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RESEARCH ADVISORY COMMITTEE MEETING

31 March - 1 April 2005

Research Achievements



INDIAN INSTITUTE OF SPICES RESEARCH

(Indian Council of Agricultural Research)

Calicut - 673012, Kerala

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**Indian Institute of Spices Research
(Indian Council of Agricultural Research)
Marikunnu P.O., Calicut- 673012, Kerala**

Research Advisory Committee Meeting

Programme

30th March 2005 Wednesday Arrival of Chairman and Members and visit to laboratories

31st March 2005 Thursday

09.15 – 10.15 Inaugural Session

Welcome and Presentation of vision 2020 : Dr. V. A. Parthasarathy
Director, IISR, Calicut

Action taken report on previous RAC : M. Anandaraj
RAC, Secretary

Introductory remarks : Prof. S. Kannaiyan
Chairman and RAC members

Vote of thanks : Dr. M. Anandaraj
Secretary, RAC

10.15 - 10.30 Tea

10.30 - 13.30 Session I Presentation of reports by project leaders

I. Collection, Conservation, characterization and cataloguing of germplasm of spice crops for yield and other economically important characters
[Project Leader : P. A. Mathew]

II. Breeding improved varieties of spice crops for yield, quality, drought and resistance to pests and diseases
[Project Leader : B. Krishnamoorthy]

III. System approach for sustainable production of spices
[Project Leader : K. Kandiannan]

IV. Production physiology of spice crops
[Project Leader : B. Chembakam]

V. Value addition and post harvest processing of spices
[Project Leader : T. John Zachariah]

VI. Production of nucleus planting materials of improved varieties of spice crops
[Project Leader : C.K. Thankamani]

13.30 – 14.30 Lunch

Introduction

The mandate crops of Indian Institute of Spices Research include Black pepper, Cardamom, Ginger, Turmeric, Vanilla, Paprika, Cinnamon, Nutmeg and Cloves. Research work carried out is conducted in three Divisions namely, Crop Improvement and Biotechnology, Crop Production and Post Harvest Technology and Crop Protection as well as in a Social Science section. Based on the recommendation of previous Research Advisory Committee, the research programmes were grouped into 12 major projects comprising of 64 subprojects (48 Institute and 16 externally funded). Each project represents a theme and is of multidisciplinary in character.

The Research problems are identified and items of work are prioritized taking into account Vision 2020 and plan priorities. The technical programmes are finalized during the Research Council meeting which is held soon after Research Advisory Committee. The technical programmes are formulated taking into account the suggestions of QRT and RAC and work executed as time targeted quarterly work schedules. A mid-term review is also held to review the progress of work and to take corrective measures. The progress of work is reviewed every year in the annual Research Council Meeting and new programmes are taken up after approval of Research Council.

In this compilation, the research achievements made so far under each project is given as background information. The current programmes and future line of work are furnished.

The help received by Dr. K. V. Saji, Dr. V. Srinivasan and Dr. A. Kumar in the compilation is gratefully acknowledged.

M.Anandaraj
Member Secretary (RAC)

Project-I: Collection, conservation, characterization and cataloguing of germplasm of spice crops for yield and other economically important characters.

Project Leader – P.A. Mathew

(Associates: B. Krishnamoorthy, M.N. Venugopal, B. Chempakam, B. Sasikumar, J. Rema, K. Johnson George, R. Ramakrishnan Nair, N.K. Leela, K.V. Saji and K.N. Shiva)

Background information

This project includes seven subprojects and one externally funded project pertaining to black pepper, cardamom, ginger, turmeric, tree spices, vanilla and paprika. The research activities envisaged in this project are survey and collection of germplasm of the mandate crops and their conservation, characterization and cataloguing for yield and other important characters, so that these may be used for crop improvement programmes.

The project mainly focuses on collecting the wild relatives, local cultivars and landraces of the mandate crops. Exploration programmes for collecting spices germplasm were conducted to forests and traditional areas. At present the germplasm repository of IISR consist of 2300 accessions of *Piper*, 403 cardamom and related genera, 662 accessions of *Zingiber*, 902 *Curcuma*, 484 of *Myristica*, 223 of *Syzygium*, 308 of *Cinnamomum*, 86 of *Garcinia*, 180 allspice trees, 82 of *Vanilla* and 63 paprika. The collections include wild types, related genera and species, elite types, mutants, special types and endangered types besides cultivated types.

Descriptors for black pepper and cardamom have been developed and published by IPGRI. In pepper endangered species like *Piper barberi* was collected and re described. Three new taxa of *Piper* were reported. This includes two new species viz. *P. silentvalleyensis* and *P. sugandhi* besides one sub species *P. sugandhi* var. *brevipilis*. The germplasm are being characterized and evaluated based on IPGRI descriptors and for improved varieties were released. One local cultivar (Coll. No 1041) was registered for its field tolerance to foot rot disease and its release as a new variety was approved by the AICRPS held on 3-5 February, 2004 held at Calicut. The germplasm accessions are being screened against diseases, pest and drought. Compiled the germplasm survey report of Kerala with the help of GIS software to understand the relationship of the species with the climate and environmental parameters.

The Cardamom Research Center, Appangala is having large assembly of elite collections made from different cardamom growing regions of the country, selections from Regional Research Stations, Mudigere (UAS, Bangalore), Indian Cardamom Research Institute, Regional station (ICRI) Sakleshpur, ICRI, Myladumpara. The present *ex-situ* gene bank comprises collections, variants, hybrids and disease resistant selections.

Three improved ginger varieties namely IISR Varada, IISR Mahima and IISR Rejatha were released. IISR Mahima is resistant to root knot nematodes (*Meloidogyne incognita* and *M. javanica*). These varieties have spread through out country and there is heavy demand for planting materials as they are proved adaptable to the different agro ecological zones. Evaluation of 12 selected Nepal ginger accessions collected from Nepal were evaluated for yield has resulted in identifying Acc. 578 as a promising line. This accession recorded a mean yield of 15.25 kg (fresh) from 3 m² bed and a dry recovery of 23.5% with low fiber content (1.5%). Evaluation of 13 high oil type ginger accessions revealed that Acc. 162 and Acc. 25 are promising in terms of fresh yield 3 m² beds (13 kg) also.

Acc. 657, an Alleppey Finger Turmeric (AFT) turmeric selection is registered as a unique germplasm with high curcumin (Reg. No. 03089). Seven improved turmeric varieties mainly IISR Suguna, IISR Suvarna, IISR Sudarsana, IISR Prabha, IISR Prathibha, IISR Kedaram and IISR Alleppey Supreme are released/ proposed for release. High curcumin lines viz, AFT 583, 585, 599, 605, 630, 656, 657, 126, 295, 330, 109, 199, 210, 257, 361, 356, 352, 142 and 358 were identified. Cytological analysis of 4 turmeric seedlings viz. 126/1, 126/4, 126/6 and 126/11 revealed somatic chromosome numbers 84, 78, 78 and 84, respectively.

Isolation and characterization of bioactive principles in turmeric has been included as one of the monitorable targets for X plan. In addition to this, the importance of the problem was felt, since the medicinal and biological properties of curcumin clearly indicates its potential as a novel drug against various disorders including cancer and other stress-induced diseases. As such, the distribution of the pigment in the available germplasm will help in the long run to identify and breed varieties with desired composition.

In addition, characterization of the levels of the three curcuminoids will help in the chemical fingerprinting of the germplasm which will be beneficial in the field of pharmacology and pharmacokinetics.

Two high yielding and high quality cinnamon varieties namely, IISR Navashree and IISR Nithyashree were released. Four cassia lines have been selected with high oil content, which are under field evaluation. In nutmeg a high yielding, high myristicin variety namely IISR Viswashree has been released and due to its compact and dwarf type, it is very popular among the nutmeg growers of the country

In Vanilla the main objective is pooling the existing genetic variability by collecting germplasm and to generate new variability through seedling progenies and somaclonal variation, so as to facilitate selection for high yield, quality and resistance to diseases. Over 1000 seedling progenies were raised *in vitro* from the selfed seeds of *Vanilla planifolia* and are being established *ex vitro*. Inter specific hybrids involving *V. planifolia*, *V. aphylla* and *V. andamanica* were produced. Morphological, cytological and molecular characterization was initiated in germplasm collections, seedling progenies, inter specific hybrids and somaclones.

At present, research on paprika is being carried out at IARI regional station, Katrain (HP), and at Indian Institute of Horticultural Research, Bangalore. Evaluation of several lines at Katrain has helped to release one variety “Kt-PI-19” capable of yielding 250 to 350 Q/ha. “Arka Abhir” has been released from IIHR, Bangalore as a pure line selection from “Bydagi” of Dharwad district of Karnataka.

Paprika spice has been identified as a mandatory crop for IISR, Calicut. To improve this crop, the available germplasm resources have to be assembled. Better varieties with high colour and disease tolerance need to be developed especially for warm humid tropics in view of the spiraling demand for paprika colour and oleoresin in the international market. At present, we do not have the required varieties to capitalize on this market to earn foreign exchange. The project envisages identifying such varieties for large scale cultivation.

Ongoing programmes

- Collection, conservation germplasm of black pepper, cardamom, ginger, turmeric, tree spices, vanilla and paprika from farmer’s and from wild habitats
- Establishing field gene banks.
- Characterization and evaluation of germplasm for better qualities

- Screening the germplasm against biotic and abiotic stresses.
- Characterization of turmeric germplasm for curcuminoids.
- Development of Paprika for warm humid tropics

Achievements during 2004-05

Black pepper

- Germplasm exploration programmes were conducted to three states viz. Assam, Arunachal Pradesh and Kerala. Dibrugarh in Assam and Lohit and Anjaw districts of Arunachal Pradesh are the areas surveyed for collection of germplasm from North East India. In Kerala Achankovil forest range, Shenturuni wild life sanctuary, Punalur, Pathanapuram (Kollam district), Pathanamthitta, Lahai, Pamba valley (Pathanamthitta-district), Kakkayam, Tusharagiri (Calicut district) Tolpetty and Tirunelly (Wynad district) were explored Altogether 168 accessions were collected and added to the germplasm. This include 151 accessions of wild species and 17 local cultivars
- 50 cultivar accessions were evaluated based on IPGRI descriptor during the year under report. 700 cultivars were already characterized previously.
- One *Piper nigrum* collected from the natural forests of Nelliampathy (Palghat district) is registered as a unique germplasm for its high oleoresin content (28.15%) and boldness of berries. (INGR. 04111, IC-370011).
- The germplasm accessions were maintained and multiplied. Two thousand three hundred accessions besides 1400 hybrids and 150 open pollinated progenies are maintained in the germplasm. The accessions multiplied were supplied to different sections for screening them for biotic and abiotic stresses.(423 accessions)
- Passport details of the collections made from Kollam, Pathanamthitta and North East were prepared and sent to NBPGR, New Delhi for assigning IC-numbers (75 nos).
- The *ex-situ* field gene bank of wild germplasm is extended to a new area to establish the wild species under forest condition. The important collections from Silent Valley, Nelliampathy, Karnataka forests, collections from North East and Andaman and Nicobar Islands were planted and established in the new area (300 accessions).

Cardamom

- Five accessions (Precocious yielders-3 and high yielder-2) were collected from Kodagu district, Karnataka. The collections are under clonal multiplication.
- Field reaction of 42 entries against foliar disease viz. leaf blight (*Colletotrichum gloeosporioides*) was recorded. The glabrous selection of Malabar type (MA-15, MA-18, MA-20) is moderately resistant. The compound paniced type (CP-9, CP-2) is resistant. The most popular land race Green Gold also showed resistant reaction.
- Four hundred and three accessions of cardamom and their allied genera are maintained in the field repository at Cardamom Research Center, Appangala.

Ginger and Turmeric

Ginger

- Seven ginger accessions from Arunachal Pradesh and two ginger accessions from Wynad were collected and added to the germplasm. Among the Arunachal Pradesh collections three accessions have extra bold rhizome types whereas the ginger type collected from Wynad has giant rhizomes. One type with red tinge inside the rhizome was collected from Nagaland.
- *Zingiber macrostachyon* (1) and *Z. zerumbet* (1) were collected from the Manalar region of Achankovil forests.
- *Z.officinale* Rosc. collected from Western Ghat (Sabarimala hills) was registered as a unique germplasm having high oil content (3.5%).

Turmeric

- Eight turmeric (*Curcuma longa*) accessions and *C. caesia* were collected from Arunachal Pradesh, besides *C. haritha* (1), *C. aromatica* (1) from Pathanamthitta and one *Curcuma* sp. from Kallar was also collected.
- Curcuminoids were separated from turmeric oleoresin using Thin Layer Chromatography. Absorption maxima of three curcuminoids correspond with authentic values confirming the purity of the components
- Separation of curcuminoids using TLC has been standardized for the analysis of curcuminoids from released varieties of turmeric.

Tree Spices

- Eleven accessions of *Garcinia gummigutta*, 11 accessions of *G.indica* and one accession each of *G. hombroniana*, *G. imbertii*, *G. wightii* and *G. morella*, seven accessions of *Cinnamomum* species (*C. filipedicillate*, *C. citriodora*, *C. gracile*, *C. malabattrum* and *C. verum*) and three accessions of *Myristica beddomeii* from Palode, Calicut, Wynad (Kerala) and South Kanara (Karnataka), were collected and added to the germplasm.
- A new germplasm plot including nine collections of *Cinnamomum* species (collected from Nepal, Mizoram, Munnar, Kuthiramukku and Silent valley), seven clove seedlings of dwarf mutant, (IC-438344) (collected from Nagercoil, Kanyakumari district, Tamil Nadu), three elite accessions of *Myristica fragrans* (Konkan Sugandha, Kerakesari 1&2) and eleven *Garcinia* accessions (*G. imbertii*, *G. malabarica*, *Garcinia* spp-(5), *G. hombroniana* (4) were established
- Accession number 197- dwarf clove (*Syzygium aromaticum*) was registered for its dwarf stature (av. 52.62 cm) with the germplasm registration committee of ICAR.

