Research Highlights 2002–03

Indian Institute of Spices Research
Calicut

Research Highlights – 2002-03

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

Correct citation

Indian Institute of Spices Research, Research Highlights 2002-03, Calicut

Publisher

Director

Indian Institute of Spices Research

Calicut - 673 012, Kerala, India

Editors

J. Rema and S. Devasahayam

April 2003

Printed at

Ad-Ventures Inc., Calicut

IISR-RH-16.

Director's Introduction

The Indian Institute of Spices Research, Calicut, has been serving as a nodal research institute for spices for over a quarter century and its research capabilities are of international standards. The year under report marks the beginning of the X Five Year Plan period and the tentative budget allocation for the institute is 75% more under Plan and 30% more under Non Plan. During the earlier Plan period, nearly 50% of the total expenditure was met from about 22 externally aided projects. A large number of research papers have been published and many technologies have been developed over the years.

Some of the steps initiated during the year include, a strong human resource development programme for the staff irrespective of the cadre to which they belong, a multi-disciplinary approach to research programmes, development of problem-oriented approaches instead of division-oriented ones and effective inter-institutional collaboration with Central Plantation Crops Research Institute, Kasaragod, and other institutes. We are in the threshold of achieving breakthroughs in some of the nagging problems confronting spices production such as *Phytophthora* foot rot disease of black pepper and rhizome rot disease of ginger. I have great pleasure in presenting the Research Highlights 2002–03 of the institute and presume that it would be of use to all concerned with spice research and development.

I place on record my gratitude to my predecessors, Dr. Y. R. Sarma and Dr. K. V. Ramana, and also express my appreciation to all my colleagues at the institute-scientific, technical, administrative and supporting, for their excellent support. I am thankful to Dr. J. Rema and Dr. S. Devasahayam, who have done a fine job of compiling the Research Highlights.

Calicut
April 2003

V. A. Parthasarathy
Director

Genetic Resources

Black pepper

Sixty-eight accessions of *Piper* species and cultivated types were collected from Kasaragod District, Peppara Wildlife Sanctuary, Neyyar Wildlife Sanctuary and Achankovil forests in Kerala and Andaman Islands. The collections include local cultivars such as, Kottanadan, Palamulaku, Jeerakamundi and Karimunda and wild accessions such as, a rare type of *Piper longum*, having light purple young spikes collected from Kulathupuzha and *P. hapnium* from Achankovil fotests. *P. sarmantosum*, a wild species that closely resembles *P. longum* and *P. hapnium* was collected from Central Agricultural Research Institute, Andamans. One hundred accessions were characterized and catalogued based on IPGRI descriptor.

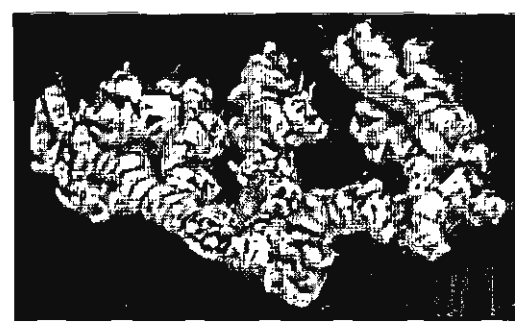
A collection of *Piper hapnium* from Andamans

Cardamom

Twenty-five new accessions of cardamom and 11 accessions of related genera were added to the germplasm. These collections include five popular land races and a recently released variety, PV-2 from Cardamom Research Station, Pampadumpara. Seventy-two accessions were evaluated for yield and vegetative characters based on IPGRI descriptor.

Ginger and turmeric

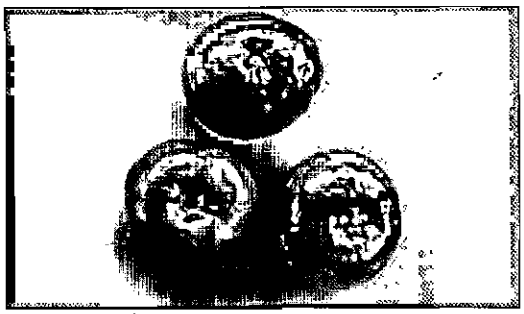
Five *Zingiber* species and cultivated types namely, a putative wild type, an unidentified *Zingiber* sp. with nutmeg rind flavour (from Alappady Meth, in Achankovil forests), a primitive *Z. officinale* type (from Neyyar), *Z. officinale* var. *rubens* (Kintoki) (from Japan), a cultivated ginger type (from Tikamgarh, Madhya Pradesh) and a *Curcuma longa* type (from Alappady Meth) were collected and added to the germplasm.



