

Research Highlights 2001-02

IIISR-RH-15



Indian Institute of Spices Research
Calicut

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Indian Institute of Spices Research
(Indian Council of Agricultural Research)
Calicut, Kerala, India.

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Director's Introduction

India has entered an era of free trade and globalization. The export of spices from the country is not encouraging in recent years compared to other spice producing countries. The Indian Institute of Spices Research is undertaking research programmes and other activities to meet the challenge posed with the changing scenario.

The institute has been addressing issues related to rearing and farming systems, pest and disease management, post harvest losses, etc. emphasized in Vision 2020. These programmes are being implemented through 29 externally funded projects on various spices like cardamom, ginger, turmeric, nutmeg, cinnamon, cassia, and paprika.

The Convention on Biodiversity envisages time bound conservation programmes and hence a high priority was given to the characterization of germplasm through molecular markers. These were continued to be given a major emphasis and various traits were identified. Two high yielding, high quality varieties are in an advanced stage of release that would help the farmers. Conventional and biotechnological approaches are being used to overcome biotic and abiotic stresses in black pepper, cardamom, etc.

Systematic research is being undertaken for integrated pest management, use efficiency for sustainable production. Studies on organic farming and identification of drought tolerant varieties are being undertaken. Emphasis has been given to develop post harvest crops, prevention of post harvest losses, processing and marketing to make Indian spices globally competitive.

Eco-friendly integrated management of pests and diseases in ginger and turmeric through tolerant and resistant varieties, products, biocontrol agents and safer pesticides are being developed by the institute. A Repository of Biocontrol Agents with over 100 strains is being maintained by the institute. These are being characterized and tested for compatibility with agrochemicals.

The institute has built up a digital information base on all aspects of spice crops through the Integrated National Agricultural Resources Information System (INARIS). The Bioinformatics Centre concentrated on development of databases and web sites and imparted training and education to keep pace with the explosion of information technology. The Agricultural Technology Information Centre (ATIC) functioned as a single window delivery system for dissemination of technology and information emanating from the institute.

Production of quality planting materials of various spice crops is a major thrust area of the institute. Standardization of seed production technology in ginger through micro tubers has become a handy tool for production of disease-free seed ginger.

The institute continued to collaborate and work in close coordination with other organizations and universities concerned with research and development of spices. The Indian Institute of Spices Research has completed 25 years of service and can legitimately take pride in the remarkable contributions it has made during the past through innovative research and development activities. It is our endeavour to ensure that the institute would continue to strive for the betterment of spice farmers in the years to come.

I gratefully acknowledge the encouragement and support given by Dr. Panjab Singh, Director General, ICAR and Secretary, DARE, Dr. G. Kalloo, Deputy Director General (Horticulture), Indian Council of Agricultural Research, New Delhi, and Dr. Manju Sharma, Secretary, Department of Biotechnology, New Delhi, in all our activities. The research achievements of the institute during 2001–02 are presented in this publication.

April 2002

Y. R. Sarma
Director

Genetic Resources

Black pepper

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

Cardamom

Twenty six accessions 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 germplasm conservatory. Seventy two accessions were evaluated and characterized for 14 characters based on IPGRI descriptor.

Ginger and turmeric

Twenty one new accessions of *Zingiber* spp. were collected and added to the germplasm. Six hundred and forty five 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.

Tree spices

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 double-nut type) were collected from Vengurla and Kozhikode District. Three accessions of *M. beddomei* 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 include 302, 482, 223 and 32 accessions of *Cinnamomum* spp., *Myristica* spp., *Syzygium* spp. and *Garcinia* spp., respectively.



A collection of *Garcinia gummi-gutta* from Thusharagiri

Vanilla

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.

Paprika

Fifteen exotic collections and 24 indigenous collections of paprika were maintained in the germplasm conservatory.