Vanilla

- A total of 82 collections of vanilla including the related species were maintained in the field/nursery comprising *Vanilla planifolia* (69), *Vanilla andamanica* (8), *Vanilla pilifera* (1), *Vanilla aphylla* (1), *Vanilla tahitensis* (1), *Vanilla vatsalae* (1) and *Vanilla* sp. (leafless) (1)

- A separate nursery shed was established for maintenance of germplasm and seedling progenies of vanilla.
- A total of 10 collections were added. Nine samples were collected from the farmers' fields at Sakleshpur and Mudigere areas and one from farmer's field at Calicut.
- New germination cultures were raised using seeds resulted from selfing. Three hundred seedling progenies were established *ex vitro*. Out of these 125 were transferred to pots for further growth.
- Seeds obtained from a cross between pink flowered *V. andamanica* (♀) and *V. planifolia* (♂) were cultured for germination and germination was not observed. Reciprocal crosses were also made, fruit set and fruit growth observed in both combinations.
- Cytological analysis of *V. andamanica* indicated $2n=40$. Variation in chromosome number in different cells of the same collection and presence of supernumerary chromosomes was also observed occasionally.
- Pollination studies indicated that white and pink flowered varieties of *Vanilla andamanica* are self and cross compatible. Reciprocal crosses of purple flowered variety with *V. planifolia* also resulted in successful fruit set and fruit growth. Progenies of a cross between white flowered *V. andamanica* (♀) with *V. aphylla* (♂) showed the leafless characters of *V. aphylla*. Crossed and selfed seeds of pink and white flowered types were germinated *in vitro* and are at different stages of growth.

Paprika

- At present, 63 accessions of paprika and paprika like chillies collected from various sources/growing tracts (Dharwad areas of Karnataka, Warangal area of A.P., IARI-RS, Katrain (H.P.), IIHR, Bangalore, AVRDC, Taiwan) are being maintained.
- In indigenous germplasm, wide range (302-1112g) was observed for yield per plant with mean value of 653 g and narrow range (0.350-1.716) was observed for weight of seeds per fruit with mean value of 0.968 g. However, wide variability was recorded with weight of pericarp (54.70%), while narrow variability with days to 50% flowering (8.08%). Among the indigenous germplasm, Selection 2, ICBD-10 and Kt-pl-19 was found promising for four, three and three characters, respectively including yield. With respect to quality, ICBD-10 registered the highest color value (330.65 ASTA units), followed by ICBD-23, ICBD-11 and Kt-pl-19. The capsaicin content (pungency) varied from 0.0065 to 0.103 with mean value of 0.0445%. Among the germplasm, ICBD-10 and Kt-pl-19 were found promising for both yield and quality.
- In the exotic germplasm also, wide range (206-999) was observed for yield per plant with mean value of 540 g and narrow range (0.650-1.696) was recorded for weight of seeds per fruit with mean value of 1.201 g. However, wide variability was recorded with weight of pericarp (80.76%), while narrow variability with days to 50% flowering (13.26%). Among the germplasm, PBC-171 and EC-18 was found promising for six characters each, while SSP-1999 for four characters including yield. With regard to quality parameters, color value ranged from 60 to 356 with mean value

of 221 ASTA units, the highest being EC-171 (356.65 ASTA units), followed by EC-6, EC-71, EC-490 and EC-18, while the capsaicin content varied from 0.0056 to 0.101 with mean value of 0.0389%. Among the germplasm, EC-18 was found promising for both yield and quality.

Future lines of work

Black pepper

1. Augmentation of germplasm by collection of germplasm from unexplored areas of Parambikulam Wild Life Sanctoning (WLS) and Chimmony WLS.
2. Characterization of germplasm (50 nos.)
3. Maintenance and multiplication of germplasm
4. Cytological studies of black pepper accessions

Cardamom

1. Maintenance of germplasm
2. Recording of foliar disease in accessions
3. Analysis of quality of germplasm accessions
4. Screening of new accessions against mosaic disease

Ginger and Turmeric

1. Characterization of the germplasm
2. Enriching the collection
3. HPLC analysis of curcuminoids from turmeric accessions (50 nos.).

Tree Spices

1. Collection and conservation of germplasm
2. Characterization and evaluation

Vanilla

1. The project will be closed and final report will be submitted.
2. New project will be proposed for attending the remaining part of work

Paprika

1. Develop comprehensive collection of paprika (exotic) and paprika like chillies (indigenous)
2. Identify the stable lines having high color, high yield and low pungency in the germplasm at different locations.

Project - II: Breeding improved varieties of spice crops for yield, quality drought and resistance to pests and diseases

Project Leader – B. Krishnamoorthy

(Associates: M.N. Venugopal, M. Anandaraj, P.A. Mathew, K. Nirmal Babu, B. Sasikumar, J. Rema, Johnson K George, K.S. Krishnamurthy, K.V. Saji, T. John Zachariah, Santhosh J. Eapen, R. Ramakrishnan Nair, V. Srinivasan, K.N. Shiva and T.E Sheeja)

Background information

Black pepper

Eight black pepper varieties namely IISR Sreekara, IISR Subhakara, IISR Panchami, IISR Pournami, PLD-2, IISR Thevam, IISR Girimunda and IISR Malabar Excel were released/ proposed for release. IISR Thevam was registered with NBPGR for their field tolerance to foot rot disease and high yield. Preliminary screening of the germplasm revealed that accessions 4216, 4226, 1228, 1343, Kottanadan 1495 and 1315 were found to be relatively tolerant to drought *Piper colubrinum* was found to be susceptible. The new promising black pepper lines identified are HP 1411, HP 780 and OPKm (tolerant to drought). The promising black pepper lines identified are also evaluated in farmer's plot in 4 northern districts of Kerala and they are proved good. Four cultivated (Acc. C 4163, 4175, 1090 and 334) and 4 wild (Acc. 3219, 3286, 3287 and 3311) accessions were found to be resistant to root knot nematode; five wild (3141, 3200, 3283, 3291 and 3299) and one hybrid (HP 309) were resistant to *Radopholus similis* in preliminary screening. A mapping population was developed in black pepper and another is in process for development of molecular maps. Five 'transgenics' which gave positive reaction in PCR screening using npt II and Osmotin specific primers in glass house and are growing. Twenty five more putative transformants using 'Osmotin' were obtained and are growing in culture. In an effort to isolate genes responsible for *Phytophthora* resistance, amplification and cloning of 3' end of 'putative resistance genes' was done. A 500 bp fragment was amplified from black pepper genomic DNA using different combinations of degenerate primers based on resistance genes. 1500 TC plants of black pepper were hardened and 3000 cultures were ready for hardening. 15 trials were planted in farmers' field with TC black pepper.

Cardamom

In Cardamom three improved varieties namely, Kodagu Suvasini, IISR Avinash (rhizome rot tolerant) and Vijetha (tolerant to *Katte* disease) were released. Hybrid vigor has been

demonstrated in cardamom inter varietal hybrids and superior hybrids are under advanced stages of field testing. Molecular characterization of Cardamom was done using RAPD, ISSR and RFLP- PCR markers. The study indicated that there are no duplicates in the 100 lines characterized and the Kerala and Karnataka populations are divergent in that they formed two separate clusters in the Phylogram. *Ammomum* is the nearest genera for cardamom among the 10 taxa studied.

Ginger

Three improved ginger varieties namely, IISR Varada, IISR Mahima and IISR Rejatha were released. IISR Mahima is resistant to root knot nematodes (*M. incognita* and *M. javanica*). These varieties spread through out the country and there is heavy demand for planting materials as they are proved adaptable to the different agro ecological zones. Protocols for micro propagation of large cardamom, ginger and turmeric were being transferred to commercial labs for a transfer fee of Rs. 50,000 each.

Turmeric

Seven improved turmeric varieties namely, IISR Suguna, IISR Suvarna, IISR Sudarsana, IISR Prabha, IISR Prathiba, IISR Kedaram and IISR Alleppey Supreme are released/proposed for release. Prabha and Prathiba are the first ever turmeric varieties developed from seedlings. They have spread almost throughout the country. High curcumin lines viz., AFT 583, 585, 599, 605, 630, 656, 657, 126, 295, 330, 109, 126, 199, 210, 257, 361, 356, 352, 142 and 358 were identified.

Protocols for micro-propagation of vanilla, through direct shoot multiplication as well as callus regeneration were standardized. A population of over 400 seed derived progenies was developed. Interspecific hybridization between *V. planifolia* X *V. aphylla*, were successful *V. aphylla* x *V. planifolia* and few Interspecific hybrids are in culture. Pollination between two collections of *V. andamanica* with different flower colour also resulted in successful fruit set. RAPD profiling of 20 different collections and seed progenies of *V. planifolia*, 3 Interspecific hybrids of *V. planifolia* x *V. aphylla* and 5 different species was done.

Tree spices

In tree spices two high yielding and high quality cinnamon varieties namely, IISR Navashree and IISR Nithyashree were released. Besides, eight elite lines have been short

listed. Four short listed high yielding and high quality cassia lines namely A₂, C₁, D₁ and D₃ are in final stage of field evaluation. In nutmeg a high yielding, high myristicin variety namely IISR Viswashree has been released and due to its compact and dwarf type is very popular among the nutmeg growers of the country. Besides, twelve high yielding lines have been selected from germplasm and their clones are evaluated for yield and quality. One hundred accessions have been analyzed for quality and lines with high myristicin, elemicin, saffrol have been identified. A number of elite lines have been identified in farmers' plots. In clove, B 95 was found to be the best performer based on yield. A number of elite lines have been identified in farmers' plots. A dwarf mutant has been registered with NBPGR, New Delhi. Vegetative propagation techniques for multiplying elite lines have been standardized. Root stock- scion interaction studies in nutmeg revealed that *Myristica beddomeii* when used as rootstock established good growth of the graft and early bearing.

Paprika

Paprika lines (Cayenee, Kt-PI-19, EC-71, EC-18, ICBD-8, ICBD-4, ICBD-2) with more than 200 ASTA colour value have been identified. Higher yield lines viz., EC-18, Kt-PI-19, ICBD-6, SSP-1999, ICBD-13, ICBD-12, ICBD-8 were identified.

Ongoing Programmes

- Breeding black pepper and cardamom for high yield, quality, and resistance to biotic and abiotic stresses.
- Biotechnological approaches for crop improvement in black pepper.
- Developing ISSR markers for black pepper improvement.
- Rootstock – scion interactions in tree spices to find out suitable root stocks to increase productivity and drought tolerance.
- Molecular characterization and *in vitro* propagation in *Myristica* species.
- Development of chilli (*Capsicum annuum* L.) hybrids for paprika (oleoresin) production.
- Determination of purity of powdered market samples of major spices using PCR techniques, protein profiling and /or HPLC techniques.
- Strengthening the cause of Geographical indication of major spices using molecular, morphological and quality profiling techniques.
- Cloning of *Phytophthora* resistance and defense genes from *Piper colubrinum*.
- Investigation on direct *in vitro* shoot regeneration from pseudostem explants of ginger (*Zingiber officinale* Rosc.) and its field evaluation.
- Studies on genetic variability in open pollinated progenies of Vanilla.
- Studies on cryo- preservation of spices genetic resources.
- Identification and cloning of chitinase genes form *Piper colubrinum*.

- Studies on somaclonal variations in Zingiberaceous crops.

Achievements during 2004-05

Black pepper

- 2300 *Piper* accessions are maintained in the nursery besides 1400 hybrids and 150 progenies. Two collections have been registered with NBPGR, New Delhi (INGR 03091 – IC 316598 and INGR 04111- IC 370011).
- Yield evaluation of 10 black pepper lines viz. OPKm, HP-780, HP-1411, Coll.1041, HP-1, HP-2, Coll. 4133 Coll. 1365, Coll. 889 along with Sreekara (control) at Peruvannamuzhi (Calicut) and farmer's plot in 4 northern districts of Kerala revealed superiority of OPKm, HP-1411 and Coll. 1041.
- Seven elite black pepper lines viz. HP-105 (IISR Girimunda) HP-728, HP-780, HP-813 (IISR Malabar Excel), HP-1411, OPKm and Coll. 1041 (IISR Thevam) characterized using molecular markers (RAPD) and morphological characters revealed unique bands in six of the seven lines and distinct morphological features. Out of the 14 random decamer primers used, 9 primers generated unique band(s) in six of the lines. The lines OPKm, HP-1411 and HP-105 also exhibited distinct morphological features too as compared to the rest. Incidentally these lines also had maximum unique RAPD bands as well.
- 115 Progenies of first mapping population P1 x Subhkara were growing in the field. Leaf and shoot tip characters of these were recorded and they tallied with earlier observations recorded last year when the plants are in juvenile stage in the nursery.
- Segregation of resistance to *Phytophthora* was studied in the mapping population. They gave actual susceptible: resistance ratios of 10: 1 for leaf lesion index, 12: 1 for stem lesion index and 13: 1 for depth penetration index the nearest ratio is 15: 1 indicating the possibility that two genes are involved in *Phytophthora* resistance and the double recessive gives resistance reaction. And all the others will give different degrees of susceptibility and the susceptibility is dominant over resistance.
- A total of 16 ISSR primers were designed for the amplification of genomic DNA isolated from 16 *Piper* species. Out of 12 primers tested, eight were found to be useful in amplifying the inter-micro satellite regions.
- Good quality DNA was isolated from six parents utilized in the development of black pepper hybrids. Initially the ISSR markers were employed to find polymorphism between the parents of three hybrids viz., HP 780 x *P. nigrum* (wild), IISR 4176 x IISR 430, Panniyur 1 x Karimunda. ISSR 02 T2 primer was found to be successful in differentiating these parents from each other.
- 1000 TC plants were hardened and 3000 cultures were ready for hardening. About 500 somatic embryo derived plants were hardened and their growth is good

Cardamom

- Molecular characterization of Cardamom was done using RAPD, ISSR and RFLP- PCR markers. The study indicated that there are no duplicates in the 100 lines characterized and the Kerala and Karnataka populations are divergent in that they formed two separate clusters in the Phylogram. *Ammomum* is the nearest genera for cardamom among the 10 taxa studied.