A collection of *Zingiber officinale* var. *rubens* from Japan

Tree spices

Six collections of kokam (*Garcinia indica*) (from Kasaragod District, Kerala), a male *Garcinia* species (from Taliparamba, Kerala), a collection of *Cinnamomum sulphuratum* (from Peppara Wildlife Sanctuary) and six wild species of *Myristica* (from Neyyar and Achankovil) were collected and added to the germplasm.



A collection of *Garcinia indica*

In vitro gene bank

Twenty accessions of black pepper, 18 accessions of turmeric, 15 accessions of ginger and 100 accessions of vanilla were added to the *in vitro* gene bank. Selfed progenies of *Vanilla tahitensis* were also added to the *in vitro* gene bank. The gene bank maintains 700 genotypes at present.

A protocol for cryopreservation of ginger embryoids was standardized. Ginger embryoids pretreated with 0.4 M sucrose for 3 days and vitrified in PVS2 solution for 30 min and plunged into liquid nitrogen directly along with the solution resulted in successful recovery of 95% of embryoids after thawing and culture.

Characterization of Germplasm

Black pepper

RAPD profiles of 14 major cultivars and 10 released varieties namely, cvs. Karimunda, Kottanadan, Balancotta, Neelamundi, Kuthiravally, Kalluvally, Arakulam munda, Narayakodi, Thomankodi, Perambramunda, Poonjaramunda, Valiakarimunda, Cheriyakaniakadan and Uthirancotta; vars. Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4, Panniyur-5, Sreekara, Subhakara, Panchami, Pournami and Palode-2 indicated that the *Phytophthora* tolerant lines among them formed a cluster of their own.

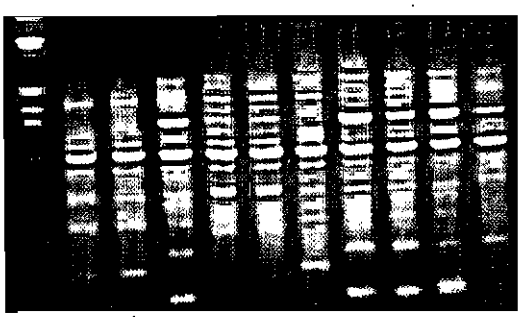
Morphological and cytological studies of micropropagated black pepper indicated that there was no significant difference between micropropagated and conventionally propagated plants in cv. Karimunda.

Cardamom

RAPD profiles of 13 species of *Elettaria* and 24 promising genotypes revealed very low polymorphism among them.

Ginger and turmeric

Genetic fidelity analysis of micropropagated somaclones in ginger using RAPD indicated variations among them. Field evaluation of micropropagated and microrhizome derived turmeric plants did not show significant morphological variations. But RAPD profiles of micropropagated plants showed profile differences, and the profiles of microrhizome derived plants were more uniform except for polymorphism in two bands. *Curcuma* species such as *C. longa, C. aromatica, C. zedoaria, C. malabarica* and *C. amada* could be discriminated based on RAPD profiling. A protocol for isolation of PCR amplifiable and restriction digestion amenable DNA from rhizomes of ginger and turmeric was also standardized. Chromosome number analysis of 16 accessions of turmeric revealed that 14 of them had 2n=63, one had 2n=61 (Acc. 30) and one had 2n=80 (Acc. 768).



PCR amplified DNA from turmeric rhizome

Crop Improvement

Black pepper

The black pepper hybrids (HP-34, HP-105, HP-780, HP-813 and HP-1411) and OP line (OPKm) continued to perform well at Peruvannamuzhi (Kerala) and Valparai (Tamil Nadu). Coll. 1041 and OPKm also performed well at farmers plots in four northern districts of Kerala.

Two mapping populations of black pepper were developed using var. Panniyur-1 x var. Subhakara (Karimunda) and P-24 (tolerant to *Phytophthora*) x var. Subhakara to prepare molecular maps. One thousand hybrids and 200 selfed progenies were established and RAPD profiling of these progenies is in progress. DNA was isolated from 12 accessions of *Piper* spp. and 8 accessions of cultivated black pepper for determination of parental polymorphism. RAPD analysis is in progress to identify male parent specific RAPD bands for identification of true hybrids in crosses involving cultivated and wild germplasm.