In vitro genebank

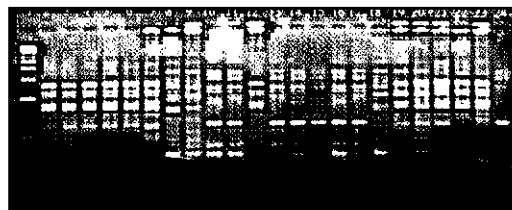
Accessions of black pepper (20), cardamom (1), ginger (9), turmeric (18), vanilla (85), capsicum (12) and other spices (81) were added to the *in vitro* genebank. Three hundred and eighty nine accessions of various spices are now available in the *in vitro* genebank.

Cytological and molecular characterization

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 such as $2n=42$ (Acc. 336), $2n=58$ (Acc. 514), $2n=63$ (Acc. 473), $2n=64$ (Acc. 761) and $2n=94$ (Acc. 561).

DNA was isolated from 70 lines of black pepper germplasm and RAPD profiles were developed in 13 spp. of *Piper* using random

primers. RAPD profiles of 4 species of *Zingiber* and 12 cultivars and 6 species of *Curcuma* were 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 lines of vanilla and 10 species of *Cinnamomum* for molecular characterization.



RAPD polymorphism in species and inter specific hybrids in vanilla

Crop Improvement

Black pepper

The promising black pepper lines namely, 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 of planting. Preliminary yield evaluation of hybrids of black pepper indicated the potential of 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.

Primary somatic embryos of black pepper (cv. Karimunda) were induced and scaled up through secondary embryogenesis for rapid clonal multiplication of black pepper through *in vitro* means.

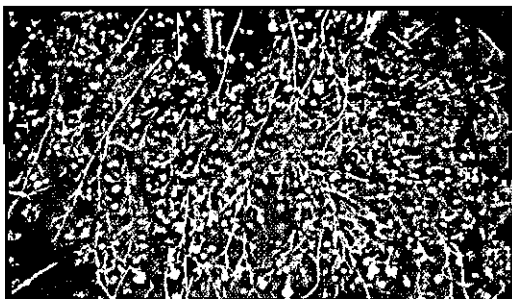


Secondary embryogenesis in primary somatic embryo of black pepper

A RAPD based molecular marker technique was developed in black pepper for identification of true hybrids. 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.

Cardamom

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. These hybrid combinations and selections were clonally multiplied for evaluation in the field.



A promising hybrid of cardamom

Cassia

Evaluation of 3 year old clonal progenies of elite lines of cassia at Peruvannamuzhi indicated that there were no significant differences among the four lines (A-2, C-1, D-1, D-3). The elite line D-1 yielded the highest with a mean fresh bark yield of 462.7 g/plant.

Clove

Evaluation of related species of *Syzygium* as rootstocks for grafting of clove for increasing productivity indicated that the growth of the grafts in the field on *S. heyneanum* and *S. aromaticum* was satisfactory even after 3 years.

Vanilla

Interspecific 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.

High yielding varieties

Ginger

Proposals for release of two ginger varieties namely, IISR Mahima and IISR Rejatha with average yields of 23.2 t/ha and 22.4 t/ha, respectively, were submitted to the State Variety Release Committee. These varieties are characterized by bold rhizomes with low fibre content.

Nutmeg

A high yielding nutmeg variety, IISR Viswashree with an average yield of 3122 kg nuts (dry)/ha and 480 kg mace (dry)/ha during the eighth year of planting was also submitted to the State Variety Release Committee.

Drought Management

Preliminary screening of 150 accessions of black pepper for various 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. Various species of *Myristica* were evaluated as rootstocks for grafting nutmeg to overcome drought, among which *M. malabarica* was superior.



Myristica malabarica, a promising rootstock for nutmeg

Integrated Nutrition Management

Black pepper

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 less than 2% due to the adoption of IPNM. Quality parameters such as oleoresin and piperine contents of berries were enhanced due to the adoption of IPNM.

Ginger

Foliar application of Zn @ 0.25% (twice) resulted in high rhizome yield (16.2 kg/3m² bed) when compared to soil application (14.4 kg). Application of neem cake increased availability of N significantly and the highest available N was recorded in beds in which half the dose of N as urea along with neem cake @ 2 t/ha was applied. Availability of soil P, Ca, Mg, Zn, and Mn increased significantly with application of neem cake, phosphobacteria and P as rock phosphate.