Turmeric & Ginger

- Nine hundred and two *Curcuma* and 662 *Zingiber* accessions are conserved in the *ex-situ* gene bank. One ginger accession with high oil content (3.5%) has been registered with NBPGR, New Delhi (INGR No. 04110).
- Ginger Acc. 578 (Nepal) recorded highest yield (15.25 kg per 3 m²) with a dry recovery of 23.5% and fibre content of 1.5%.
- Ginger Acc.162 was found to be a good yielder (13 kg per 3m²) with 2.3% oil.
- Protocols for isolation of amplifiable DNA from turmeric and chill powder are developed.
- Protocol for micropropagation of turmeric and ginger is being transferred to commercial labs with a technology transfer fee of Rs 50,000 each.

Tree spices

Cassia

- Evaluation of clonal progenies of 4 elite lines (A₂, C₁, D₁, D₃) at Peruvannamuzhi indicated that C₁ showed significant differences for no. of main shoots and no. of harvestable shoots only. This line also gave the highest dry recovery (32%) and gave an yield of 600 and 180 g of fresh and dry bark per plant. D₄ recorded the highest fresh and dry bark yield (694 g and 219 g/plant) with 30.4% dry recovery

Nutmeg

- The following 9 accessions were found to be promising out of 106 accessions evaluated during 2004-2005.
- A4/12 (822 fruits), A9/18 (933 fruits), A9/53 (536 fruits), A9/63 (695 fruits), A9/116 (602 fruits), A11/5 (558 fruits), A11/10 (557 fruits) A11/25 (644 fruits) and A11/29 (597 fruits). Three different rootstocks viz. *Myristica fragrans*, *M. malabarica* and *M. beddomeii* were evaluated in nutmeg. Among the various rootstocks *M. beddomeii* continued to perform better by inducing more number of fruits in the fourth year of planting.
- Bud break was observed in nodal explants on SH and WPM media (1/4 the strength) within 30 days of initial culture. Callus induction was observed from mace explants in presence of 0.5% charcoal and 2 mg/l BAP and 0.5 NAA. White healthy callus was induced in 100% of the cultures.
- RAPD analysis was done in IISR Viswashree, its seedlings and clonal progenies. A number of bands were identified that distinguished between them. Absence of a band of 472 bp amplifiable with primer OPC 06 in clone no. 16 distinguished it

from the rest. Seedling No. 15 and clone No. 14 were conspicuous due to absence of a band of 101 bp and 142 bp amplifiable by OPE 09 and OPA 05. Two male associated loci of 101 bp amplifiable by primer OPA 05 and another of 179 bp amplifiable by primer OPE 08 could be observed.

Clove

- Approach grafts of dwarf clove (mutant- Acc. No. 197- IC 438344) using normal clove as rootstock had been produced. The grafts are expressing the morphological characters of rootstock. Acc. No. B.95 was found to be continuously promising based on yield characters at Appangala. A similar trend is observed in Peruvannamuzhi trial also.

Allspice

- Fourteen soft wood grafts, utilizing scions collected from an identified high yielding and early bearing tree in Wynad, are ready for field planting at Appangala.

Garcinia

- Preliminary field evaluation revealed that grafted plants of *G. xanthochymus* flowered within two to three years after planting, while seedling trees did not flower even 7 years after planting.
- Seventeen accessions of *G. indica* and 21 accessions of *G. gummi-gutta* were field planted for evaluation.
- Out of 7 accessions of *G. gummi-gutta* planted in 2000, one accession (IC G 7-7) flowered during the year.

Future Programmes

Black pepper

1. Inter varietal hybridization and evolving black pepper varieties having high yield and tolerance to biotic and /or abiotic stresses.
2. Morphological and molecular characterization (RAPD) of new lines of black pepper.
3. Molecular profiling of mapping population and preparation of molecular map.
4. Isolation of R genes in pepper

Cardamom

1. Hybridization between elite selections
2. Evaluation of hybrids for better yield, quality and resistance to mosaic virus

Ginger and turmeric

1. Yield evaluation of low fibre / high oil type ginger
2. Yield evaluation of Nepal collections of ginger
3. Production of nucleus seeds of released ginger and turmeric varieties
4. Cytological studies in seedling progenies of turmeric and pollination studies in ginger

Tree spices

1. Evaluation of elite lines of cassia, nutmeg and seeding progenies of elite clove.
2. Standardization of grafting nutmeg on *Knema andamanica* using interstock
3. Evaluation of nutmeg grafts for productivity and drought tolerance
4. Standardization of grafting *Garcinia indica* and *G. gummigutta* on *G. cowa* as rootstock
5. Evaluation of *G. indica* and *G. gummigutta* accessions

Vanilla

1. Collection and maintenance of vanilla germplasm.
2. Raising seedling progenies and evaluation of vanilla cultivars.
3. RAPD characterization of new collections of vanilla germplasm
4. Inter-specific hybridization and establishment of hybrid progenies of *V. andamanica* x *V. planifolia*

Project - III: System Approach for Sustainable production of Spices

Project Leader: K. Kandiannan

(Associates: R. Dinesh, C.K. Thankamani, K.S. Krishnamurthy, V. Srinivasan, S. Hamza and Utpala Parthasarathy)

Background Information

Black pepper

Knowledge on the role of weather in black pepper production is a prerequisite as the inter-annual yield variability of the crop is mainly due to weather. Therefore, developing crop weather models will help to forecast the yield of black pepper. A study was initiated during 2003 with the objectives of surveying and summarizing the existing data on the effect of meteorological factors on black pepper yield, to relate weather elements to yield response of black pepper and studying the quantitative dependence of black pepper yield on weather variables. Correlation between black pepper production and monthly rainfall of Kerala showed that September rainfall had a positive significant association with production. A regression model was developed to predict the production.

The nutritional requirement of improved varieties of black pepper was standardized to meet the major, secondary and micronutrient requirements. Detailed soil survey was done to characterize the main growing tracts to find the nutrient status. Recommendation on lime requirement and NPK requirement under chemical and integrated nutrition methods

were recommended. Diagnosis Recommendation Integration System (DRIS) norms were also developed for optimum soil and leaf nutrient status of black pepper and cardamom.

The experiments to find the nutrient requirement for targeted production of black pepper was taken up and based on the soil nutrient status, crop uptake and yield, parameters like kg of nutrient required for berry production (NR), contribution of nutrient from soil (CS) and contribution from fertilizer (CF) were worked out. With these parameters the fertilizer requirement for getting a targeted pepper yield was derived tested at different locations.

As the major black pepper growing soils are acidic, better source (rock phosphate) and dose of application of P on incubation with FYM (10 t ha⁻¹) were standardized (55 kg P₂O₅ ha⁻¹) to improve the agronomic efficiency of applied P. Micronutrients such as zinc @ 6.2 kg/ha as zinc sulphate increased spike intensity, yield by 25% and molybdenum @ 1.0 kg/ha as sodium molybdate increased yield by 14% and quality of the produce in black pepper.

The increasing cost of chemical fertilizers, growing environment concern and energy crisis have created considerable interest for search of alternative sources of plant nutrients. Use of biofertilizers have emerged as an important component of Integrated Nutrient Supply System (INSS) and enhanced the crop yield and nutrient supplies. Hence a study was initiated to find the efficacy of *Azospirillum* sp. on growth and yield of black pepper.

To quantify the extent of deterioration in soil quality due to anthropogenic activities and to monitor and arrest further deterioration of soils under spice based cropping systems a yardstick has to be developed through physico-chemical, biochemical and microbial characterization and to subsequently determine the relationships between these parameters to define a “good” and a “poor” quality soil associated with spices.

Cardamom

Cardamom is mainly cultivated in the hilly tracts of Western Ghats where soil erosion and drought during summer are of major concerns. Trials were done to conserve the soil

moisture and compare the system of irrigations on yield and the soil loss parameters. Drip and sprinkler irrigations have positive impact on yield parameters and soil and moisture conservation. Planting cardamom on contour staggered trenches in alternate rows recorded less runoff and soil loss.

Ginger

The nutritional requirement of improved varieties of ginger was standardized to meet the major, secondary and micro nutrient requirements. Under IPNM dosage of organic amendments *viz.*, neem cake, groundnut cake and gingelly cake (@ 1 to 2.5 t/ha) for improving the physicochemical properties of soil, increasing the yield and quality of ginger was standardized. As the major spice growing soils are acidic, better source (rock phosphate) and dose of application of P on incubation with FYM (10t ha⁻¹) was standardized for ginger (25 kg P₂O₅ ha⁻¹) to improve the agronomic efficiency of applied P. The optimum zinc fertilizer dose for getting maximum rhizome yield was found to be 6 kg ha⁻¹. The maximum limit of soil DTPA-Zn for getting higher rhizome yield also was found to be 3.4 mg kg⁻¹.

A study to quantify the extent of deterioration in soil quality due to anthropogenic activities and to arrest further deterioration of soils under ginger based cropping systems through physico-chemical, biochemical and microbial characterization and to subsequently determine the relationships between these parameters to define soil quality has been started.

To standardize the package for organic cultivation of ginger experiments were conducted and the mean yield of organically grown ginger (Varada) was recorded to be 7.3 kg/bed as compared to 5.4 kg per bed in case of conventional farming system.

Turmeric

The nutritional requirement of improved varieties of turmeric was standardized to meet the major, secondary and micro nutrient requirements. Recommendation on lime requirement and NPK requirement under chemical (1-1.5 t ha⁻¹ lime and 60: 50: 120 kg N, P₂O₅ and K₂O ha⁻¹) and integrated nutrition methods were made. Under IPNM dosage of organic amendments *viz.*, neem cake, groundnut cake and gingelly cake (@ 1 to 2.5 t/ha) for improving the physicochemical properties of soil, increasing the yield and

quality of turmeric was standardized. As the major spice growing soils are acidic, better source (rock phosphate) and dose of application of P on incubation with FYM (10t ha⁻¹) was standardized for turmeric (25 kg P₂O₅ ha⁻¹), to improve the agronomic efficiency of applied P.

To standardize the package for organic cultivation of turmeric, experiments were conducted and the mean yield of organically grown turmeric (Prathiba) was 6.5 kg/3 m² as compared to 5.5 kg in conventional system.

Ongoing programmes

- Bio-meteorological investigations and modeling in black pepper
- Nutritional requirement of improved varieties of spices
- Efficacy of biofertilizers on nutritional management of black pepper
- Assessment of soil quality under spices based cropping systems
- Soil and water conservation measures for sustainable cardamom production

Achievements during 2004-05

Black pepper

- Black pepper yield was analysed in relation to district wise total annual rainfall for the period of five years (1998 and 2002) of Kerala state. It was observed that rainfall at Wynad district is progressively decreasing from 2433 mm in 1998 to 1911 mm in 2002. As a result, pepper yield also decreased over the years from 452 kg ha⁻¹ in 1998-99 to 295 kg ha⁻¹ in 2002-03.
- Black pepper yield and weather (*viz.*, weekly rainfall, maximum temperature and maximum relative humidity) relationship was established with multiple regression model and it was found that weekly rainfall during crop period (June to January) had a positive association with yield ($R^2=0.834$), whereas weekly maximum temperature during crop period had negative relationship with yield ($R^2=-0.6113$). The effect of maximum relative humidity showed negative relation during initial 18 weeks, subsequently its influence was positive ($R^2=0.9997$).
- The deviation from the fixed targets of 10,15 and 20 kg/vine of fresh berry yield in black pepper was calculated to be +30, -6.9 and -19.0% respectively and at the targets levels of 15 and 20 kg/vine, we could achieve up to 93 and 81% of the yield targets fixed.
- The physico-chemical and biochemical characteristics of soils associated with pepper based cropping systems at Panniyur, Calicut and Kasargod revealed that the levels of macro-, secondary- and micro-nutrients differed markedly between depths and sites. The 0-15 cm layer registered considerably higher nutrient levels at almost all sites. The available N, P and K levels in the 0-15 cm layer ranged between 151.2-197 mg kg⁻¹, 0.0-20.2 mg kg⁻¹ and 99.0-324.5 mg kg⁻¹ respectively. The corresponding levels

in the 15-30 cm layer were 120.7-176.4 mg kg⁻¹, 0-13.5 mg kg⁻¹ and 84.5-232.0 mg kg⁻¹.

- The soils were also assayed for a few enzymes involved in N, P and C cycles. At the 0-15 cm depth, the levels of acid-phosphatase (22.2-81.7 μmol p-nitrophenol g⁻¹ soil h⁻¹), alkaline-phosphatase (5.07-8.98 μmol p-nitrophenol g⁻¹ soil h⁻¹), inorganic pyrophosphatase (1.34-5.06 μmol p-nitrophenol g⁻¹ soil h⁻¹), CM-cellulase (0.24-0.47 μmol glucose g⁻¹ soil h⁻¹) and BAA-protease (3.6-7.0 μmol NH₃-N g⁻¹ soil h⁻¹) were consistently higher relative to the 15-30 cm layer.

Cardamom

- Drip irrigation or sprinkler irrigation once in 12 days recorded significantly higher number of clumps, more number of leaves per tiller and panicles per plant. No significant variation was observed in soil moisture content between irrigation treatments.
- Drip irrigation @ 8 L plant⁻¹ daily from January 15th onwards recorded higher yield (575 kg ha⁻¹) followed by sprinkler irrigation once in 12 days (395 kg ha⁻¹).
- Trench system of planting is superior over pit system of planting with less run off (10.8 mm) and soil loss (66.34 kg ha⁻¹).