Differential display RT-PCR was done with total RNA isolated from leaves of black pepper plants (var. Sreekara) having spikes with developing berries and juvenile plants

for identification of genes involved in piperine biosynthesis and other quality attributes. Two cDNA fragments (300 bp approx.) corresponding to differentially expressed genes were tagged using two random 13 mer primers in second strand synthesis.

DDRT-PCR was done with total RNA isolated from *Piper colubrinum* leaves challenged with *Phytophthora capsici* and normal leaves from uninoculated plants as control. Gene specific primers were designed for amplification of disease resistance and disease response genes. cDNAs corresponding to a putative chitinase gene (~600 bp) and disease resistance gene (2 cDNAs of ~250 bp) was amplified using one chitinase specific primer and two primers based on disease resistance genes.

Cardamom

Based on *per se* performance, heterosis and specific combining ability for 3 years, 15 hybrid combinations were identified as promising for yield and tolerance to leaf blight (*Colletotrichum gleosporioides*). The standard heterosis for yield varied from 23.22 to 150.33 in the hybrid combinations.

Tree spices

Budding of nutmeg on *Myristica malabarica* was successful; however, the percentage of success was low (30%). *Garcinia gummi-gutta* could be grafted on *G. hombroniana* and *G. cowa* by softwood grafting with 90% success. *G. indica* was also successfully grafted on *G. gummi-gutta* with 55% success.

High yielding varieties

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

Evaluation for Quality

Black pepper

The cultivated wild *Piper* germplasm were analysed for quality and Acc. 5411 recorded 31.0% oleoresin and 6.2% piperine, followed by Acc. 5442 with 21.0% oleoresin and 6.0% piperine.

The chemical quality of black pepper grafted on *P. nigrum* and *P. colubrinum* adopting various grafting methods was evaluated. There was no variation in quality when various grafting techniques were adopted and all samples including control gave 3.2% to 4.0% oil, 3.8% to 4.1% piperine and 9.5% to 11.0% oleoresin.

Cardamom

Among the 115 accessions evaluated for quality, Accs. 60, 63, 75 and 273 had more than 8% volatile oil. Accs. 257, 258, 259, 277 and 325 had about 30% α-terpinyl acetate (which gives a sweet flavour) and about 25% 1,8-cineole (which gives a camphoraceous note).

Ginger

Among the 60 accessions evaluated for quality, Gurubathani, Kozhikkalan, Accs. 121, 260, 340 and 342 had above 5.5% oleoresin; Kozhikkalan and Gurubathani had 4.0% crude fibre. Many accessions contained only 2.0% to 2.5% crude fibre.

Turmeric

Studies on effect of locations on curcumin content in turmeric varieties Alleppey, Prabha and Prathiba indicated that a decline of 20% in curcumin content was observed in Niyamthi (Karnataka) compared to Calicut (Kerala). The curcumin content in these varieties were 5.6%, 5.2% and 5.7%, respectively, at Niyamthi.

Enhanced activity of phenylalanine ammonia lyase (PAL) was found to be associated with curcumin levels during early stages of rhizome development in turmeric. In accessions with low curcumin levels (less than 2%), the activity was lower as compared to accessions with high curcumin (greater than 5%), thus confirming the key role of PAL in initiation of curcumin biosynthesis.

Nutmeg

Among the 30 nutmeg accessions evaluated for quality, the essential oil content in nutmeg ranged from 7.67% to 13.89% and that in mace from 7.48% to 20.99%. A9-49 recorded the highest oil content in both nut and mace. Myristicin content in nutmeg ranged from 2.26% (A11-25) to 29.6% (A11-21) and in mace from 1.70% (A11-25) to 28.68% (A9-4-11). Elemicin content in nutmeg ranged from 1.51% (A9-37) to 29.71% (A11-26) and 1.05% (A9-49) to 29.85% (A9-4-11) in mace. All the accessions showed similar amino acid profile in HPLC.

Paprika

Colour value of paprika accessions ranged from 42 to 171 ASTA units and from 33 to 176 ASTA units in indigenous and exotic germplasm collections, respectively.

Integrated Plant Nutrient Management

Black pepper

Application of vermicompost @ 1.25 kg/pot significantly increased build up of soil P from 2.1 to 55.0 mg/kg, K from 103 to 262 mg/kg and yield by 51% over chemical fertilizer sources in bush pepper. The microbial biomass in the rhizosphere was also significantly high under vermicompost and leaf compost treatments.

