एस आर 11 और ऐ ऐ एस आर 51 फतूरसेंन्ट स्यूडोमोनाड स्ट्रेन जब एकल रूप से तथा मिश्रण रूप से या मेटालक्सिल मान्कोजेब फफूदनाशी के साथ उपचार किया तो काली मिर्च के बेलों को पुरुज्जीवित करने में सफल पाया गया। ऐ ऐ एस आर 8 ऐ ऐ एस आर 13 और ऐ ऐ एस आर 51 आदि फतूरसेंट स्यूडोमोनाड स्ट्रन भी प्रतिजैविकियों से प्रतिरोधी पाया गया।

फलूरसेन्ट स्यूडोमोनाड और ट्राइकोडेर्मा ने फाइटोफतोरा के भित्ति अपचय करने वाले एनजाइम, चानी, लिपेस β -1,3 ग्लूकनेसस और β-1,4 ग्लूकनेसस का उत्पादन किया। दोनों जैविक नियंत्रण एजेंट, फलूरसेन्ट स्यूडोमोनाड ऐ ऐ एस आर 51 और ट्राइकोडेर्मा स्पी. (ऐ ऐ एस आर 1369) भी संगत थे। काली मिर्च के संकवकी से संचयित ट्राइकोडेर्मा स्पी. (ऐ ऐ एस आर 1369) और फलूरसेंट स्यूडोमोनाड के मिश्रण अदरक और इलायची में मिटटी द्वारा संक्रमित होने वाले रोगजनकों से बचाने में सक्षम पाया गया।

फिल्लोडी रोण (Phyllody disease)

कोडन्चेरी पंचायत (कोषिकोड जिला) में फिल्लेडी रोग के लिए किए गए सर्वोक्षण से पाया गया कि कुछ बागों तीव्र रूप से संक्रमित हैं और उनमें 90% पौधों में इस रोग के लक्षण पाए जाते हैं। जंगलों के निकटवर्ती इलाकों में इस रोग ज्यादा पाया जाता है।

फिल्लोडी रोग संक्रमित पौधों के डी एन ए अलगकर जब फाइटोप्लास्मा रोग के लिए प्रयोग करनेवाले भौगोलिक प्रैमर के प्रयोग करके पी सी आर परीक्षण किया तब इन सांपिलों में बहुत इसका बंध मात्र था लो इस रोग के फाइटोप्लास्मल हेतुविज्ञान का घोतक है। फिल्लोडी रोग संक्रमित पौधों से कीटों के १२ स्पीशीसों में दो प्रकार के पौधे कीट इस रोग से हढ संबद्ध है।

शीरा प्रकटन रोग

निकोटियाना स्पी. और फाइसलिस स्पी सहित इलायची के छ पोषद पौधों के शिकटन प्रकटन रोग के विषाणुओं के यांत्रिक संक्रमण पर किए गए अध्ययन से पाया गया कि इन विषाणुओं का संक्रमण यांत्रिक रूप से नहीं हो सकता है। माइसस पेरसिके, एफिस स्पी. और टोक्सोटीरा स्पी. जैसे एफिडस भी इन विषाणुओं का संक्रमण नहीं कर सकता है।

जैवाणुक मुरझान रोग पिशेषताएं पौधों के जैवाणुम मुरझान रोक के हेतुक आर. सोलानेसियेरम के प्रभेदों को पहचानने के लिए आर एफ एल पी पी सी आर (RFLP-PCR) तकनीक का मानकीकरण किया गया। यादृच्छिक रंजको के प्रयोग करते हुए किए गए आर ए पी डी पी सी आर (RAPD-PCR) से व्यक्त हुआ कि करेल, कर्नाटक और उत्तर पूवीरय राज्यों के दरक की खेती करने वाले इलाकों से प्राप्त राल्सरोनिया सोलानेसियेरम के अदरक पृथक्करणों परस्पर संबंधित थे। प्रोटीन तथा ऊष्मा और ग्लूटार एलडीहाइड से उपचारित आर सोलानेसियेरम ऊत्तकों के विरुद्ध पॉलिक्लोनल प्रतिजैविकियाँ उत्पन्न हुई। पश्चिम ब्लोट विश्लेषण से पाया कि ऐसे उत्पन्न हर प्रतिजैविकियाँ इनके साथ