Ginger

- In ginger, critical concentrations for soil and foliar zinc levels to obtain profitable yield were calculated by graphical method of Cate and Nelson (1965) and found to be 2.1 mg kg⁻¹ for soil and 27 mg kg⁻¹ for foliar concentrations. These critical levels when verified by Mitscherlich model at 90% sufficiency level were higher than that of graphical method and found to be 3.4 mg kg⁻¹ and 37 mg kg⁻¹ respectively for soil and leaf concentrations.
- The effect of application of Zn in combination with phosphorus to alter the soil and leaf P/Zn ratio for higher rhizome yield was studied on ginger and turmeric. The application of Zn to soil decreased the soil P/Zn ratio significantly up to 1.03 in ginger as compared to control and foliar applications where the ratio was up to 6.21. The leaf P/Zn ratio ranged from 35.6 in zinc foliar sprayed twice to 80.7 in single spray of Zn, which was on par with soil Zn application (77.4). (Table.1)
- There existed a significant positive correlation among leaf P/Zn ratio and ginger rhizome yield and a significant negative correlation between soil P/Zn ratio and leaf P/Zn ratio and yield. Significantly highest yield of 10.68 kg bed⁻¹ was observed when P₂O₅ was applied @ 50 kg ha⁻¹ along with one foliar application of Zn @ 0.25% on par with soil application of Zn (9.87 kg bed⁻¹).

Table. 1 Correlation of P/Zn ratios to rhizome yield of ginger

	L P/Zn	S P/Zn	R Yield
L P/Zn	-	-0.450**	0.563**
S P/Zn	-0.450**	-	-0.415**
R Yield	0.563**	-0.415**	-

** Significant at the 0.01 level

- The investigation on nutrient requirement for targeted production of ginger shows that in the targets with 10, 15 and 20 kg fresh yield/3 m² the mean yield recorded is 11.04, 11.93 and 12.2 kg/3 m² respectively. The deviation from the fixed targets was calculated to be +10.4, -20.4 and -39.0% respectively, stating that at targets level of 15 kg/bed, we could achieve up to 80% of the targets fixed. At 10 kg /3 m² target, the yield exceeded the target fixed.
- The physico-chemical, biochemical and microbial characteristics of soils from ginger grown under different management systems like chemical, integrated and organic systems showed that the organic C levels were relatively higher in the 0-15 cm layer (1.89-2.61%) compared to the underlying 15-30 cm layer (1.08-2.42%). The levels of both secondary- (Ca and Mg) and micronutrients (Zn, Cu, Fe, Mn) also followed a similar trend.
- The variations in the activities of individual soil enzymes like acid-phosphatase, alkaline-phosphatase, inorganic pyrophosphatase, CM-cellulase and BAA-protease between depths and sites closely reflected the concomitant changes occurring in the levels of available soil organic matter, nutrients and substrates.
- Ginger (var. Varada) when grown organically by applying FYM, vermi-compost, ash and rock phosphate and *Pseudomonas* sp. as bio control agent for rhizome rot control, the mean yield recorded was 7.5 kg/ 3 m² with a reduction of 25% and 22.8% rhizome yield as compared to chemical and integrated farming, respectively. Foliar infection with *Phyllosticta* sp. disease was the major constraint noticed.

Turmeric

- The application of Zn to soil decreased the soil P/Zn ratio and it ranged from 0.7 to 6.87. The leaf P/Zn ratios ranged from 63.2 to 129.4 with the highest in single spray of Zn on par with soil Zn application. Turmeric yield also showed a positive correlation with leaf P/Zn ratio and a negative correlation with soil P/Zn ratio. Significantly highest rhizome yield of 21.6 kg bed⁻¹ was observed when one foliar application of Zn @ 0.25% was done on par with soil application of Zn (20.9 kg bed⁻¹). (Table. 2)

Table. 2 Correlation of P/Zn ratios to rhizome yield of turmeric

	L P/Zn	S P/Zn	R Yield
L P/Zn	-	-0.154	0.301
S P/Zn	-0.154	-	-0.281
R Yield	0.301	-0.281	-

- The investigation on nutrient requirement for targeted production of turmeric showed that in the targets with 15, 20 and 25 kg fresh yield/3 m², the mean yield recorded are 26, 24.2 and 26.6 kg/3 m² respectively. The deviation from the fixed targets was calculated to be +73, +21 and +6.3% respectively, stating that at all targets levels the rhizome yield exceeded the target fixed.
- Turmeric was grown organically by applying FYM, vermi compost, ash and rock phosphate and *Pseudomonas* sp. as bio control agent for rhizome rot control. The mean

yield recorded in turmeric (var. Alleppey) was 15.5 kg/ 3 m² under organic cultivation with a reduction of 15.3% rhizome yield as compared to the conventional system.

Future programmes

- Crop-weather relationship and modeling studies in spices
- Studies on INM and nutrient scheduling of new varieties of black pepper, cardamom, ginger and turmeric for targeted yield.
- Water management studies in spices
- Efficacy of biofertilizers on nutrient management of black pepper
- Standardization of package for organic production of spices
- Assessment of soil quality under spices based cropping systems

Project - IV: Production physiology of spice crops

Project Leader: B. Chempakam

(Associates: T. John Zachariah, K. S. Krishnamurthy and S. J. Ankegowda)

Background information

Black pepper

The effort was to identify the parameters (morphological, physiological and biochemical) that have direct influence on drought tolerance in black pepper and screen the germplasm for drought tolerance based on identified parameters. The main morphological parameters studied are leaf area development and root-shoot ratio. The physiological parameters are chlorophyll and carotenoids, stomatal resistance, transpiration rate, leaf wax, leaf water potential, relative water content, membrane leakage, abscisic acid content, photosynthetic rate, stomatal conductance and leaf temperature and the biochemical parameters are Catalase, Peroxidase, SOD, glutathione reductase, PPO, nitrate reductase and acid phosphatase activities, isozyme and protein profiles and lipid peroxidation.

Parameters found to be associated with tolerant accessions (during later stage of stress) are;

1. Higher stomatal resistance and lower transpiration (mild stress)
2. Higher relative water content and lower membrane leakage
3. Higher catalase activity and
4. Stabilized photosynthetic rate.

Based on these parameters the following accessions have been identified as tolerant to drought: Kottanadan, 1495, 4057, 4226, 1228, 1368, 4015, 828, 892. Similarly the physiological and biochemical parameters that have direct influence on productivity and

to screen germplasm for higher productivity based on the identified parameters were also studied and it was found that high yielders had more reducing sugars in petioles and protein content in roots than in leaves compared to low yielders. High yielders in general had higher phenols than low yielders. Leaf peroxidase isozyme had a distinctive pattern in high yielders, which was not so conspicuous in low yielders.

Cardamom

Since the majority of land under cardamom is rainfed, it experiences drought from December to May. Efforts were made to screen the cardamom germplasm collections and to characterize the drought tolerant cultivars based on identified parameters. Studies revealed that plant height, number of tillers, dry weight of leaves, stem and root were reduced under water stress conditions. Relative water content decreased and membrane leakage increased under stress treatment. Mysore types were found to be susceptible to moisture stress compared to Malabar and Vazhuka.

Turmeric

Studies on the biosynthesis of curcuminoids were initiated to assay, localize and characterize the key enzymes involved in the biosynthetic pathway and to identify the precursors and intermediates during biosynthesis. The primary rate-limiting enzyme initiating the biosynthesis of curcuminoids was found to be Phenylalanine Ammonia Lyase (PAL). Higher levels of PAL were indicated in the early germination phase, suggesting the formation of phenolic precursors. The role of phenylalanine as the starting material for the biosynthesis was also confirmed through tracer studies.

Ongoing programmes

- Characterization of drought tolerance in black pepper and cardamom
- Physiological and biochemical basis for productivity in black pepper
- Biogenesis of pigments in spice crops

Achievements during 2004-05

Black pepper

- Acc. Nos. 5001, 5670 and 5619 showed drought tolerance in preliminary screening among 145 accessions screened and the tolerant accessions showed stabilized chlorophyll fluorescence values while values started declining in susceptible accessions during later stages of stress.

- Both drought tolerant and susceptible accessions showed similar profiles of catalase, peroxidase and SOD, isozymes.
- Metabolite partitioning studies revealed that during juvenile stage high yielders had higher total starch content (stem + leaf), higher photosynthetic rate and higher transpiration compared to low yielders.
- Catalase and acid phosphatase isozyme patterns were similar for both high and low yielders.

Cardamom

- Four collections were made for bold capsule size (8.2 mm) and high biomass characters. Preliminary screening of twenty-five accessions was done for parameters like relative water content, specific leaf weight and stomatal count. Significant variations were observed among the accessions. CP1, NKE 19, RR1 and NHY-15 recorded less reduction in relative water content.

Turmeric

- Effect of kinetic parameters *viz.*, pH, temperature and phenolic inhibitors on PAL activity indicated the optimum pH of the enzyme as 8.8 and optimum temperature as 25°C ambient.
- Inhibition of PAL activity was seen during exogenous addition of phenolic acids (cinnamic, ferulic, caffeic and coumaric acids) at varying concentrations.

Future programmes

- Investigations on protein profile associated with drought tolerance in black pepper and cardamom.
- Transference of drought tolerance to high yielders in black pepper and cardamom.
- Gas exchange parameters and activities of MDH and SPS enzymes in relation to productivity of black pepper.

Project - V: Value addition and post harvest processing of spices

Project Leader: Dr. T. John Zachariah
(Associates: N. K. Leela and E. Jayashree)

Background information

Black pepper

Identifying varieties or accessions among the germplasm for rich oil, oleoresin and pungent principles is the major priority for value addition. In pepper the parameters of

interest are grades of black pepper berries, bulk density, green pepper products, white pepper, oil, oleoresin and Piperine content. Average bulk density of pepper is about 500g. Export quality grades are TGSEB (4.7 mm), TGEB (4.2 mm) and MGI (3.8 mm). Bulk density above 550 gm is highly desirable. Oleoresin above 13%, Piperine above 4% and oil above 5% are highly desirable in the industrial point of view. Some of the high quality varieties identified are Kottanadan, Kumbhakodi, Balankotta, Sreekara, Subhakar, Jeerakamundi and Malabar Excel. Caryophyllene is the sesquiterpene that imparts the peculiar aroma to pepper oil. Accessions with over 30% caryophyllene are identified. Importance was also given to develop processing techniques, harvesting tools and techniques, which add value to the primary products. Techniques have been standardized to prepare white pepper from red berries and pepper in brine from tender berries. Panniyur-1 and Balankotta are the cultivars found good for preparing white pepper.

Cardamom

In cardamom thrust was given to identify cultivars/accessions with high oil and also accessions with high alpha terpinyl acetate in oil. Many accessions with more than 8% oil (based on seed weight) and 50% α -terpinyl acetate were identified. Some of the high quality accessions are APG-218, 221, 57, 7, 30, 65, 135 and 106. In good quality cardamom, proportion of husk to seed varies between 25: 75 and 20: 80.

Ginger

Among the parameters that define ginger quality, thrust was given to crude fibre content, oil and oleoresin. Crude fibre content varies between 2.5 to 8% based on agro climatic conditions. Crude fibre content of about 3% is ideal for fresh ginger products like salted ginger, syrupy ginger etc. Among the traditional varieties, Rio-de-Janeiro, Gurubathani etc. contain more than 6% fibre. Maran, Himachal etc. contain 5-6% fibre. New varieties like Varada, Mahima, Rejatha etc. are relatively low fibre types. High fibre types are more ideal for oleoresin. Many accessions with 3% fibre were identified. Techniques have been standardized for fresh ginger products like salted ginger, ginger based jam, squash etc.

Turmeric

Main thrust was to identify turmeric accessions with high curcumin. In the industrial point of view turmeric with more than 5.5% curcumin are highly desirable. Many

accessions with more than 6% curcumin were identified. Curcumin content varies with location. Some of the high curcumin lines identified are Suguna, Sudarshana, Prabha, Prathibha, IISR Alleppey supreme etc. Planting turmeric in May and harvesting in November yield 30% more curcumin compared to harvesting at full maturity. However, there will be slight reduction in yield.

Tree Spices

Bark oil, leaf oil, cinnamaldehyde and eugenol oil, bark oleoresin etc. are the quality constituents in cinnamon. In *Cinnamomum cassia* both leaf and bark oil contain more than 80% cinnamaldehyde and trace of eugenol. Clove bud, leaf and stem yield oil. The oil of all three fractions contains eugenol as the main constituent. In nutmeg both nut and maces are used for extracting oil. Both contain about 13 to 16% oil. Major constituents in the oil are sabinene, myrcene, limonene, myristicin, elemicin and saffrol. Among the nutmeg accessions at IISR, myristicin content ranged from 3.6 to 4.5% in nutmeg oil and 1.0 to 36% in mace oil. Myristicin is an established hallucinogenic principle.

Ongoing programmes

- Quality evaluation in spices
- Studies on drying and storage parameters in black pepper, ginger, turmeric and nutmeg
- Development of chilli hybrids for oleoresin production

Achievements during 2004-05.

Black pepper

- Among the accessions evaluated, Acc. 1637, 1566 and 1493 contained 4% oil, Acc. 1602 contained 19% oleoresin followed by KS-127, 4073 and KS 147 with over 16%. W-3001 contained 5.6% Piperine followed by HP-1523 with 4.3% and Acc. 836, 1261 and KS-139 with above 3.6% Piperine.
- Grading of pepper accessions indicate about 9 accessions with more of TGSEB (4.7 mm) and 8 accessions with more of TGEB (4.2 mm) grade.

Cardamom

- Among the 33 germplasm accessions evaluated for oil Acc. CP contained 7.6% followed by HY-2 with 6.8% and NHY-2 with 6.4% in capsules.