Evaluation for Quality

Black pepper

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

Ginger

Among the 54 germplasm accessions evaluated for quality, Acc. 197 was promising with 2.5% oil, 7.0% oleoresin and 2.8% fibre.

Turmeric

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 mitochondria.

Nutmeg

Among the 37 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 A9/18 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. A9/71 and A9/95 were promising with high sabinene and myrcene, along with low myristicin and δ -elemicin contents. The high yielding accession A9/4 had high myristicin (12.5% in nut oil and 22.0% in mace oil) and δ -elemicin (13.7% in nut oil and 20.8% in mace oil).

Clove

In the trial on evaluation of elite clove lines at Peruvannamuzhi, 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 2.8% to 7.7% and B-59 had maximum pedicel oil.

Post Harvest Management

Drying of *Piper chaba*

Drying of *Piper chaba* at 60–65°C for 9 h was essential to reduce the moisture content to a safe level. After drying, the moisture content of mature, ripe and over-ripe spikes was reduced to 5.6%, 5.7% and 6.5%, respectively, while the oleoresin content increased to 8.1%, 7.1% and 6.6%, respectively.

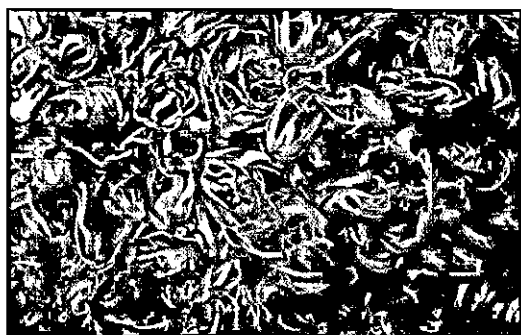
Storage of ginger

Storage of fresh ginger in polyethylene bags with 2% ventilation 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. Storage in zero energy chamber also did not result in dehydration. 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.

Dried leaf powder of various plants were evaluated for prevention of infestation by cigarette beetle (*Lasioderma serricorne*) during storage of dried ginger rhizomes. The trials indicated that storage of dried rhizomes in leaf powder of *Glycosmis pentaphylla* and *Azadirachta indica* and in sealed polypropylene containers was more effective in preventing the infestation by the pest.

Drying of nutmeg

Studies were undertaken to standardize techniques for drying of mace. Hot air drying of 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 of hot air dried and blanched mace were comparable.



Hot air dried mace

Drying of cassia

Evaluation of drying techniques in cassia indicated that hot air drying of cassia required 3 h at 50°C while sun drying took 1 or 2 days. The dry recovery of hot air dried and sun dried cassia were 34.0% and 33.7%, respectively.

Evaluation of threshers

Four black pepper threshers were evaluated for their threshing efficiency and capacity and the TNAU drum type thresher gave the highest efficiency of 99.6% and could thresh 150 kg of spikes per hour.

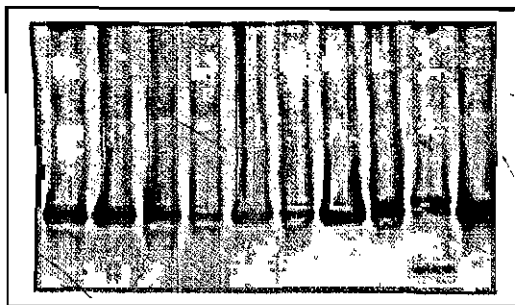
Diseases

Black pepper

Phytophthora foot rot

Characterization

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. Fifty two isolates of *Phytophthora* from betel vine were characterized morphologically among which 39 isolates belonged to *P. parasitica* and 13 to *P. capsici*. Biochemical characterization of *P. capsici* from black pepper and *P. parasitica* from betel vine using isozyme analysis revealed the existence of two sub populations in both these species. Protocols were standardized for RAPD analysis of *Phytophthora* isolates from black pepper and cardamom.