प्रयोग किए एन्टीजन के अलावा इसके अपने एन्टिजन से भी प्रतिक्रियाशील हो गया।

विभिन्न तापमान में 3 महीनों तक भंडारण किए गए अदरक-प्रकन्दों में आर सोलानेसियेरम के अतिजीवन के लिए सीरम वैज्ञानिक अध्ययन किया गया। 0 से और 4 सेलेशियस में रखे गए प्रकन्दों में अध्ययन की पूरी अवधि में लगातार न्यूनतम जीवाणु पाया गया, जो प्लेट संख्या तथा एलिसा (ELISA) अध्ययन से पाया था और पॉट कल्चर कस्थतियों में रोग संक्रमण की दर नगण्य था।

पोषद प्रतिरोध

टिश्यू कल्चर किए गए अदरक सोमाक्लोनों में अर. नामक जैवाणुक मुरझान रोगजनक को प्रत्यक्ष् रूप से संचारण करते हुए प्रतिरोध स्त्रों के पृथक्करण केए एक सरल छानबीन तकनीक विकसत किया गया। जैवाणुक मुरझान के विरुद्ध लगभग 250 अदरक जर्मप्लाज्म लाइनों का छानबीन किया गया और कोई भी प्रतिरोधी नहीं था।

अदरक के सहिष्णु ऊत्तक लाइनों के चयन के ए जैवाणुक मुरझान रोगजनक के विषाक्त उपचर्सजरें के प्रति अदरक कॉली की संवेदनशीलता के मूल्यांकन के लिए एक नयाचार विकसित किया गया।

अदरक के सूक्ष्म प्रकन्दों के प्रयोग करते हुए किए गए प्रोभिक खेत परीक्षणों से पाया कि इनको खेती में रोगमुक्त रोपण सार्माग्र के रूप में प्रयोग किया जा सकता है। सूक्ष्म प्रकन्दों के खेत मूल्यांकन से पाया कि साधारण रोपण सामग्रियों की अपेक्षा इनकी बढती अच्छी थी।

प्रबंधन

कृषक खेतों में किए गए प्रकन्द सौटीकरण से पाया गया कि पूर्वाहन में 9-11 बजे तक सौरीकरण किए गए बीज प्रकन्दों में रोग संक्रमण नगण्य था (<1%) और 10-12 बजे तक पूर्वाहन में सौरीकरण किए गए बीज प्रकन्दों में रोपण के तीन महीनों के बाद बिना सौरीकृत प्रकन्दों की अपेक्षा रोग संक्रमण शून्य था, और इनमें 33.6% मृत्यु दर पाया गया।

पौधों के पहलीवी निमाकृमियों को प्रबंधन

पोषद प्रतिरोध

राडोफोलस सिमिल्सि के विरुद्ध साठ काली मिर्च अधिमिलनो को छानबीन किया गया और छ अधिमिलनें पानी सी 1204, डब्ल्यू 254, डब्ल्यू 348 एच पी 39 एच पी 47 और एच पी 532 से प्रतिरोधी प्रतिक्रिया मिली। अदरक और हल्दीके छ अधिमिलनों को मेलोडाजैन इनकोग्निटा के प्रति प्रतिक्रिया के लिए छानबीन किया गया और हल्दी के दो अधिमिलनें (अधि 1 और 8) प्रतिरोधी प्रतिक्रिया प्रदान किया१

जैविक नियंत्रण

काली मिर्च, हल्दी तथा अदरक के बागों में एम इनकोग्निटा के दबाव के लिए ग्यारह प्रोमिसिंग प्रतिरोधी फफूद और एक बैक्टीरियल ऐसोलेट (पास्चूरिया पेनिट्रन्स) का ममूल्यांकन किया गया और पाया कि ये सभी सूत्रकृमियों के दबाव में महत्वपूर्ण सफलता प्राप्त की। वेर्टिसिल्लियम क्लामिडोस्पोरियम फयूसेरियम स्पी. और स्कोपुलेरियोप्सिस स्पी. ने काली मिर्च तथा अदरक में सूत्रकृमियों के नियंत्रण करने के अलावा इनकी उपज में भी वृद्धि की। वी. क्लामिडोस्पोरियम की बढती एवं गुणन के लिए अनुकूलतम पी एच और तापमान क्रमश पाँच और 26 डिग्री सेलश्यिस निश्चित किया गया है। इस फफूंद की अधिकतम बढती जापोक टोक्स अगार माध्यम में पाया गया। इस फफूद का गुणन स्टार्च पानी तथा नारियल पानी मे अच्छी तरह होता है। इस