Ginger

- Eleven Nepal collections, 13 high oil types, 6 low fibre types, 59 germplasm collections were evaluated for oil, oleoresin and crude fibre. Acc. 694, 695, 633, 632 and 630 contained high oil, oleoresin. A positive correlation is found between oleoresin and crude fibre.
- Storage of ginger and turmeric in open condition and using Zero energy chamber indicate that about 50% weight loss takes place in open condition compared to storing in zero energy chamber in which weight reduction varies between 29-35%. However storage in zero energy cool chamber showed varietal variation.

Turmeric

- Accessions such as 773, 715, 772, 781, 727, 445 and 126 showed more than 12% oleoresin and except for Acc. 126 all others yielded less than 5% curcumin.

Paprika

- An alternative method of colour estimation using acetone was standardized. Among the chilly (paprika) accessions, SH KC-19 recorded 343 ASTA colour units and SH KC-16 recorded the lowest (0.4%) capsaicin.

Tree Spices

- Among the 51 cassia lines evaluated Acc. 57 and 60 showed highest oil and oleoresin in bark (8% oil and 14% oleoresin). Other high quality accessions are 25, 49 etc. Leaf oil showed a range of 0.1 to 0.5%.
- Among the clove samples evaluated B-2, B-95, K-9 and K-7 contained above 20% bud oil. In immature clove the eugenol content in bud oil is low (about 58%) while the oil in pedicel contains about 70% eugenol.

Future programmes

- Evaluation of intrinsic principles among germplasm accessions of spices
- Isolation of bioactive principles such as turmerone, caryophyllene, zingiberene etc.

Project - VI: Production of planting materials of improved varieties of spice crops.

Project Leader: Dr. C. K. Thankamani

(Associates: P. A. Mathew, K. Kandiannan and S. J. Ankegowda, P. Rajeev, T. K. Jacob, Nirmal Babu)

Background information

Planting materials of spices like black pepper, ginger, turmeric, nutmeg, clove, cinnamon and cardamom were produced and distributed to developmental agencies and progressive farmers in the states of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Goa, Pondichery, Orissa, Himachal Pradesh, North eastern states and Andaman & Nicobar Islands. The Ministry of Agriculture, Government of India identified Indian Institute of Spices Research as one of the implementing agencies for IPDS.

Achievements during 2004-05

Planting materials production

IPDS

Black pepper rooted cuttings (No.)	-	20000
Ginger seed rhizomes (tonnes)	-	4
Turmeric seed rhizomes (tonnes)	-	11
Nutmeg grafts (No.)	-	6498

CRC, Appangala

Cardamom seedlings (No.)	-	8000
Black pepper rooted cuttings (No.)	-	3000
Cardamom suckers (No.)	-	1000
Cardamom capsules (kg.)	-	20

ATIC, Chelavoor

Black pepper rooted cuttings (No.)	-	3842
Piper chaba rooted cuttings (No.)	-	36

KVK, Peruvannamuzhi

Bush pepper rooted cuttings (No.)	-	1314
Vanilla rooted cuttings (No.)	-	750
Garcinia grafts (No.)	-	650
Mango grafts (No.)	-	74
Arecanut seedlings (No.)	-	5000
Guava layer (No.)	-	70
Rose apple rooted cuttings (No.)	-	240
Anthurium plants (No.)	-	67
Sapota graft (No.)	-	25
Coconut seedlings (No.)	-	500
Pathimukham seedlings (No.)	-	300
Stevia rooted cuttings (No.)	-	70
Insulin plant (No.)	-	150
Jatropha seedlings (No.)	-	110

On farm evaluation of tissue cultured black pepper plants	-	1500 tissue culture plants were hardened. 3000 stock plants are ready for hardening.
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Future programmes

Targets for the year 2005-06

IPDS

Black pepper rooted cuttings (No.)	-	1.7 lakhs
Ginger (tonnes)	-	5
Turmeric (tonnes)	-	5
Nutmeg (No.)	-	3000

CRC, Appangala

Cardamom capsules (kg.)	-	100
Cardamom seedlings (No.)	-	16000
Cardamom suckers (No.)	-	3000

ATIC, Chelavoor

Black pepper	-	2000
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Project - VII: Identification, characterization and development of diagnostics against pests, pathogens, nematodes of spice crops.

Project Leader: M.N. Venugopal

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Background information

Most of the economically important diseases and nematode pests of black pepper, ginger, vanilla and cardamom are introduced through planting material. Developing diagnostic kits to detect pathogens in the planting material will help in long way in eliminating primary sources of pathogens. The project aims to identify and characterize any new pathogens, pests, nematodes and their races/strains infecting major spices.

Black Pepper

Stunted and Phyllody diseases of black pepper

Stunted disease was the first viral disease reported in black pepper during 1981 from Idukki district of Kerala. In recent survey of 276 plantations in 96 locations in major black pepper (*Piper nigrum* L.) growing areas of Karnataka and revealed that the incidence of

the disease was highest in Wyanad District (45.4%) followed by Idukki District (29.4%) in Kerala. In Karnataka, Kodagu District (14.9%) had the highest incidence of the disease followed by Hassan District (5.2%). In general the incidence and severity of the disease was higher in black pepper plantations situated at higher altitudes of Kerala such as Idukki and Wyanad districts. Mosaic, reduction in leaf size and internodes length leading to stunting of the vine, and bright yellow mottling along veins were the two types foliar symptoms observed on diseased vines. All cultivars and improved varieties including hybrids were susceptible to the disease under natural conditions. Vines of all ages raised on all kinds of standards were also found affected by the disease. Two viruses namely, *Cucumber mosaic virus* (CMV) and a *Badnavirus* were identified to be involved in the disease. Of these, CMV was purified and virus specific antiserum produced in rabbits. DAS-ELISA was standardized for the detection of CMV in diseased samples. The coat protein gene of CMV was cloned and sequenced. Sequence comparisons with other CMV isolates showed that CMV infecting black pepper belongs to CMV subgroup-IB and was more close to other CMV isolates occurring in India.

Phyllody disease on black pepper was first reported during 1986 from Wyanad District of Kerala. The disease was characterized by malformation of the entire spike and the affected vines showed conspicuous tufts of malformed branches giving a witches broom appearance with yellowing symptoms that were well discernible from a distance. Although based on the symptomatology, involvement of a phytoplasma was suspected in the disease, the etiology has not been fully resolved.

Vanilla

Viral diseases of vanilla

Vanilla is affected by both fungal and viral diseases. In a survey conducted for the distribution of viral diseases revealed the presence of two kinds namely, mosaic and stem necrosis with an average incidence per locations ranging from 0% to 5% and 0% to 10% respectively. The distribution of the diseases was random and not restricted to any particular region or locality. Electron microscopy of leaf dip preparations of the diseased plants showed three kinds of flexuous particles resembling *Potexvirus*, *Potyvirus* and *Closterovirus*, and an isometric particle. Among the fungal diseases, important ones include premature bean fall, bean rot, stem rot and root rot.

Ginger and Turmeric

Etiology of rhizome rot of ginger and turmeric

Rhizome rot of Zingiberaceae members like Ginger and Turmeric is caused by several microorganisms such as bacteria, fungi and nematode. Bacteria belonging to genera *Ralstonia*, *Erwinia*, *Enterobacter*, *Pseudomonas* etc have been implicated in the rhizome rot of ginger and turmeric. Among the fungi, two genera, *Pythium* and *Fusarium* are constantly associated with the rhizome rot of ginger and turmeric and ginger yellows. *Radopholus* and *Meloidogyne* are among the nematode genera responsible for rhizome rot mainly due to their interaction with fungi particularly with the genus *Fusarium*. These organisms either alone or in combination causes severe crop loss in all the ginger and turmeric growing regions of the country and other countries. The term rhizome rot is loosely used to describe any ultimate state of rhizome due to any of the above organisms. Though each of the above organisms causes their own disease on ginger and turmeric, the final state of rhizome is complete rotting or partial rotting.

Pathogen characterization revealed the wide spread occurrence of biovar 3 of *Ralstonia solanacearum* causing bacterial wilt of ginger in India. Sensitive pathogen detection in soil and rhizome using ELISA and PCR has been standardized for bacterial wilt of ginger.

With this background information an institute project on etiology and management of rhizome rot of ginger and turmeric was revived mainly to address issues in the causal agents of soft rot of ginger and turmeric, as well as issues related to the disease management particularly using ecofriendly approaches.

Nematodes infesting spice crops

Plant parasitic nematodes like *R. similis*, *Meloidogyne* spp. and *Pratylenchus* spp. constitute an important group of pathogens in spices. Their distribution, pathogenicity and crop loss caused etc. were studied in detail and technologies to manage them were devised. However, nematode damage often goes unnoticed for want of clear-cut external symptoms. The problems get aggravated due to the unwitting use of infested planting materials. To contain the problems, nematode diagnostics that are accurate, reliable, and affordable and that does not rely on traditional morphology should be developed. This project aims to refine accurate diagnosis of nematodes.

Ongoing programmes

Black Pepper

- Characterization and development of diagnostics against viruses causing stunted disease in black pepper
- Characterization of phytoplasma causing Phyllody disease
- Estimation of yield loss and quality parameters in diseased vines

Vanilla

- Identification and characterization of virus (es) causing mosaic and necrosis disease
- Identification and characterization of fungi associated with immature bean shedding, bean rot, stem rot and root rot diseases of vanilla

Ginger

- Isolation of fungal pathogens, bacterial pathogens and nematodes from ginger and turmeric
- Reaction of ginger to sequential inoculation of pathogens
- Reaction of turmeric to sequential inoculation of pathogens
- Determination of infectivity titer of *Pythium*, *Fusarium* and *Ralstonia*
- Evaluations of endophytic bacteria against rhizome rot pathogens
- Screening of ginger germplasm for tolerance to rhizome rot
- Screening of turmeric germplasm for tolerance to rhizome

Nematodes infesting spice crops

- Genetic diversity in nematodes

Achievements during 2004-05

Black Pepper

Stunted disease

Badnavirus particles were purified from infected black pepper samples. Negative staining of the purified preparation revealed the presence of typical bacilliform particles with dimensions of 120 x 30 nm. The antiserum against *Badnavirus* was produced in New Zealand white rabbit by injecting purified virus preparations intramuscularly six times at 10-day intervals. The animal was bled 15 days after the last injection and antiserum collected. Immunoglobulin G (IgG) was purified from the crude polyclonal antiserum by affinity chromatography. One mg of this IgG was used for conjugate preparation. One step glutaraldehyde method described by Avrameas (1969) was followed for the preparation of IgG-alkaline phosphatase conjugate. Double antibody sandwich (DAS) ELISA was standardized for the detection of *Badnavirus* in field samples with 1µg/ml of IgG coating and conjugate dilution of 1:2000. The virus could be detected in stunted disease affected black pepper samples collected from different geographical areas.

Total DNA was extracted from *Badnavirus* infected black pepper leaves were used as template in PCR to amplify its genome. Out of the four primer pairs tested, one pair yielded a fragment of 750 bp consistently. The PCR product was purified, cloned in pPCR Script Amp SK(+) and competent *Escherichia coli* (strain DH5 α) were transformed by following standard molecular biology procedures. Recombinant clones were identified by restriction endonuclease digestion, and selected clones are being sequenced.

Citrus mealybug (*Planococcus citri* (Risso), commonly found associated with black pepper (*Piper nigrum* L.) was shown to transmit the *Badnavirus* associated with stunted disease. The transmission of the virus was confirmed by symptomatology and polymerase chain reaction using *Badnavirus* specific primers.

The yield loss due to stunted disease was studied in a fixed plot located in hilly zone (Pollibetta, Kodagu, Karnataka). Based on severity, infected plants were stratified into four groups and yield was recorded in relation to canopy size of 10 to 12 year old Panniyur I plants. In the virus infected plants loss in yield varied from 16 to 85%. An increase in the constituents evaluated for essential oil, oleoresin and piperine were observed with berries collected from stunted disease affected plants. Variation in the constituents was seen among plants showing different levels of disease severity, the least being observed in severely diseased vine.

Phyllody disease

Using polymerase chain reaction (PCR), the phytoplasma was detected in black pepper with phyllody symptoms in India. A 1.20 kb DNA fragment encoding the portion of phytoplasma 16S rDNA consistently amplified by nested PCR was cloned and sequenced. The sequenced region contained 1230 nucleotides. Sequence analyses showed that the gene was most closely related to members of aster yellows group (16Sr I) of phytoplasma. The sequence identity with members of aster yellows group (16Sr I) was >98% while that with members of other groups (16Sr II to 16Sr XV and other undesignated groups) ranged from 88 to 96%. On the basis of sequence identity, it is concluded that phytoplasma infecting black pepper in India belongs to aster yellows group.

Vanilla

Cucumber mosaic virus (CMV) causing mosaic, leaf distortion and stunting of vanilla was characterized on the basis of biological and coat protein (CP) nucleotide sequence properties. In mechanical inoculation tests, the virus was found to infect members of Chenopodiaceae, Cucurbitaceae, Fabaceae and Solanaceae. *Nicotiana benthamiana* was found to be suitable host for the propagation of CMV. The virus was purified from inoculated *N. benthamiana* plants and polyclonal antiserum was produced in New Zealand white rabbit. Immunoglobulin G (IgG) was purified and conjugated with alkaline phosphatase enzyme. DAS ELISA method was standardized for the detection of CMV infection in vanilla plants. CP gene of the virus was amplified using RT-PCR, cloned and sequenced. Sequenced region contained a single open reading frame of 657 nucleotides potentially coding for 218 amino acids. Sequence analyses with other CMV isolates revealed the greatest identity with black pepper isolate of CMV (99%) and the phylogram clearly showed that CMV infecting vanilla belongs to subgroup IB.

Fungal root and stem rot diseases

Root rot along with stem rot disease was reported from 4 different locations at Kannur, Wyanad, Malappuram and Calicut districts. The associated organisms have been isolated from all the locations. The three consistent isolates were tested for their pathogenicity under green house conditions. The typical root rot followed by yellowing of vine was seen in *R. solani* inoculants. Rotting in nodal region extending to internodal region was seen in *Colletotrichum vanillae* inoculated plants.