Isozyme profile of diaphorase in *Phytophthora parasitica* isolates from betel vine

Host resistance

Three hundred and forty three black pepper hybrids, 7 cultivars and 9 wild accessions were screened for their reaction to *P. capsici* among which 9 hybrids, 4 cultivars and 2 wild accessions showed tolerant reaction. Thirty one promising hybrids (based on preliminary screening) were further tested for their reaction to *P. capsici* among which 6 hybrids (HP-293, HP-400, HP-674, HP-1372, HP-1375 and HP-1389) showed tolerant reaction consistently. Seedling progenies of P-24 (resistant line) and KS-27 (susceptible line) were screened against *P. capsici* and the percentage of seedlings showing tolerant reaction was more in the progenies of P-24.

Management

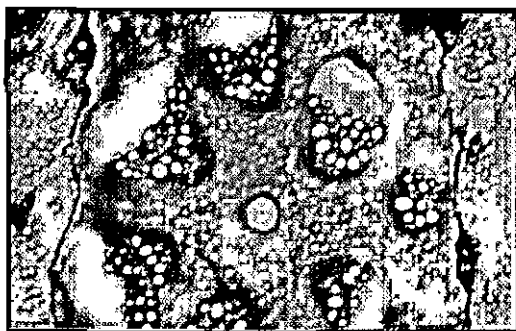
Cultural practices

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 compared to plots with weeds. However, the population of *Trichoderma* sp. was higher in plots with weeds (0.44×10^3 – 15.50×10^3 cfu/g) than under clean cultivation (0.27×10^3 – 13.00×10^3 cfu/g).

In disease affected plots, where replanting was done after soil 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 (28.80×10^3 cfu/g) compared to plots with weeds (15.84×10^3 cfu/g) and under clean cultivation (12.49×10^3 cfu/g).

Trials with resistant rootstocks of *Piper colubrinum* in a farmer's field (low-lying area) indicated that there was no deterioration in growth of grafted vines even after 5 years after grafting. The average yield obtained from these vines (cv. Karimunda) was 11 kg (green) per standard with an average height of 6.4 m. Histological studies of one year old grafted vines indicated that the graft union between *P. colubrinum* and *P. nigrum* was complete.



Anatomy of graft union of *Piper colubrinum* and *Piper nigrum*

Chemical control

The sensitivity of 29 isolates of *P. capsici* obtained from various parts of Kerala and Karnataka to potassium phosphonate was studied. The estimated ED₅₀ and ED₉₀ values for different isolates showed that there was a significant variation in the sensitivity of these

isolates to the chemical and sporulation was the most sensitive stage (ED_{50} value: 0.3 to 36.3 mg/ml and ED_{90} value: 2.1 to 129.3 mg/ml).

The fungitoxic principle in leaf oil of allspice which inhibited mycelial growth of *P. capsici* was identified as monoterpene eugenol.

The compatibility of *Trichoderma* sp. and potassium phosphonate was studied *in vitro* and *in vivo*. The chemical did not show any deleterious effect on *T. harzianum* (*in vitro* up to 60 mg/ml and *in vivo* up to 1200 mg/ml).

Biocontrol

Characterization

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. They belonged to 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* species using 12 random primers indicated that all the 22 isolates could be grouped into three clusters, the predominant being *T. harzianum*.

Protoplast regenerated colonies of *T. virens* P-12 tolerant up to 300 ppm of copper oxychloride, *T. aureoviride* 25 tolerant up to 800 ppm of metalaxyl and *T. harzianum* P-26 tolerant up to 500 ppm of metalaxyl were obtained.

Screening of efficient fluorescent pseudomonad strains namely, IISR-8, IISR-13 and IISR-51 to antibiotics indicated that they were resistant to NaI. 40, Chl. 30, Str. 100 and Cyc. 100. IISR-8 was also resistant to Amp. 100, Tet. 15 and Gen. 10. IISR-13 showed additional resistance to Tet. 15 and Gen. 10.