फफूद के लिए कार्बन और पत्रजन का सबसे अच्छी स्त्रोत फ्रक्टोस तथा सोटियम नैट्रैट है इस ऐसोलेट में माबा के प्रति सहिष्णुता (कोप्पर ओक्सिक्लोराइड 2000 पी पी एम) भी पाई गई।

क्रोमोलीना ओडोरेटा, पिमेन्टा डायोका, पैपर कोलुब्रिपम तथा स्ट्रैकनोस नक्स वोमिका जैसे सूत्रकृमि प्रतिरोधी पौधों के राइजोस्पियर से 16 स्यूडोमोनास स्पी और 20 बासिल्लस स्पी. अलग किया गया और काली मिर्च से पहचान न किए गए 4 बैक्टीरिया प्राप्त हुए। राइजोबैक्टीरिया के 20 ऐसेलेटों को आर सिमिलिस के लिए तथा 52 ऐसोलेटों को एम इनकोग्निटा के लिए इन विट्रो स्थितियों में छानबीन किया गया। कई ऐसोलेट एम. इनकोग्निटा के प्रति अच्छी तरह प्रभावपूर्ण थे, लेकिन आर सिमिलिस के प्रति प्रोमिसिंग पाया गया एक पादप गृह परीक्ष्णं में मूल्याकन किए गए 84 ऐसोलेटों में से 21 राइसोबैक्टीरियल ऐसोलेटो ने एम. इनकोग्निटा के 100% दबाव किया।

सूत्रकृमियों के प्रबंधन के लिए किए गए काब्रनिक अमेंन्डेमेट के मूल्यांकन से पाया गया कि कालीमिर्च के आधारों में पैपर कोलुब्रिनम और स्ट्रैकनोस नक्सोविमा के पत्ते मिला देने से सूत्रकृमियों का नियंत्रण हो सकता है।

शलभ कीटों का प्रबंधन

पेल्लु बीटल (*लोजिटार्सस नैग्रिपेन्निस*) से प्रतिरोध पाने के लिए स्त्रोतों को ऐसोलेट करने के उददेश्य से कालीमिर्च के 186 कल्टिवार 34 सेकरों और 3 सोमाक्लोनों को छानबीन किया गया और काली मिर्च के एक मुख्य शलभ कीट ने सूचित किया कि सभी अधिमिलनें इस कीट के संक्रमण से प्रभावित है। काली मिर्च के प्रतिरोधी तथा प्रभाव्य अधिमिलनों के पत्तों के जैवरासायनिक वृत्त से पाया गया कि प्रतिरोधी अधिमिलनों में कार्बोहाइड्रेट, फीनोल तथा शून्य अमिनों एसिड उच्चतर गाढा है। प्रतिरोधी अधिमिलनों तथा जंगली स्पीशीसों में (पैपर छाबा) पी कोलुग्रिनम पी बारबेरी और पी लोंगाम सतही वैक्स घटकें उच्चतर पाया गया।

पोल्लु बीटल के भोजन गतिविधियों को जानने के लिए विभिन्न स्पीशीस के बीज तथा पत्ते निचोडों का मूलयांकन किया गया और पाया कि ए स्कामोसा बीजों के मेथनोल एवं हेक्सेन निचोडों के कारण ये १ऽ सान्द्रता में इन कीटों के भोजन क्रियायें पूर्णतः निवारण करने में सफल है।

जड का आक्रमण करने वाले मीली बग

वयनाडु में काली मिर्च के जडों का आक्रमण करनेवाले मीली बग(*प्लानोकोकस* स्पी) के प्रबंधन के लिए चार कीटनाशियों का मूल्यांकन किया गया और इससे पाया गया कि वेलों को क्लोरपैइरीफोस ०.०७५ऽ से उपचार करने से इसका प्रबंधन प्रभावपूर्ण ढंग से किया जा सकता है।