Ginger and Turmeric

Pathogen collection and isolation

Rhizome rot affected ginger samples were collected from Wyanad & Calicut (Kerala), Coorg and Dharwad (Karnataka), Raigarh (Chattisgarh), Pottangi (Orissa), Kumaraganj (UP), Sikkim, Gudalur (Tamil Nadu). Rhizome rot affected turmeric samples were collected from Kumaraganj (UP), Medak (Andhra Pradesh) Sikkim, Gudalur (Tamil Nadu), Satara (Maharashtra). 27 *Ralstonia*, 34 *Pythium* and 7 *Fusarium* were isolated from samples of ginger. 3 *Pythium* and 2 *Fusarium* were isolated from turmeric samples. The *Pythium* from ginger and turmeric was identified as *Pythium myriotylum*. Turmeric (*Curcuma longa*) was found to be a host for Ginger strain of *R. solanacearum* under artificial inoculation.

Characterization

Twenty-nine isolates of *Pythium* isolated from various locations in the country were characterized by adopting certain phenotypic and molecular methods. Besides, the isolates were also assayed for their pathogenicity on ginger. Morphological characterization revealed five clusters among the isolates which were identified as *P. myriotylum*, *P. ultimum* var. *ultimum*, *P. ultimum* var. *sporangiferum*, *P. deliense* and *P. vexans* based on the keys given by Vander Plaats-Neiterink (1981). The molecular analysis by ITS-PCR-RFLP placed all the isolates in five clusters in conformity with their identity based on morphological criteria. PCR with the primers ITS1 & ITS4 can be potentially used for identification of *Pythium*. Among the species *P. myriotylum* was frequented the isolation.

Reaction of ginger to sequential inoculation of pathogens

Ginger cv. *Himachal* was inoculated with three major pathogens viz., *Pythium*, *Ralstonia* and *Fusarium* simultaneously and in different succession to assess the reaction of ginger. Irrespective of the pathogen and its sequence of inoculation, the symptoms of bacterial wilt was found to be dominating in ginger plants.

Plant parasitic Nematodes

Isolation of DNA from root knot and burrowing nematode populations using two methods viz. phenol-chloroform-isoamyl alcohol method and sodium hydroxide digestion method was standardized. The rDNA was amplified using the 18S primers, P1 and P2. Species specific primers were designed using Bioinformatics tools for *R. similis* and *Pratylenchus* species. Single egg mass cultures of five root knot nematode populations were established for studying their genetic diversity.

Future Programmes

- Characterization of *Phytophthora* isolates infecting spice crops
- Diagnostics for the detection of viruses in black pepper and vanilla
- Characterization of virus inducing stem necrosis disease in vanilla
- Characterization of fungal pathogens and their relative role in causing stem and root rot in vanilla
- Identification and characterization of pathogens associated with rhizome rot of ginger and turmeric
- Studies on genetic diversity of nematodes infecting spices
- Development of nematode diagnostics

Project - VIII: Conventional and Molecular Approaches for Developing Pest, Pathogen and Nematode Resistance in Spice Crops

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Background information

Pests, pathogens and plant parasitic nematodes cause severe economic losses in spice crops and has been regarded as one of the production constraints. Major genera of fungi involved are *Phytophthora* and *Pythium*. Among plant parasitic nematodes *Meloidogyne*, *Radopholus* occur on all major spice crops. Among insect pests *Conogethes punctiferalis* is a common pest on cardamom, ginger and turmeric. *Ralstonia solanacearum* causing bacterial wilt in ginger and viral diseases of black pepper and cardamom are other major problems. Host plant resistance is given priority in the disease management strategy. Conscious efforts have been made to identify sources of resistance to pests and pathogens from the rich germplasm collections maintained by the institute. Germplasm accessions of black pepper, cardamom, ginger and turmeric were routinely screened against major pathogens and pests.

Black pepper

Resistance to P.capsici

In black pepper resistance to *P.capsici* is assessed by stem, leaf and root inoculation techniques. Cultivars and hybrids are screened adopting stem inoculation technique where lesion size and depth of penetration are taken as criteria for initial selection. Seedling

progenies are screened with root inoculation technique. So far 581 cultivars, 380 hybrids, 33 Karimunda selections and 10 Kottanadan selections have been screened. Besides, lakhs of seedling progenies have also been screened. Hybrid seedling progenies involving Panniyur-1 and Subhakara and also selfed progenies of Panniyur- 1, Subhakara and *Phytophthora* tolerant IISR-Shakthi have been screened. The seedling progenies show varying degrees of tolerance, indicating segregating nature of resistance though the parents are susceptible.

None of the cultivated germplasm screened so far has shown resistance but various levels of tolerance have been recorded. The short listed lines are tested in hotspots and after ascertaining yield potential and desirable agronomic traits released as tolerant lines. One of the tolerant lines an open pollinated progeny has been recommended for release as IISR-Shakthi. The mechanism of resistance to *P.capsici* in IISR-Shakthi is by the activation of defence related genes and early induction of PR proteins especially β 1-3 glucanases and chitinases.

Resistance to nematodes

Germplasm accessions of black pepper are routinely screened against target nematodes under greenhouse conditions. The host damage measured as lesion index or gall index (also egg mass index) is the primary criteria used in this preliminary round. In black pepper 468 and 298 germplasm accessions were screened against *R. similis* and *M. incognita*, respectively. The short-listed accessions are once again screened in the greenhouse and the nematode multiplication rate is recorded besides the crop damage. The identified accessions are finally evaluated in microplots or simulated field conditions to confirm the nematode resistance. Their agronomic qualities are tested in multi-location trials and suitable accessions are released for large scale cultivation. One black pepper variety IISR- Pournami resistant root knot nematode *M. incognita* has been released so far. The post infection changes in scavenging antioxidant enzymes of the nematode resistant 'Pournami' indicated a hypersensitive mechanism for the suppression of nematodes.

Resistance to insect pests

Germplasm accessions are assessed for pollu damage by recording the per cent berry damage in the field. If the damage is less than 1% consistently for 3 years such accession

is considered to be resistant. Among one hundred and eighty five accessions of cultivated black pepper screened for pollu damage four accessions (Accn. Nos. 816, 841, 1084 and 1114) were identified as resistant to the pest. Seven related species of *Piper* were screened for berry damage against pollu beetle and six of them namely, *P. attenuatum*, *P. barberi*, *P. chaba*, *P. colubrinum*, *P. hymenophyllum* and *P. longum* were resistant to the pest. The mechanism of pollu resistance was due to the higher epicuticular wax content and presence of several free amino acids.

Among wild germplasm *Piper colubrinum* was identified as a common source of resistance to *P. capsici*, *R. similis* and *M. incognita*.

Cardamom

Resistance to diseases

In cardamom the two major diseases are rhizome rot caused by *Pythium vexans* and *Rhizoctonia solani* and mosaic (Katte) caused by a *maclura virus* (poty viridae). For both, diseases resistant sources have been located from disease escapes and germplasm accessions through rigorous screening under green house and sick plot conditions. They were also evaluated for yield, quality and pest tolerance and later recommended for release in hot spots as IISR- Avinash (Rhizome rot tolerant) and IISR-Vijetha (Virus resistant). The breeding potential of aphid vector on virus resistant lines were studied and it was found that the vector is able to multiply normally indicating that there is no vector feeding and breeding deterrence.

Ginger and turmeric

Resistance to diseases

Till date more than 600 accessions of ginger germplasm were screened against bacterial wilt pathogen as well as soft rot pathogen both by conventional screening methods and through Invitro selection methods. None of the accessions was resistant to soft rot and bacterial wilt in ginger and rhizome rot of turmeric.

Resistance to nematodes

One of the accessions of ginger resistant root knot nematode *M. incognita* has been released as 'IISR- Mahima'.

Resistance to insect pests

The shoot borer *Conogethes punctiferalis* is a major pest of cardamom, ginger and turmeric. Out of about 555 accessions of ginger screened one accession showed zero per cent infestation.

Ongoing Programmes

- Screening of cultivars, hybrids and seedling progenies for resistance to *P. capsici*
- Culturing of nematode populations and screening of germplasm
- Screening of black pepper germplasm and hybrids against pollu beetle
- Screening of ginger against shoot borer and storage pests.
- Inducing heterosis by crossing disease resistant lines of cardamom and evaluating their field performance

Black Pepper

Screening for resistance to P. capsici

Open pollinated seeds from 29 cultivars and 42 hybrids were collected during December 2003. They were raised in basins containing potting mixture. The seedlings germinated were screened in the 3-4 leaf stage using zoospore drenching method. The seedlings survived in this after 5 months of inoculation were transplanted into polybags for multiplication. This will be subjected for secondary screening after multiplication.

Screening of wild accessions

Ninety-five wild accessions were subjected to stem and leaf inoculation using the most virulent isolate of *P. capsici*. In the preliminary screening, five accessions showed tolerant reaction.

Screening of short listed tolerant lines

Out of 117 short listed hybrid lines, 31 accessions were screened and one accession showed tolerant reaction.

Screening for resistance to nematodes

Forty six hybrids and 12 cultivated germplasm accessions were multiplied during the period and Cultures of root knot nematodes and *R. similis* were maintained. Preliminary screening of 33 (26 hybrids, wild – 6 and cultivated – 1) black pepper germplasm accessions against *R. similis* has been carried out. Out of these two wild accessions (Acc. 3283 and 3290) and one hybrid (HP 125) showed resistance to the nematode.

In the *in situ* screening experiment at Peruvannamuzhi Farm, out of the nine accessions under field evaluation, only three accessions Acc. 820 (IC No. 316481), Acc. 1090 (IC

No. 316635) and HP 39 were healthy and free from nematode infestation after two years of planting.

Screening for insect pests

Screening of 167 cultivars and 57 hybrids of black pepper at IISR experimental farm, Peruvannamuzhi against pollu beetle, *Longitarsus nigripennis* revealed that the infestation by the pests on the berries ranged from 1.7-37.5% in cultivars and 1.8 to 32.8% in the case of hybrids.

Cardamom

Disease resistance

To induce heterosis, controlled crosses were made between virus resistant selections and high yielding selections (green gold). Evaluation of 2084 hybrid seedlings for three years was undertaken and 24 high yielding hybrids are short listed based on the yield for the screening and comparative yield evaluation trials.

Ginger and Turmeric

Screening for soft rot and bacterial wilt

During 2004-05, forty ginger accessions obtained from Nagaland were screened against bacterial wilt using soil inoculation method. None of the germplasm found to survive the disease. A simple screening procedure was developed for large scale screening of ginger accession for bacterial wilt resistance. However incidence of disease escapes were found during the course of screening. Reasons for disease escapes while performing germplasm screening for bacterial wilt resistance were found to be failure of the pathogen to sustain its threshold population to cause the disease which necessitates three rounds of inoculation with the pathogen during initial stages of screening. A simple PCR confirmed the absence of the bacterial wilt pathogen in the escaped accession which was succumbing to wilt upon repeated inoculation.

Rhizome rot potential of 30 *Pythium* isolates were assessed just by observing the rhizome rot rather than the typical soft rot and yellowing symptoms. The ability of the pathogen to cause rhizome rot was calculated by a formula* as furnished below. Among the isolates evaluated *Pythium deliense* and *Pythium myriotylum* was found to completely rot the rhizomes. These pathogenic species can be used in future screening programmes. The rhizome yield under inoculated conditions can be considered while scoring for resistance.

*Rhizomes yield with pathogen-Rhizome yield without pathogen X100

Rhizome yield without pathogen

Screening against root knot nematode

Ginger

Fifty germplasm accessions were screened against root knot nematodes. Nine of them which had an EMI<2 were short-listed for further screening. Out of the four accessions

viz. Acc. 36, 48, 59 and 210 planted in micro plots for confirming their resistance to root-knot nematodes, Acc.36 was superior.

Turmeric

Twelve out of the 50 germplasm accessions screened against *M. incognita* were resistant in the preliminary screening. Acc. 31, 35, 43, 54, 56 & 57 were subjected to final round of screening against root-knot nematodes of which Acc. 43, 56 and Acc.57 were superior in yield and other agronomic traits.

Screening against shoot borer

Screening against shoot borer of ginger *Conogethes punctiferalis* was carried out at monthly intervals on 555 accessions. One accession was found free of pest infestation.

Future programmes

- Screening of germplasm of cardamom, black pepper, ginger and turmeric for pests, pathogens and nematode resistance.
- Field evaluation of short-listed accessions.
- Studies on molecular basis of resistance.

Project IX. Developing integrated pest and disease management strategies in spice crops

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Background Information

Though several chemical pesticides are effective for the control of pests and diseases of spice crops, their indiscriminate use could cause pesticide residues in the produce, affect non-target organisms and result in other ecological hazards. Hence, the project was initiated to develop integrated management schedules against major insect pests, nematodes and pathogens of spice crops in sustainable agricultural systems.

Diseases

Phytophthora foot rot caused by *P. capsici* is the most serious disease of black pepper. Integrated disease management strategies involving phytosanitation, cultural practices, chemical and biological control and host resistance have been developed. A large number of bio-control agents have been isolated and screened in laboratory, greenhouse and field

trials. Efficient strains of vesicular arbuscular mycorrhizae such as *Glomus fasciculatum* and *Gigaspora gigantea* have been identified that enhanced growth of black pepper plants and suppressed root pathogens in the nursery. Effective strains of *Trichoderma harzianum* and *Pseudomonas fluorescens* have also been identified and commercialized. The compatibility of biocontrol agents with agrochemicals has been studied. A large number of plant species were screened to identify bioactive principles among which *Chromolaena odorata* was promising indicating its potential in the management of the disease. Emphasis is now being given to develop a biocontrol consortium for the management of the disease. Another approach for the management of disease-affected gardens is cultivation of *P. nigrum* grafted on *P. colubrinum* root stocks that is resistant to the pathogen and various farmer's plot are being monitored for the performance of these grafts.