Ginger and turmeric

Studies on effect of different levels of zinc on nitrate reductase and acid phosphatase activity indicated that zinc levels did not influence the activity of these enzymes. However, the activities were higher in foliar application compared to soil application.

Drought Management

Black pepper

Among the black pepper hybrids screened for drought tolerance, HP-29 maintained higher water status, lower membrane damage and higher SOD activity during water stress. However, all the accessions showed similar protein banding pattern during water stress and it was comparable with that of control.

Cardamom

Six genotypes were screened for drought tolerance under rain out shelter and APG-18 was superior in withstanding stress. Screening of 20 cardamom genotypes for relative water content, specific leaf weight and stomatal count revealed significant variations.

Evaluation of various soil and water conservation measures in cardamom based cropping systems indicated that planting of pineapple as live barriers in between cardamom was promising.

Intercropping of pineapple in a cardamom plantation for soil conservation

Disease Management

Black pepper

Phytophthora *foot rot*

Characterization

Morphological and pathogenic variability of

46 *Phytophthora capsici* isolates indicated significant differences in their pathogenicity and five isolates, namely, 98-3, 98-59, 98-146, 98-173 and 02-51 were less virulent inducing <10 mm lesion after 48 h of incubation on the host tissue. The pathogenic variability was not correlated with morphological characters such as sporangial size, length: breadth ratio and pedicel length.

Host resistance

Seventy hybrids were screened against *P. capsici* using stem inoculation method in the greenhouse and seven accessions (HP-9, HP-117, HP-477, HP-528, HP-561, HP-599 and HP-1660) showed a tolerant reaction with a disease index between 3.4-4.0. Among the 25 cultivars subjected for secondary screening, 3 accessions (C-888, C-1199 and C-1204) showed a tolerant reaction. Sixteen Kottanadan selections were screened to confirm their tolerance and nine (Accs. 2420, 2425, 2426, 2428, 2432, 2433, 2466, 2535 and 2575) were tolerant. Coll. 1041, a promising *Phytophthora* foot rot tolerant black pepper line maintained its field tolerant nature and superiority in yield at Valparai.

Management

The performance of black peppe cv. Karimunda on rootstocks of *P.* (resistant to *Phytophthora ca* satisfactory in a farmer's field duri year also with no incidence of foot A maximum yield of 13 kg/vine recorded.

Fungal and bacterial isolates (14 e were effective against nematodes for their effect on *P. capsici* in *in v* Three fungal (IISRF-559, IISR IISRF-567) and three bacteri (IISR-526, IISR-632 and exhibited >50% growth inhi *P. capsici*. The promising bacterial i suppressed the disease under g conditions. These three isolates previously identified efficient PGPRs (IISR-6 and IISR-51) wer slow decline affected black pepp the field and there was reduction of yellowing in treated vines.

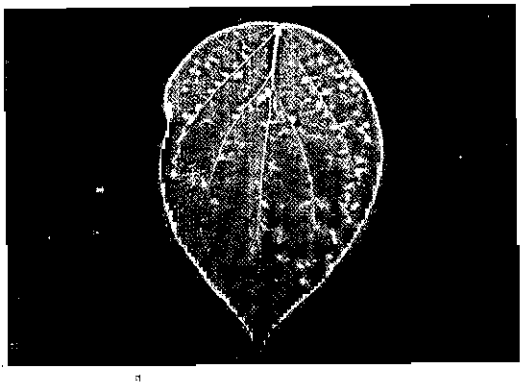
Molasses (at 0.5% concentra suitable for multiplication of PGP application. Coir compost with ratio supported good growth of *harzianum*. Decomposed coir pit could be effectively used as carrier

biocontrol agents such as *T. harzianum* and *Pseudomonas fluorescens.*

Stunt disease

Etiology

The association of a badnavirus with stunt disease affected leaf samples collected from Kozhikode and Wyanad districts (Kerala) was established on the basis of symptomatology, vector transmission, electron microscopy and serology. The virus induced vein clearing, chlorotic flecks, chlorotic mottling along veins and curling of leaves leading to reduced vigour and yield. The virus was transmitted from diseased to healthy black pepper plants by grafting and by the striped mealybug (*Ferrisia virgata*). The virus showed positive serological relationship with banana streak virus and sugarcane bacilliform virus in direct antigen coated (DAC) ELISA tests.