प्ररोह वेधक

प्ररोह वेधको के प्रबंधन के लिए निर्धारित छिडकाव तरीकों को अपनाए गए अदरक में कीटनाशियों के अवशेष निश्चित किया गया। 0.1% मालथयोन और 0.075% मोनोक्रोटोफोस के चार दौर का छिडकाव या इन कीटनाशियों के दो दौर के छिडकाव संक्रमित प्ररोहों में करने से अदरक के सूखे प्रकन्दों में कीटनाशियों का अवशेष नही के बराबर पाया गया।

प्रकन्द स्केल

अदरक को भण्डारण में आक्रमण करने वाले प्रकन्द स्केल (आस्पडियेल्ला हार्टी) के प्रबन्धन के लिए भण्डारण सामग्री के रूप में प्रयोग के लिए कई पौधों

की सूखी पत्रियों का मूल्यांकन किया गया। इन परीक्षणों से पाया गया कि बीज प्रकन्दों को 0.075% क्विनालफोस में डुबाकर स्ट्राइकनोस नक्स वोमिका की सूखी पत्तियों में भण्डारण करने से प्रकन्दों से उच्चतर उपज, उच्चतर मुकुलन और प्रकन्द स्केलों का आक्रमण कम पाया गया।

भण्डारण के कीटें

कालिकट और कोची के व्यापारियों के भण्डारों में किए गए सर्वेक्षण से पाया गया कि अदरक और हल्दी के सूखे प्रकन्दों को आक्रमण करने वाले कीटों में लासियोडेर्मा सेरीकोम. राइजोपेरथा डोमीनीका, ट्राइबोलियम कस्टानियम, अरेसिरस फासिकुलेटस और टेनिब्रोडस मोरिटानिकस मुख्य है।

अर्थविज्ञान

केरल और कर्नाटक में किए गए सर्वेक्षण से पाया गया कि मुख्य मसाले फसलों के उत्पादन लागत काफी मात्रा में बढ गई। काली मिर्च का उत्पादन 1:9 के लाभ लागत अनुपात में लाभकारी सिद्ध हुआ। लेकिन, अदरक और हलदी का उत्पादन <1 के लाभ - लागत अनुपात में पाया गया क्योंकि इनके मूल्य में अतयंत उतार हुआ है। विभिन्न मसाले फसलों के क्षेत्रफल, उत्पादन, मूल्य, माँग एवं पूर्ति, निर्यात तथा कीट और रोग का प्रभाव आदि शामिल करते हुए एक डिजिटाइज्ड डाटाबेस तैयार किया गया है।

रोपण सामग्री का उत्पादन

काली मिर्च के जड कलमें (25,000) इलायची पौद (14000) इलायची बीज क्याप्सुल (100 कि. ग्राम) अदरक बीज प्रकन्द (6 टन) हल्दी के बीज प्रकन्द (5 टन) और जायफल के ग्राफट (6800) तैयार करके कृषंकों और विभिन्न अभिकरणों को वितरण किया गया। प्रगामी कृषकों तथा विकासात्मक अभिकरणों के द्वारा अदरक (वरदा, महिमा और रजता) और हल्दी (प्रभा और प्रतिभा) के लगभग 1000 कि. ग्राम बीज प्रकन्दों का उत्पादन किया गया।

विस्तार

इस संस्थान में प्रगामी कृषकों और राज्य कृषि और बागवानी विभागों के अधिकारियों तथा निजी अभिकरणों के लिए मसाला उत्पादन तकनीकी में प्रशिक्षण कार्यक्रम आयोजित किया गया। विभिन्न मसालों के उत्पादन को विवरण करने वाले विस्तार पत्रकों का निर्मोचन इस वर्ष के दोरान किया गया। 14 उघमकर्ताओं को ट्राइकोडेर्मा स्पी. के उत्पादन की तकनीकी की बिक्री की गई। संस्थान के वैज्ञानिकों द्वारा की गई परामर्श सेवा के द्वारा 2.5 लाख रुपए प्राप्त हुए।