In ginger, pathogens like *Ralstonia solanacearum* and *Fusarium* spp. are rhizome-borne and movement of seed rhizomes from one location to another is chiefly responsible for the spread of bacterial wilt and rhizome rot diseases in various regions. A simple rhizome solarization procedure has been standardized and initial trials with small quantities of rhizomes yielded promising results which is now being scaled up. Soil solarization and application of biocontrol agents and fungicides have been recommended earlier for the management of rhizome rot of ginger. However, due to different methods of cultivation, interaction among the microbes and varied environmental factors prevailing in different regions, the control measures are often not effective. Hence, new studies have been initiated for the management of the disease using consortium of biological control agents and rhizome solarization.

In vanilla, surveys conducted in various regions indicated the widespread prevalence of flower and bean shedding (especially during summer) and root rot disease. *Colletotrichum* sp. was observed to be associated with bean shedding and *Fusarium* sp., *Rhizoctonia* sp. and *Colletotrichum* sp. with root rot disease. Evaluation of irrigation schedules and application of fungicides for the management of bean shedding and biocontrol agents for the management of root rot disease is being undertaken.

Plant parasitic nematodes

Among the several species of plant parasitic nematodes infesting spice crops, burrowing nematode (*Radopholus similis*), root-knot nematodes (*Meloidogyne* spp.) and root lesion nematodes (*Pratylenchus* spp.) are more serious. Several fungal and bacterial biocontrol agents like *Paecilomyces lilacinus*, *Trichoderma* spp., *Pochonia chlamydosporia* and rhizobacteria such as *Pseudomonas fluorescens* have been identified against these nematode species. Most of these bioagents are very effective against root-knot nematodes, but against *R. similis*, only a few rhizobacterial strains are effective. Studies on endophytic bacteria to manage *R. similis* are also in progress. At present the promising bacterial antagonists are being evaluated under field conditions.

Insect pests

Among the insect pests of black pepper, the pollu beetle (*Longitarsus nigripennis*) which is the most serious pest can be managed by regulation of shade in the plantation and spraying of endosulfan 0.05% or quinalphos 0.05% during June-July followed by a neem-based product such as Neemgold 0.6% at 21 day intervals during July-October. Leaf extracts of *Strychnos nux-vomica* and *Chromolaena odorata* and seed extract of *Annona squamosa* possessed appreciable anti-feedant activity indicating their potential in utilizing them in IPM schedules. Scale insects such as *Lepidosaphes piperis* and *Aspidiotus destructor* that are major insect pests at higher altitudes can be managed by pruning and destruction of severely affected shoots, spot application of insecticides such as monocrotophos 0.1% or dimethoate 0.1%, release of coccinellid predators such as *Chilocorus* spp. followed by spraying of plant products such as neem oil 0.3% or Neemgold 0.3% or fish oil rosin 3%.

In ginger and turmeric, spraying of a *Bacillus thuringiensis* product such as Dipel 0.3% at 21 day intervals during July-October was effective for the management of shoot borer (*Conogethes punctiferalis*) which is the most serious pest on these crops. An integrated strategy involving pruning and destruction of freshly infested shoots at fortnightly intervals during July–August and spraying malathion 0.1% at monthly intervals during September–October was effective for the management of the pest. Various parasitoids were documented against the shoot borer among which *Apanteles taragammae* was important. Dipping of seed rhizomes of ginger and turmeric in quinalphos 0.075%, after

discarding severely infested rhizomes and storage in dried leaves of *Strychnos nux-vomica* and *Glycosmis pentaphylla* was effective for the management of rhizome scale, a serious pest in storage. At present, emphasis is being given to develop IPM schedules against root mealybugs (*Planococcus* spp.) that are serious pests of black pepper especially in Wayanad and Madikeri districts and rhizome scale of ginger and turmeric.

On-going programmes

- Rejuvenation of *Phytophthora* foot rot affected black pepper plantations.
- Development of consortium of bioinoculants for the management of diseases and nematodes in black pepper.
- Evaluation of *P. colubrinum* grafts in farmers fields for the management of *Phytophthora* foot rot of black pepper.
- Characterization and evaluation of bioactive compounds from *Chromolaena odorata* against *P. capsici*.
- Evaluation of irrigation schedules, fungicides and biocontrol agents for the management of immature bean shedding and root rot diseases in vanilla.
- Isolation, characterization, evaluation and mass multiplication of biocontrol agents against nematodes affecting black pepper, ginger and turmeric.
- Bioecology and evaluation of plant products and microbial pathogens against root mealybugs infesting black pepper.
- Evaluation of storage materials for the management of rhizome scale of ginger and turmeric.

Achievements during 2004-05

Black pepper

***Phytophthora* foot rot disease**

Rejuvenation of black pepper plantations

In order to develop a technology to rejuvenate foot rot disease affected black pepper plantations, an experiment is in progress with various treatment combinations including maintenance of weed cover in the interspaces (zero tillage), clean cultivation (periodical removal of weeds) and growing of disease susceptible and tolerant varieties, organic and inorganic nutrition and chemical and biological methods of disease control. The initial growth and establishment of vines was better in the plot under clean cultivation and after 3 years the yield was also higher in this plot. The soil availability of N, P and K was also monitored in various plots.

Evaluation of biocontrol consortium

A new trial on development of biocontrol consortium for managing *P. capsici* and plant parasitic nematodes in black pepper was laid out at Peruvannamuzhi. The organisms

include *Trichoderma harzianum* and 9 promising bacterial isolates which were short-listed from greenhouse studies. The build up of population of the introduced organisms and the native population are being monitored along with growth response and disease incidence.

Compatibility of biocontrol agents

Thirty seven bacterial isolates which were inhibitory to pathogens of black pepper (*P. capsici*-19, *M.incognita*- 17 and *R. similis*- 1) were tested for their compatibility to *Trichoderma harzianum* (IISR-1369) that has been identified as a promising biocontrol agent for *P. capsici*. Among them, 12 isolates inhibited the growth of *T. harzianum*; the inhibition varied from 13.3% to 76.3% by these isolates.

Characterization and evaluation of bioactive compounds

The bioactive compounds in *Chromolaena odorata* were tested for their fungitoxic properties on *P. capsici*. The per cent inhibition of mycelial growth by the hexane fraction of the compound ranged from 2.2% to 66.8% at 0.1% to 2.0% concentrations and for the methanol fraction from 61.7% to 80.4%. The compounds were isolated by column and thin layer chromatography from the fungitoxic fraction of the hexane and methanol extracts and are being identified by their IR, NMR and mass spectral studies.

Evaluation of *Piper colubrinum* grafts

A total of 220 grafts of *P. nigrum* grafted on *P. colubrinum* and trailed on arecanut and glyricidia were established at IISR farm, Peruvannamuzhi. In evaluation of grafts at farmers fields, there was decline in the vigour of grafts at Peruvannamuzhi due to drought and the yield was reduced to 340 kg (dry) from 600 grafts; 90 grafts also succumbed due to drought. At Kottayam, an yield of 4 to 5 kg (green) per graft was obtained where the grafts are trailed on concrete poles. At Wayanad, an yield of 3 kg (green) per graft was obtained from the grafts trailed on arecanut. At Dakshina Kannada, the growth of grafts on arecanut was satisfactory and 1000 *P. colubrinum* rootstocks were supplied for grafting.

Plant parasitic nematodes

Isolation of endophytic bacteria

Seventy three new isolates of endophytic bacteria were collected from black pepper. Generally, roots of black pepper plants harbored maximum endophytes compared to leaves and stems. Among the 11 improved varieties of black pepper tested, HP-813 possessed the maximum population of endophytic bacteria while the lowest was found in Panniyur-4.

Evaluation of promising biocontrol agents in the field

The field evaluation trials (two trials) using promising bacterial and fungal biocontrol agents for the control of nematodes in black pepper gardens were continued. However yellowing and mortality increased in the vines irrespective of the rhizobacterial treatments.

Characterization of rhizobacteria and endophytic bacteria

Molecular characterization of 39 isolates of rhizobacteria, diverse in their morphology, phenotypic characters, antibiotic resistance and antagonistic activity, was completed through ARDRA and rep-PCR. In the highly discriminatory Rep-PCR, the 39 strains were grouped in to 33 clusters at 70% similarity coefficient.

The endophytic bacterial isolates were characterized based on colony morphology, nematicidal bioassay and colonization studies. *In vitro* screening of 110 isolates for nematicidal activity was completed and the mortality of nematodes ranged from 0% to 31.0%; 8 isolates caused more than 20% mortality. Techniques for molecular characterization of endophytic bacteria were standardized and genomic DNA was isolated from 70 isolates. PCR based screening based on molecular markers was standardized to identify strains with specific biocontrol activity. Twelve isolates that produced HCN were identified through PCR based screening and biochemical tests. None of the 39 isolates screened possessed the gene for DAPG.

Mass multiplication of promising biocontrol agents

Experiments on developing liquid formulations of *Pochonia chlamydosporia* and promising bacterial isolates were initiated.

Root mealybug

Distribution

Surveys conducted in Wayanad and Kozhikode districts in Kerala indicated that in addition to an undescribed species of *Planococcus*, *P. citri* also infested basal portions of stems and roots of black pepper. Root mealybugs were also observed on banana, turmeric, coffee, *Erythrina* sp. and 14 weed plants in black pepper gardens severely infested with the pests. Larvae of *Spalgis epius* (Lycaenidae) were observed to predate on root mealybug colonies in the field in Kozhikode and Wayanad districts.

Life history

The life histories of *Planococcus* spp. were studied in the laboratory. The pre-oviposition and oviposition periods, fecundity of females, and duration of various instars were determined. The morphometrics of various stages were also determined.

Evaluation of microbial pathogens

Evaluation of 12 bacterial isolates (promising against *P. capsici* and nematodes) and 5 fungal isolates against root mealybug is in progress in the laboratory.

Evaluation of plant and organic products

Extracts (aqueous and alcohol) of 10 plant species and 12 plant and organic products are being evaluated against root mealybug in the laboratory.

Ginger and turmeric

Bacterial wilt and rhizome rot diseases

Isolation and evaluation of endophytic bacteria

Among the seven endophytic bacteria isolated from turmeric, four isolates were antagonistic against *Pythium* sp., *Fusarium* sp. and *R. solanacearum*. Thirteen rhizome associated bacteria isolated from ginger were also found to inhibit the growth of *Pythium* sp. and *R. solanacearum* *in vitro*.

Evaluation of endobacteria consortium

Efficient endophytic bacteria short-listed during 2003-04 were evaluated against bacterial wilt of ginger in the greenhouse. The data indicated that the endophytic bacteria can be exploited for reducing the bacterial wilt incidence in ginger.

Compatibility of rhizobacteria

An *in vitro* experiment conducted to study the mutual interaction among the rhizobacterial strains effective against different pathogens affecting ginger revealed the co-existence of few rhizobacteria in a common multiplication medium. The PCR assay further confirmed the existence of the bacterium in the bacterial consortium.

Evaluation of rhizobacteria consortium

An integrated disease management trial conducted in the field at Peruvannamuzhi involving rhizome solarization as well as rhizobacterial consortium in ginger yielded good results with the combined treatment resulting in higher yield of rhizomes with lesser incidence of rhizome rot. In turmeric, evaluation of rhizobacteria consortium in the field at Peruvannamuzhi for rhizome rot management showed that two bacterial consortia were significantly superior to other combinations with regard to yield. No rhizome rot incidence was noticed during the period in the experimental field.

Large scale seed rhizome solarization

In order to meet the requirement of bulk treatment of seed rhizomes of ginger for disinfection, the rhizome solarization methodology was modified wherein the bulk (100 – 200 kg) of the material was spread on a polythene sheet directly under sunlight. The rhizomes were covered with another sheet of polythene and the borders were sealed with wet soil. The lethal temperature for *R. solanacearum* was achieved within 60 min when the rhizomes were exposed from 12 noon onwards. The solarized rhizomes recorded higher germination and yield when compared to un-solarized rhizomes. The incidence of

bacterial wilt was negligible in the field where only one clump in the untreated control recorded bacterial wilt.

Plant parasitic nematodes

Field trials with promising biocontrol agents

Ten promising isolates of rhizobacteria were evaluated in the field at Peruvannamuzhi on ginger (Himachal) and turmeric (Prathibha) among which two isolates significantly improved the yield of ginger and three isolates were promising in turmeric.

Rhizome scale

Management

Dried leaves of *Strychnos nux-vomica* and *Glycosmis pentaphylla* and saw dust were evaluated as lining materials in various proportions for the management of rhizome scale (*Aspidiella hartii*) after dipping the rhizomes in quinalphos 0.075%. The trials indicated that storage of rhizomes in dried leaves of *S. nux-vomica* alone, *G. pentaphylla* alone, *S. nux-vomica* + saw dust (1:1 proportion) and *G. pentaphylla* + saw dust (1:1 proportion) were as promising as storage in sawdust alone, for the management of rhizome scale.

Vanilla

Bean shedding

Management of flower and bean shedding

A field trial was undertaken at Kodencherry to evaluate the efficacy of various schedules and methods of irrigation and fungicides on the incidence of flower dropping and bean shedding. Bean shedding was less in plots where sprinkler irrigation was adopted, whereas flower dropping was less in plots treated with mancozeb 0.2%.

Root rot disease

Management of root rot disease

A trial was initiated in the greenhouse at Calicut to study the effect of biocontrol consortium on managing root rot disease.

Future programmes

- Development of consortium of bioinoculants for management of diseases and nematodes in spices.
- Evaluation of *P. colubrinum* grafts for the management of *Phytophthora* foot rot in farmers fields.
- Characterization and evaluation of bioactive compounds from *Chromolaena odorata* against *P. capsici*.
- Evaluation of fungicides and cultural methods for the management of immature bean shedding and root rot disease in vanilla.