Black pepper leaf infected with badna virus

The cucumber mosaic virus (CMV) infecting black pepper was easily transmitted on to *Nicotiana benthamiana* and *N. glutinosa* by sap inoculation. A protocol was standardized for purification of CMV from tobacco. The molecular weight of coat protein the purified virus particles determined through SDS-PAGE was ~26 Kda. The virus could be detected both in DAC ELISA and electro blot immuno assay using polyclonal antisera against CMV.

Spike shedding

Etiology

Periodical observations on production of bisexual flowers in spikes of Panniyur-1 revealed very low percentage of bisexual flowers during August (3.9%), which could be one of the reasons for sparse setting and spike shedding in this variety particularly at high altitudes. The corresponding bisexual status of flowers in Panniyur-1 located in moderate rainfall and low altitude areas was 68%.

Host resistance

The reaction of black pepper cultivars and varieties to natural infection of anthracnose (*Colletotrichum gleosporioides*) was recorded in coffee based cropping systems. Panniyur-1 was the most susceptible and Panniyur-5,

Subhakara, Panchami, Balankotta and Kottanadan were tolerant to natural infection of anthracnose.

Ginger

Rhizome rot

Host resistance

One hundred and ninety-nine germplasm accessions were screened against *Pythium* spp., the causal organism of rhizome rot disease. Thirty-three accessions that escaped infection in the preliminary screening were subjected to secondary screening and five accessions (Accs. 6, 17, 130, 155 and 208) were promising.

Bacterial wilt

Characterization of pathogen

Six new collections of *Ralstonia solanacearum* were added to the Repository of Plant Pathogens. Rep-PCR analysis grouped 28 isolates into 4 major haplotypes with a similarity coefficient of 0.70. Among them, two clusters caused bacterial wilt in ginger. ITS-PCR (using primer ITS ALL F) and RAPD (using primer OPA-2) analysis further confirmed the narrow genetic base of the bacterial wilt pathogen.

Detection of pathogen in soil

A protocol was refined for isolation of DNA of the pathogen from soil. The protocol yielded PCR amplifiable DNA with A260/280 ratio ranging from 1.51 to 2.09 and A260/230 ratio ranging from 0.53 to 2.14. The DNA yield ranged from 0.095 to 1.840 µg/g of soil. *R. solanacearum* was detected in soil at a concentration of 104 cells/g soil using PCR. The pathogen could be selectively detected in the presence of high population of fluorescent pseudomonas in a co-cultured soil.

Host resistance

Over 250 ginger accessions were screened for bacterial wilt resistance using soil inoculation method and all the accessions wilted 2 months after inoculation. A few accessions that regenerated were maintained for further screening.

Management

The thermal death point (TDP) and thermal death time of *R. solanacearum* was determined. The TDP for *R. solanacearum* was 45.8°C at 30 min of exposure. However, the bacterium was completely killed even at 10 min exposure at 50.8°C. The time and duration of rhizome solarization was optimized. The effect of rhizome solarization on heat build up in rhizomes and consequent heat retention was studied. The heat

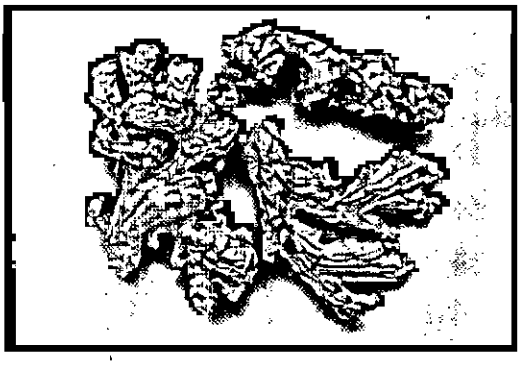
was retained in the rhizomes up to 30 min. Prolonged rhizome solarization on a cloudy day (ambient temperature 28°C) was detrimental for germination, though the peak rhizome temperature was only 47°C.

Studies on storability of solarized rhizomes indicated that 1 month of storage soon after rhizome solarization did not affect germination. However, exposure beyond 2 h affected the firmness of the rhizome tissues. A synergistic effect of rhizome solarization and rhizome bacterization was observed under greenhouse conditions.