Antagonistic efficacy

Two hundred and twenty two isolates of *Trichoderma* spp. were screened *in vitro* for their antagonism to *P. capsici*. The inhibition of *P. capsici* by different isolates of *Trichoderma* varied from 20% to 84%. Among the 79 promising isolates tested *in vivo*, 29 isolates were plant growth promotive. The increase in growth of black pepper plants over control varied 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.

Combinations of *T. harzianum*, *T. virens*, *T. aureoviride* and *T. pseudokoningii* were tested *in vivo* for growth promotion of black pepper and disease suppression in comparison with their individual application.

Various combinations of these biocontrol agents resulted in 107.5–132.5% increase in plant growth over control and showed 75% disease suppression as against 0% in control. In individual applications, the disease suppression ranged from 50% to 75%.

Bioassays were conducted with different concentrations (10^1 to 10^8 cfu/g of soil) of *T. harzianum* P-26, *T. virens* P-12, *T. aureoviride* 25 and *T. virens* 17 by challenge inoculation with *P. capsici* to determine the optimum dose required for application of biocontrol agents. In the bioassay using *T. harzianum* P-26 and *T. virens* 17, the disease incidence was 20% at an antagonist dose as low as 10^4 cfu/g of soil as against 90% in control. Whereas, *T. aureoviride* 25 and *T. virens* P-12 required 10^7 cfu/g of soil to reduce the incidence of the disease.

Plant Growth Promoting Rhizobacteria (PGPR) obtained from Silent Valley were tested for growth promotion and disease suppression. The strains IISR-310, IISR-314 and IISR-331 could increase the growth of black pepper cuttings by 147–228% in greenhouse conditions. 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. However, the rejuvenation of infected

cuttings was pronounced when the bacterial treatments were supplemented with the fungicide metalaxyl-mancozeb.

Fluorescent pseudomonads and *Trichoderma* isolates induced *Phytophthora* wall degrading enzymes such as lipases, α -1,3 glucanases and α -1,4 glucanases. *In vitro* and *in planta* studies revealed the mutual compatibility of the two efficient biocontrol agents namely, fluorescent pseudomonad (IISR-51) and *Trichoderma* (IISR-1369). The combination of *Trichoderma* (IISR-1369) and fluorescent pseudomonad (IISR-11) collected from black pepper rhizosphere could impart greater protection against soil-borne pathogens in ginger and cardamom thereby indicating their plasticity and adaptability.

Phyllody disease

Distribution

A survey for incidence of phyllody disease in Kodencherry Panchayat (Kozhikode District) showed that a few gardens were severely affected with more than 90% of the plants showing the symptoms of the disease. The disease was confined to areas adjacent to forests.



Phyllody disease of black pepper

Etiology

DNA from phyllody affected plants was isolated and subjected to PCR test using universal primer for phytoplasma disease. There was a very faint band in the samples from affected vines thereby confirming the phytoplasmal etiology of the disease based on EM studies. Among the 12 species of insects collected from phyllody affected plants, 2 plant hoppers (unidentified) were consistently associated with diseased vines.

Ginger

Bacterial wilt disease

Characterization

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. A RFLP-PCR technique was standardized for identifying the strains of the *R. solanacearum* causing bacterial wilt of crop plants. High molecular weight membrane protein (42.3 kDa) specific for biovar III of *R. solanacearum* was purified by native gel electrophoresis.

Polyclonal antibodies were developed against the protein as well as heat and glutaraldehyde treated *R. solanacearum* cells and their dilution end point was determined as 1 : 50,000. Further, 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 by plate count and ELISA studies for 3 months. Rhizomes stored at 0°C and 4°C sustained minimum bacterial population and negligible disease incidence was observed in the plants raised from these rhizomes under pot culture conditions.

Host resistance

A simple screening technique for identifying 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.