- Evaluation and mass multiplication of biocontrol agents against nematodes affecting black pepper, ginger and turmeric.
- Evaluation of plant products, microbial pathogens and newer insecticides against root mealybugs infesting black pepper.

Project- X: Economics, Statistics and Modeling

Project Leader: Dr. M. S. Madan

(Associates: K.N. Kurup, P. Rajeev, K. Kandiannan, V. Srinivasan and Utpala Parthasarathy)

Background Information

The cost of cultivation for major spices crops (black pepper, ginger, cardamom, turmeric and vanilla) was estimated and the marketing system for spice crops was analysed. A detailed database for spices was created. Economic evaluation of spices production technologies was done. Paper maps from Kerala Land Use Board (KLUB) were collected and digitized to create administrative boundaries (up to panchayat level) for the target district (Wayanad). Major and micro watersheds including rivers, streams, canals and other water bodies in the district were digitized. In the process of creating land use/land cover maps, soil map for the whole of Kerala was digitized using the source map from NBSSLUP. Under Integrated National Agricultural Resources Information System (INARIS) Database ‘Spicestat’ has been prepared at IISR and integrated with the national database at IASRI. The database contains 19 tables with 33573 records: Area & production -17030, Country-60, Crops-50, Crop type- 2, District-558, Grade-89, Market-42, Price-8171, State-31, Trade-2056, Tradetyp-2, Value added-161, Currency-4, Grade-89, International prices-951, International trade-3459, Major producers-441, Unit-17, Year convention-3 records. The database contains 29 tables and 1618 records of 2.476 MB memory size.

Ongoing programmes

- Estimation of cost of cultivation and marketing of major spices
- Economic evaluation of technologies developed and transferred by the institute
- Prediction system in spice crops – production and marketing
- Development and maintenance of spice data base
- Application of Remote Sensing (RS) and Geographical Information System (GIS) for creating spatial database
- Impact analysis and estimation of returns to research investment

Achievements during 2004-05

- Using the census data (1990-91) i.e. base year for the program the following socio-economic data layers were created:
 - Population & population density
 - Workers and non workers
 - Agricultural labourers
 - Household income & literacy etc.
 - Number of farm holdings and size
- A questionnaire has been prepared for collection of location specific attributes like crops, yield, occupants, inputs, outputs, markets, processing etc. The data collection and attaching the same to boundaries of plots and fields will be done in this year. Area under forest & vegetation categories is to be collected and added to the system.
- The database 'Spicestat' was updated with new data and images for varieties and disease symptoms were inserted into the database. Updating the website www.spicestat.com using new data and the same has been given to INARIS Lead centre for hosting.
- Research impact analysis of the technology - Development and evaluation of soil and water conservation measures and land use systems for sustainable crop production in the Western Ghats of coastal region - indicated that the Net Present Worth (NPW) is much higher (Rs.480856) in the case of adopters when compared to non adopter's Rs.166798.
- The Benefit Cost Ratio (BCR) estimated taking into account the future value of money and the Internal Rate of Return (IRR) of more than 140% indicated the better benefits derived from the new technology.
- Research investment of Rs.13.27 lakhs over a period of 3 years to develop soil and water conservation measures for the cardamom based cropping system in Coorg district returned a net economic surplus of Rs.60.0 lakhs with IRR of 52% and BCR 1.3:1 after 7 years after introduction.
- Research impact analysis of the technology- Development, Production and Demonstration of Biocontrol Agents *Trichoderma* mass multiplication - indicated that all the *Trichoderma* producing units in Kerala obtained the technology and guidance from IISR, while the certification for the end product was done by Agricultural University.
- With the BC ratio of 1.84 the industry was highly profitable for the entrepreneur. The investment on the venture returned a Net Present Worth (NPW) of Rs.242618 @ 11% for 10 years period and the IRR was 121 %. The in house research and developmental activities initiated by the entrepreneurs enabled them to decrease unit cost production (Table 3)

Table 3. Measures of project worth

Sl. No	Criteria	Quantity
1.	Pay-back period (years)	<2
2.	Net Present Worth (NPW) at 11% discount rate (Rs.)	242618
3.	Benefit Cost Ratio (BCR) at 11% discount rate	1.84
4.	Internal Rate of Return (IRR) %	121

- Estimating the returns to research investment of Rs.14.2 lakhs over a period of 5 years for developing and commercialization of a mass multiplication technique for *Trichoderma harzianum* for control of *Phytophthora* foot rot disease in black pepper generated a net economic surplus of 11.39 lakhs after 6 years of adoption with a maximum adoption level of 5%. The investment has returned an internal rate of return (IRR) 19% and benefit cost ratio (BCR) 2.5:1. (Table 4).

Table 4. Sensitivity of estimated return to various assumptions

Assumptions	Level	Net Value (Rs. '000)	Present Internal Rate Return	Benefit: of Cost Ratio
Maximum/ceiling adoption level (%)				
Baseline	5	1139	19	2.5
Medium	10	1800	22	1.9
10% more cost +	10	1633	20	2.1
Research period: years to reach output reaching farmers				
Baseline	4	1139	19	2.5
Longer research period	6	181	10	10.2
Research cost (Rs.'000)				
Baseline	1419.0	1139	19	2.5
Decrease by 20%	1135.2	1472	24	1.9
Increase of 20%	1702.8	806	15	3.5
Discount rate (%)				
Base line	8	1139	19	2.5
Medium	11	696	19	3.2
Higher	20	-71	19	16.2

- Impact of Information System Development survey conducted among the scientists indicated that all the scientists of the institute are connected to Local Area Network (LAN) and have their own e-mail account. About 71.43 % scientists reported that they regularly get hooked to LAN and Internet.
- However, only 42.85 % scientists made attempts for trouble shooting with the LAN facility. About 71.43 scientists reported having individual direct access to e-mail/Internet, while 42.86 % reported sharing the Internet / e-mail facility with other members in the laboratory. The scientists are also accessing the open access journals through internet.
- In the office and administration side, the most common work for which the computer is used is for typing i.e. word-processing. Computer is also used in maintenance of project budgets/ accounts (20.63 %) mainly by the accounts section. The other activities for which the computerized facility used include, maintenance of financial

schedule (10%), financial bookkeeping and accountancy (10%), maintenance of institute assets and liabilities (6.25%) and personnel database management (5.63%).

Project- X1: Extension and training

Project leader: Dr. P. Rajeev

(Associates: T.K. Jacob)

Background Information

The partnership services offered by the institute include Training, Consultancy and Contract research. The Institute offers training programme on demand from various agencies targeted for field extension functionaries of departments and research workers of other ICAR Institutes and State agricultural Universities (SAU). The modules for these training programmes are prepared based on technologies developed by the institute and research achievements. The topics covered included spices production technology nursery, pest and disease management in major spices, post harvest technology and computer applications. The details of training programme organized since the year 2000 are furnished below.(Table.5)

Table. 5 Training programme organized since the year 2000

Sl No.	Title of Course	Period	No. of Participants	Target region
1.	Spices research and development	15-20 th May 2000	9	Allahabad Agri. University
2.	Nursery Mgt. and Spices	18-20 th Sept. 2000	10	Kerala, Karnataka, West Bengal and NE States
3.	Spices Production Technology	24-31 st August 2000	13	Kerala, Karnataka and NE States
4.	Spices Production Technology	22-29 th November 2000	19	Projects Staff of IISR, Calicut.
5.	On farm processing of spices	17-19 th Jan. 2001	4	Kerala, Tamil Nadu and NE States.
6.	Spices Production Technology	3-7 th Sept. 2001	21	Dept. of Agri. Andhra Pradesh
7.	National Training Programme on Spices Production Technology	10-17 th Sept 2001	15	National
8.	Spices Production Technology	19-26 th Nov. 2001	5	Karnataka, Kerala and Maharashtra
9.	Spices Production Technology	10-12 th Dec. 2001	8	NE States
10.	Spices research and development	7-9 th Jan. 2002	15	Allahabad Agri. University
11.	On farm processing of spices	23-25 th Jan. 2002	9	Kerala, Maharashtra and NE States
12.	Nursery Mgt. and Spices	24-26 th June 2002	7	Spices Board, Cochin
13.	Spices Production Technology	26 th Nov-2 nd Dec. 2002	7	Hariyana and Kerala
14.	Spices Production	13-15 Jan. 2003	12	NE States

	Technology			
15.	On farm processing of spices	22-24th Jan. 2003	5	A.P, Gujarat, Hariyana and NE States
16.	Spices Production Technology	12-14 th June 2003	16	State Dept. of Agriculture, Malappuram.
17.	Spices Production Technology	6-7 th August 2003	22	Technical Staff of IISR.
18.	Spices Research and Development	17 th August 2003	13	PG students of Calicut University.
	Basis statistics and computer applications in Agri. Research	16-26 th Sept. 2003	8	AICRPS Scientists
19.	Pepper Production Mgt.	14 th Jan 2004	26	Agri. Officers of State Dept. Farms, North Kerala.
20.	Spices Production Technology	19-21st Jan 2004	9	NE States
21.	Spices Production Technology	2-4th March 2004	20	Progressive farmers of Darjiling, West Bengal
22.	Good Agricultural Practices for rural youth	24-27 th April 2004	21	All Kerala
23.	Vanilla Production Mgt.	24-25 th June 2004	29	Extension Officers of Coffee Board-Wynad, Idukki and Palakkad
24.	Pepper Production Mgt.	15-17 th July 2004	4	ATMA, NATP, Palampur.
25.	Good agricultural practices	26-28 Oct 2004	21	Rural youth from Kerala, TN
26.	Spices Production Technology	2-4 Dec 2004	10	NE states
27.	Ginger and turmeric production	3-5 Jan 2005	6	Progressive farmers from Satara

Ongoing programmes

- Training of research and extension workers
- Agriculture Technology Information Centre

The ATIC at IISR started functioning in the year 1999. As per mandate, the centre is involved in technology dissemination functions through various division of IISR. The major activities of center are,

- Production and distribution of quality planting material
- Production and distribution of printed literature
- Farm advisory services including crop diagnostic services
- Information dissemination through multimedia, video and interactive databases
- Providing audio visual aid support to the institute activities
- Organising technology dissemination services like exhibitions, seminars to farmers and other users

A study was carried out to assess the level of adoption, diffusion and the impact of integrated disease management of foot rot disease of black pepper in Wyanad district. Fifty farmers selected randomly from a list of farmers who sought information and inputs

on the said technology from Indian Institute of Spices Research, Calicut constituted the sample for the study.

Achievements during 2004-05

- The materials distributed to farmers and other en users include planting material of major spices including those produced at IISR experimental farm, Peruvannamuzhi, Krishi Vigyan Kendra under IISR, institute publications, extension literature and bio control agent viz., *Trichoderma harzianum* for the control of soil borne fungal diseases of spices. The details of revenue generated through distribution of technological inputs since inception is as follows.(Table.6)

Table.6 Revenue generated through distribution of technological inputs

Particulars	Amount (Rs)
Planting material	293184
Trichoderma formulation	12,65057
Publications	149280

- One video film on post harvest technology and value addition of spices was produced by the funding from Ministry of Agriculture, Govt. of India. A film introducing the activities and services of the institute was telecast through Asianet, a reputed cable TV channel having coverage all over the world. Besides, the participation of institute in routine farmers seminars, exhibitions etc was monitored through ATIC. Since inception, 4611 beneficiaries who visited the centre were provided with advisory and diagnostic services.
- The study to assess the level of adoption and the impact of integrated disease management of foot rot disease of black pepper in Wyanad district revealed that, seventy three percent of farmers in the sample opted for the use of one or other chemicals prior to the period they were exposed to the intervention by IISR and twenty seven percent farmers were not resorting to any chemical control other than cultural practices to manage the disease.
- Since intervention by IISR, seventy five percent of farmers adopted application of biocontrol agents and other integrated management practices for the control of the disease. However adoption of the practice was limited only to symbolic and partial level as against precise scientific recommendations. One fourth of the sample discontinued the practice after one time application.
- The mean adoption index score of the sample for the total package of integrated disease management methods was only 0.61 indicative of only partial adoption. The difference in yield reduction due to the adoption of technology is only 4.53%.
- The loss of crop due to diseases reduced by 8.43% in case of respondents who adopted the technology. At the same time, the farmers who discontinued with the technology reported an increase in yield loss from 40.66% to 52.27% during the same time frame.

- Organic agriculture movement, which is gaining momentum especially in Wyanad district at grass root was one of the factors that favoured the trial of alternative methods of disease control other than conventional control methods using chemicals. Development agencies, local organizations and NGO's are promoting the practice of organic agriculture. There is a clear indication that farmers are resorting to protective and conservationist management approach as against input intensive agriculture.
- The trade of between technology push and market pull factors strongly influenced the investment options on technology and labour in the "cropping systems". Drastic fluctuations in prices and consequent lack of willingness of farmers to bear the uncertainty evidently hampered the continued adoption of the technology.
- The study clearly implies the need for supportive policies, reforms and programmes from the part of development stakeholders. Realistic market interventions in the form of product procurement, assured market and price support are the need of the hour.

Project - XII: Developing customized software and Expert Systems on Spices

Project leader: Dr. K. N. Kurup, S.J.Eapen, V.Srinivasan, K. Jayarajan

The project aims at development of information systems/expert systems on spices, development of diagnostic software and development of MIS for administration. Under this project a few databases and software have been/are being developed. Examples are

- SPICEPAT - a database on patents granted for discoveries related to spices and spice related products
- SOILLAB - software for classifying soil in to categories of low, medium and high for major, secondary and micronutrient status and recommending fertilizer doses for major spices and plantation crops based on soil test values
- PAYROLL, IMPRESTSOFT and ADVANCESOFT – software's developed as tools for Management Information.
- Action has been taken for engaging a reputed firm for developing software for facilitating automation of entire administrative operations with technical support from the Institute.

Compilation

Dr. M.Anandaraj

Dr. A. Kumar

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Dr. V. Srinivasan