Minor diseases

Etiology

Macrophomina sp. was found to be the causal organism of dry rot disease and *Fusarium oxysporum* rhe causal organism of eye rot disease of ginger occurring during the post harvest period. *Colletotrichum* sp., *Phoma* sp. and *Pestalotiopsis* sp. were associated with leaf spot disease specimens collected from Peruvannamuzhi, Wyanad and Kannur areas respectively, and their pathogenicity proved. Among the 650 germplasm accessions evaluated under natural conditions, 281 accessions were infected by chlorotic leaf streak virus.



Ginger rhizomes affected with dry rot disease

Management

Carbendazim and a combination of mancozeb-carbendazim (mancozeb 63% + carbendazim 12%) were found to be inhibitory to *Macrophomina* sp. and *Fusarium* sp. even at 50 ppm when compared to mancozeb, Ridomil, Bordeaux mixture and copper oxychloride which had no effect even at 500 ppm in *in vitro* bioassays.

Nematode Management

Host resistance

Twenty-four accessions of ginger and 59 accessions of turmeric were screened against root-knot nematode, *Meloidogyne incognita*, among which, four ginger (Accs. 79, 197, 216 and 219) and four turmeric accessions (Accs. 54, 56, 57 and 106) showed promise in the preliminary screening.

Management

Biological control

Characterization

Five isolates of rhizobacteria (IISR-522, IISR-528, IISR-658, IISR-853 and IISR-859) having dual nematicidal action (suppressing both *Radopholus similis* and *M. incognita*) were short-listed from a collection of 291 isolates. Twenty-five isolates of rhizobacteria were evaluated for their carbon utilization and antibiotic resistance. Many of them utilized succinic acid indicating that they belong to fluorescent pseudomonas group. Genomic DNA of these isolates was isolated through the CTAB-SDS method and a procedure for Rep-PCR finger printing was standardized.

Field evaluation

Field evaluation of promising fungal (*T. harzianum* and *Verticillium chlamydosporium*) and bacterial (*Pasteuria penetrans*) isolates indicated that black pepper vines treated with *V. chlamydosporium* yielded the highest when compared to other treatments. In another trial, all the four fungal isolates (*V. chlamydosporium*, *T. harzianum*, *Paecilomyces lilacinus* and *Scopulariopsis* sp.) significantly reduced foliar yello black pepper vines. Field applica promising rhizobacteria (IISR-8 IISR-859) also reduced foliar yello black pepper vines.

Mass multiplication

Studies on mass multiplicat *V. chlamydosporium* on solid substr rice bran, tapioca powder, decompo compost and neem oil cake indica rice bran was the best substrate. A extracts of *Azadirachta indi Chromolaena odorata* that po nematicidal properties had a synergis on mass multiplication of *V. chlamyd* and supported good growth and spo of the fungus.

Insect Pest Management

Black pepper

Pollu *beetle*

Host resistance

Screening of cultivars, hybri somaclones of black pepper acc available in the Germplasm Conse against *pollu* beetle (*Longitarsus nigr* indicated that three cultivars had l 1% infestation on the berries.

Root mealybug

Distribution

Surveys conducted at 39 black pepper gardens at 13 locations in Kodagu District, Karnataka, to study the distribution of root mealybug (*Planococcus* sp.) on black pepper indicated that 16 gardens in 7 locations were infested by the pest.

Management

Evaluation of microbial pathogens and entomopathogenic nematodes (EPNs) against root mealybug indicated that EPNs caused up to 32% mortality of the pest in laboratory bioassays.

Ginger

Shoot borer

Host resistance

Screening of 485 accessions of ginger available in the Germplasm Conservatory against shoot borer (*Conogethes punctiferalis*), indicated that 8 accessions had less than 5% shoots infested by the pest.

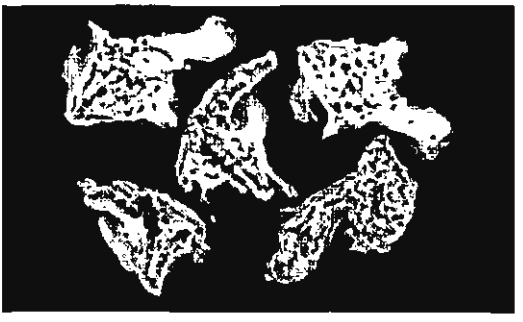
Management

Evaluation of neem oil and a commercial neem product against shoot borer of ginger and turmeric indicated that fortnightly sprays of neem oil 1% or Nimbicidine 1% during July to October was promising for reducing the pest infestation on ginger.