The sensitivity of ginger calli to the toxic metabolites of *R. solanacearum* was evaluated to select tolerant cell lines of ginger. The survival of ginger calli was inversely correlated to concentrations of cell-free culture filtrate of the pathogen with 100%, 90% and 75% death at 16%, 8% and 4% concentrations, respectively. Further growth in toxin-free medium was observed in the calli obtained from 4% toxin amended medium.

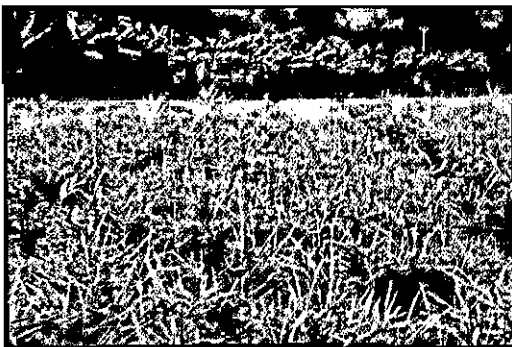
Preliminary field trials with microrhizomes of ginger indicated that they can be

used as disease-free planting material for cultivation. Field evaluation of micro rhizomes indicated that they performed well when compared with normal planting material.

Rhizome rot disease

Management

Trials on rhizome solarization conducted in farmers fields indicated that solarization of seed rhizomes for 2 h during 9-11am resulted in negligible disease incidence (<1%). Solarization for 2 h from 10 am-12 noon resulted in a crop completely free from disease after 3 months of planting as compared to unsolarized rhizomes where 33.6% mortality of plants was observed. Aerated steam treatment of rhizomes at 51°C for 15 min was also promising in controlling rhizome rot of ginger.



Disease-free ginger raised from solarized rhizomes

Plant Parasitic Nematodes

Host resistance

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 in the preliminary screening. 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. The host status of eight turmeric and seven ginger accessions was confirmed by screening them in microplots with nematode sick soil.

Biological control

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 nematodes.

The optimum pH and temperature conditions for growth and multiplication of *V. chlamydosporium* were determined to be 5°C and 26°C, respectively. Maximum growth of the fungus was observed in Czapek-Dox agar medium. The fungus multiplied well in starch water and coconut water also. The most preferred carbon and nitrogen sources by the fungus were fructose and sodium nitrate; tolerance 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 were screened against *R. similis* while 52 isolates were screened against *M. incognita* under *in vitro* conditions. In a greenhouse trial, 21 rhizobacterial isolates caused 100% suppression of *M. incognita* among the 84 isolates evaluated.

Insect Pests

Black pepper

Pollu beetle

Host resistance

Screening of 186 cultivars, 34 hybrids and 3 somaclones of black pepper accessions available in the Germplasm Conservatory against pollu beetle (*Longitarsus nigripennis*), a major pest of black pepper, indicated that all the accessions were susceptible to the pest. The biochemical profile of leaves from pollu resistant and susceptible black pepper accessions revealed higher concentrations of carbohydrates, phenols and free amino acids. Higher levels of methionine, histidine and arginine were also associated with resistance. Surface wax components were consistently higher in resistant accessions and

wild species (*Piper chaba*, *P. colubrinum*, *P. barberi* and *P. longum*). The pollu resistant lines were subjected to headspace analysis and there were significantly different peaks in resistant and susceptible lines.

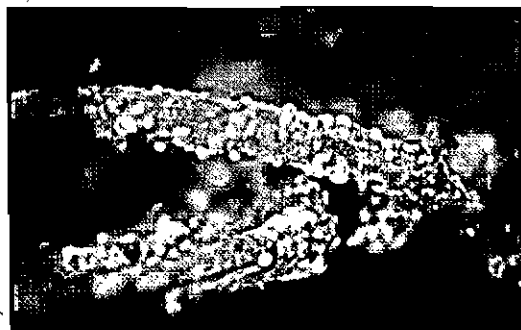
Evaluation of plant products

Evaluation of methanol and hexane extracts of *Annona squamosa* seeds, *Polyalthia longifolia* leaves, *Melia dubia* seeds and essential oil from *Zanthoxylum rhetsa* seeds against feeding activity of pollu beetle indicated that methanol and hexane extracts of *A. squamosa* seeds were the most promising resulting in complete deterrence of feeding activity at 1% concentration.