कृषि विज्ञान केन्द्र

फसल उत्पादन, बागवानी, पशु विज्ञान और मत्स्यकी में इक्यावन ह्रस्वकालीन पाठयक्रम चलाया गया। नारियल के साथ सहफसल के रूप में अदरक और हल्दी के कृपया करने से अतिरिक्त आमदनी के रूप में 37000/- रूपए प्रति एकड की दर से प्राप्त होता है। गहरी-पानी के धान की प्रजातियों के मूल्यांकन से पाया गया कि क्षेत्रीय प्रजाति मुण्डन की अपेक्षा सविता और नीरजा उपज में उत्कृष्ट पाया गया। जब पशुएँ छः महीने के उम्र के हो जाते है, या 25 कि. ग्राम भार के हो जाते है, तब बिक्री करने से ब्रोयलर बकरी का उत्पादन लाभकारी पाया गया। जब साधारण भोजन के साथ रोज मछली-तेल और नीम के पत्ते देने से उनकी बढती में वृद्धि दिखाई पडी। पेरुवन्नमुषी में सौ स्पीशीस के औषधीय पौधों की यूनिट की स्थापना की गई। कृषि विज्ञान केन्द्र ने रोपण सामग्रियाँ तथा सब्जी बीज उत्पादन, वर्मी कम्पोस्टिंग और गोयाटरी

(goatary) में ग्रामीण नवयुवकों को स्वयं नौकरी में मदद की१ आवर्तक निधि योजना के प्रयोग करके 3 लाख रूपए के रोपण सामग्रियों का उत्पादन किया।

मसाले फसलों के अखिल भारतीय समन्वित अनुसंधान परियोजना

खोजात्मक सर्वेक्षणों और विनिमयों के द्वारा पहचान किए गए प्रोमिसिंग अधिमिलनों से मसालों के जर्मप्लाज्म परिपुष्ट किया गया। काली मिच्र के एक पा्रमिसिंग लाइन के रूप में अधिमिलन 239 पहचान किया गया। इलायची में उच्च उपजवाली (अधि 8-4-डी 11 और 7-24-डी 11) और सूखा से सहिष्णु (सी एल 668, पी-6, डी 237, 2-2 डी 11) अधिमिलनें पहचान लिया गया! प्रोमिसिंग लाइन के रूप में अदरक में V_3 S1-8 और हलदी में पी टी एस 59 और पी टी एस 55 को पहचान लिया गया और ये निर्मोचन के लिए तैया स्थिति में थे। अदरक के V1E8-2 और हल्दी के पी टी एस -43, टी सी पी 1 और टी सी पी 2 प्रजातियाँ निम्रोचन के लिए प्रस्तावित किया गया है। हल्दी के आलीपी और बी डी जे आर-1260 प्रजातियों में बडी मात्रा में करक्युमिन होने के कारण उनका चयन किया गया। पत्तों के लिए सबसे अच्छे प्रकार के रूप में धनिया के श्रेष्ठ लाइन (ई सी - 2-32666) को पहचान लिया गया। जीरा में सबसे अधिक बाष्पशील तेल ई सी 232684 (4.4%) और जे सी 147 (3.9%) में और सौंफ में यु एफ 144 में पाया गया।

काली मिर्च में सिंचाई तथा उर्वरकों के प्रयोग संबंधी विसरणियाँ विकसित करके निधा्ररित किया गया। इलायची में कार्बनिक तथा अकार्बनिक खादों के साथ 100:100:175 कि. ग्राम नत्रजन फोसफरस पोटाश प्रति हेक्टर की दर से सिफारिश किया गया। सूक्ष्मपोषकों के प्रयोग से सौंफ और धनिया की उपज में वृद्धि हुई।

पौध संरक्षण के लिए विकसित किए गए कृषि क्रियाएँ काली मिर्च में फाइटोफतोरा पाद गलन के प्रवंधन के लिए सिफारिशं किए गए। ट्राइकोडेर्मा स्पी. के बडी मात्रा में गुणन के लिए कम लागतवाली तकनीकी विकसित की गई। डाइथेन एम 45 और बाविस्िअन मिलाकर रतीली गडढों में बीज प्रकन्दों के भण्डारण करके भण्डारण किए गए अदरक के प्रकन्द गलन का नियंत्रण किया जा सकता है।

धनिया के RCr 441 RCr 435, RCr 436, UD 446 ओर UD 684 प्रजातियाँ जड गाँठ सूत्रकृमियों के प्रतिरोधी थे। जीरा में मुरझान को कम करने एवं उच्च उपज मिलने के लिए 10 नवंबर से लेकर बुआइर करना अनुकूल पाया गया है। गुज कुम 3 आधि 1136 अधि 1145, अधि 1165 आदि फयुसेरियम मुरझान से अपेक्षाकृत प्रतिरोथी थे ।