Storage pests

Management

Evaluation of dried leaves of various plant species as storage material for prevention of infestation by cigarette beetle (*Lasioderma serricorne*) indicated that storage of dried rhizomes in dried leaves of *Clerodendron infortunatum* in polypropylene containers was effective.



Ginger rhizomes damaged by cigarette beetle in storage

Host resistance

Dried rhizomes of 91 accessions of ginger were screened for damage by cigarette beetle and 22 accessions were free of pest infestation.

Post Harvest Technology

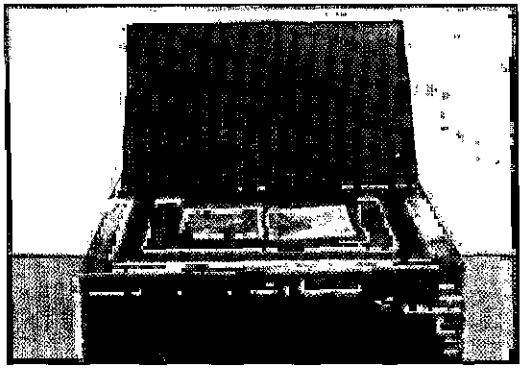
Preparation of white pepper

Ten isolates of *Bacillus* sp. and *Pseudomonas*

sp. were isolated from black pepper berries that were effective in conversion of black pepper to white pepper.

Storage of ginger

Evaluation of various containers for storage of fresh ginger indicated that zero energy chamber (a double walled brick structure filled with sand between the walls, frequently moistened with water) was ideal for storing fresh ginger. The loss in weight of rhizomes was only 23% after storing for 4 months in zero energy chamber compared to open condition. The ginger stored in open conditions was shrunken in 4 months time.



Zero energy chamber for storing fresh ginger

Transfer of Technology

Training and development programmes

The institute organised four training programmes for field extension functionaries of State Department of Agriculture and Horticulture and research workers of ICAR institutes and agricultural universities on production technology of spices in which 32 trainees participated. Two short-term training programmes on bioinformatics sponsored by Department of Biotechnology (DBT) were also organised in which 21 trainees participated. A training programme on 'Molecular Biology Techniques for Horticultural Crops' was conducted for biotechnologists from various ICAR institutes.

As part of Human Resources Development programme, various categories of staff of the institute were also trained in administrative rules, statistical methods and computer applications at the institute. Sixty-five short-term research projects carried out by post graduate students from various universities were supervised by scientists. These projects were effectively integrated into the research activities being carried out at the institute in various disciplines.

The institute participated in 16 extension programmes organised by various institutions. *Kisan divas* was celebrated on 23 December 2002 and progressive farmers were honoured.

Production of planting material

Sixty thousand rooted cuttings of black pepper, 10,200 grafts of nutmeg, 23,000 seedlings and 2000 suckers of cardamom were produced and distributed to farmers and other agencies.

Agricultural Technology Information Centre

The Agricultural Technology Information Centre (ATIC) functions as a single window delivery system of technology inputs, products and services of the institute for farmers and other end users. Planting material of improved varieties of black pepper and *Piper chaba* were produced and sold from the demonstration nursery of ATIC. About 850 kg of *Trichoderma* sp. was sold to farmers and other agencies. Extension pamphlets and technical bulletins and other publications were also sold. Six hundred and seventy-five farmers were benefited by farm advisory services. An on line version of extension literature was regularly updated at the institute web site on the internet.

Krishi Vigyan Kendra

The Krishi Vigyan Kendra (KVK) conducted 65 training programmes for farmers, unemployed youth, school drop outs and extension functionaries in which 2051 trainees, including 1023 women, participated. A training programme of 1 month duration was organized for 20 educated, unemployed rural women in bamboo handicraft and artificial flower making to equip them for self employment. The KVK conducted frontline demonstrations in farmers fields on high yielding short duration tapioca, high yielding coleus, and composting of coir pith. On-farm testing of effectiveness of pheromone traps for the control of rhinoceros beetle and red palm weevil on coconut and external application of boiled *Glyricidia* leaves + neem oil for control of ectoparsites and healing of wounds and skin diseases of farm animals were also conducted.