Root mealybug

Distribution

Surveys were conducted in 14 black pepper areas in north eastern Kozhikode District, Kerala, to study the distribution of root mealybug (*Planococcus* sp.) on black pepper. However, the pest infestation was not observed in any of the locations surveyed.



Root mealybug of black pepper

Management

Evaluation of four insecticides for the management of root mealybug on black pepper at Wynad indicated that drenching of affected vines with chlorpyrifos 0.075% was effective for the management of the pest. The addition of a wetting agent (Sandovit) did not improve the effectiveness of the insecticide.

Ginger

Shoot borer

Pesticide residues

The pesticide residues in ginger in which the recommended spraying schedules were adopted for the management of shoot borer were determined. Spraying of 2 and 4 rounds of malathion 0.1% and monocrotophos 0.075% resulted in non detectable levels of pesticide residues in dried ginger rhizomes.

Rhizome scale

Management

Dried leaves of various plants were evaluated as storage material for the management of rhizome scale (*Aspidiella harti*) on ginger during storage. The trials indicated that dipping of seed rhizomes in quinalphos 0.075% and storing in dried leaves of *Strychnos nux-vomica* was more effective for obtaining a higher recovery of rhizomes, higher number of sprouts and lower 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. Dried rhizomes of 50 accessions of ginger were screened for damage by *L. serricorne* and 20 accessions were free of pest infestation.

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. 2.5 lakhs was obtained through consultancy services offered by scientists of the institute.

Krishi Vigyan Kendra

Fifty one short term courses in crop production, horticulture, animal sciences and fisheries were conducted in which 1265 trainees took part. Frontline demonstration of inter-cropping in coconut gardens with ginger and turmeric indicated that an additional income of Rs. 24,000/- to Rs. 37,000/- per acre can be obtained. Evaluation of deep-water rice varieties indicated that Sabitha and Neeraja were superior in yield compared to the local

variety Mundon. Broiler goat production was profitable when the animals were sold after 6 months of growth or attainment of 25 kg of weight. Superior growth performance was observed in goat kids when fed daily with fish oil and neem leaves along with normal feeding. A medicinal plant unit with 100 plant species was established. Planting materials worth Rs. 3 lakhs were produced by utilizing the funds of the revolving fund scheme.

All India Coordinated Research Project on Spices

The All India Coordinated Research Project on Spices (AICRPS) has 19 coordinating centres and 8 voluntary centres located in 15 states of India and has the mandate to conduct research on 12 spice crops namely, black pepper, cardamom, large cardamom, ginger, turmeric, cumin, coriander, fennel, fenugreek, nutmeg, cinnamon and clove.

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 (8-4-D11 and 7-24-D11) and drought tolerant (CL-668, P-6, D-237, 2-2-D11) accessions were identified. V₃S₁-8 in ginger and PTS-59 and PTS-55 in turmeric were identified as promising lines and are in an advanced stage of release. The ginger variety V₁E₈-2 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 was recorded in EC-232684 (4.4%) and JC-147 (3.9%) in cumin and UF-144 in fennel.

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

A package of plant protection practices was recommended for the management of *Phytophthora* foot rot of black pepper. A low-cost technology for mass multiplication of *Trichoderma* sp. for field application was developed. Rhizome rot of ginger during 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 *Furarium* wilt.

Silver Jubilee Celebrations

The institute has completed 25 years of fruitful service to the nation, and the silver jubilee celebrations were held during 8-9 October 2001. Dr. 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), during the occasion. An exhibition depicting the achievements of the institute during the past 25 years was organized and various publications focusing the research achievements and technologies developed by the institute were also released. Two interfaces, one between scientists and exporters of spices and another between scientists and farmers were also held to understand the problems faced by these clientele. The retired staff of the institute were honoured in recognition of their services to the institute.



Dr. M. S. Swaminathan being felicitated during the silver jubilee celebrations of the institute

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