The KVK organised 8 *kisan melas* cum exhibitions and 4 study tours for farmers. The officials of KVK delivered radio talks and published popular articles in farm magazines to disseminate technologies developed at the

A progressive farmer being honoured during *kisan divas* celebrations

institute. The animal clinic took up consultancy and advisory services. Several tural youth generated self employment in agri-nurseries, vermi-composting, fruit processing and goatary with the help of the KVK. An income of Rs.1,06,826/- was generated through sale of planting materials of spices, fruits, plantation crops and ornamentals and Rs.16,745/- through the animal clinic.

Information Services

A web page, www.spicestat.org giving details of area, production, export and other statistics of major spices was launched. CDs on cultivation of black pepper and a cumulative index of the first 10 volumes of Journal of Spices and Aromatic Crops were brought out. Two databases namely, chitinase database and PAL database were developed. Two softwares namely, Restalyzer (a software to find out the restriction sites in a nucleotide sequence) and Translator (a software to predict the aminoacid sequence from nucleotide sequences) were also developed. A web enabled intranet information hub, SPICENET, with interactive user-friendly menus, links and pointers was developed and launched for the benefit of the institute staff. Networking of libraries of Central Plantation Crops Research Institute, Kasaragod, National Research Centre, Puttur and Indian Institute of Spices Research, Calicut, was also initiated for sharing of resources and facilities.

All India Co-ordinated Research Project on Spices

The mandate of the All India Co-ordinated Research Project on Spice (AICRPS) is to conduct and co-ordinate spice research being conducted in 27 centres on 12 spice crops in the country.

Crop improvement

The AICRPS centres strengthened their genetic resources and new germplasm collections were made in ginger, turmeric, coriander and fenugreek by the Pundibari and Dapoli centres. The cardamom clones CL-629, CL-681 and CL-730 and OP progenies D-237, CL-730, 8-4-D-11 and 7-24-D11 were identified as promising at Mudigere. The clones P-6, D-237 and CL-746 were drought tolerant at Mudigere. The turmeric accessions 126, 360, 361, 585 and T4-11 were resistant to *Taphrina* leaf blotch disease and Sudarshana and RTS-1 were resistant to leaf spot disease at Raigarh. Kohinoor and GL Puram were resistant to leaf blotch at Dholi. The coriander selections RCr-41, RCr-435 and RCr-436 were

immune to stem gall disease and RCr-435, RCr-436, RCr-684, RCr-685, RCr-686 and UD-446 were resistant to root knot nematode at Jobner. In coriander, Pant Haritima and R. Swati were resistant to stem gall disease at Dholi. The cumin accession UC-223 recorded minimum incidence of wilt at Jobner. In fenugreek, UM-305 was immune to root knot nematode and powdery mildew disease at Jobner. At Jagudan, the cumin entries Gujarat Cumin-3, Acc-1136 and Acc-1145 were moderately resistant to *Fusarium* wilt. The ginger collections Lajhan, SG-503, Kalichanog and Kindi were resistant to *Phyllosticta* leaf spot at Solan. Evaluation of quality of turmeric accessions indicated that the variety SG-685 gave high dry recovery. In coriander, JCo-331 had high percentage of oil (0.45%).

Crop production

Micronutrients such as boron and molybdenum influenced capsule yield in cardamom at Mudigere. The package of practices for ginger and turmeric production were standardized at Chintapalli. A fertilizer package, including application of biofertilizers was standardized for clove and nutmeg at Yercaud. The yield and quality of coriander and fennel increased by application of Zn, Fe, Mn and Cu. In Gujarat, sowing of cumin on 15th 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 31st October in Jobner for fenugreek. Sowing of fenugreek variety RMt-1 by the last week of October and UM-305 up to 15th November at 25–30 cm row spacing was recommended to obtain higher seed yield under semi-arid conditions.

In black pepper, irrigation at 2 litres water/day resulted in increased spike number, green berry yield and spike length at Panniyur. Application of micronutrient Fe as foliar spray @ 1% significantly increased the yield in ginger at Dholi. In vegetative propagation of nutmeg, the percentage of success was high in approach grafting (90%) than in epicotyl grafting (70%).

Crop protection

Metalaxyl Gold M'Z and *Trichoaerma* sp. were effective for the management of *Phytophthora* foot rot of black pepper. Two sprayings of either monocrotophos (0.05%) or dimethoate (0.05%) at fortnightly intervals after harvest of berries was effective for the management of mussel scale (*Lepidosaphes piperis*) on black pepper at high ranges of Idukki District in Kerala.