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2006-07

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Front Cover: A black pepper vine showing proliferating spikes
White pepper- a value added pepper

Back cover (inner): Agricultural Technology Information Center at IISR, Calicut and the services it offer to the farming community

FOREWORD

I have great pleasure in presenting the Research Highlights 2006-07 of the Indian Institute of Spices Research. Incidentally this year is the end of the 10th Five Year Plan. Looking back on the achievements made during this plan, it would indicate interesting findings of the research leading to the development of a large number of technologies. It is time these technologies are taken to the farmers' field for adoption and refinement, if needed. India's strength in spices is amply indicated by the vast wealth of germplasm the country possesses but most of them are in danger of being extinct or being threatened by genetic erosion. Indian Institute of Spices Research is seized of these problems and has made great efforts to collect this available genetic variability in its gene bank. Most of them have been characterized and many have been used in crop improvement programme and many of these materials have been registered with NBPGR, New Delhi. To circumvent all the maladies affecting production of spices such as foot rot in black pepper, soft rot in ginger and viral diseases of cardamom, research efforts have culminated in development of strategies for the management of these diseases. Post-harvest processing and flavour chemistry are being studied. The Research Highlights 2006-07 presented herewith is an embodiment of the summary of the results of research carried out during the period under report.

I place on record my appreciation to the members of the Editorial Board for their excellent editing. To Dr. H.P. Singh, present Deputy Director-General (Hort.) and Dr. G. Kalloo, former Deputy Director-General (Hort.), I owe a great deal for their encouragement and support. Dr. K.V. Ramana, Assistant Director-General (Hort.II) has been a pillar of support for all our activities. I convey my gratitude to him.

Calicut-12
27-05-2007

V.A. PARTHASARATHY
Director

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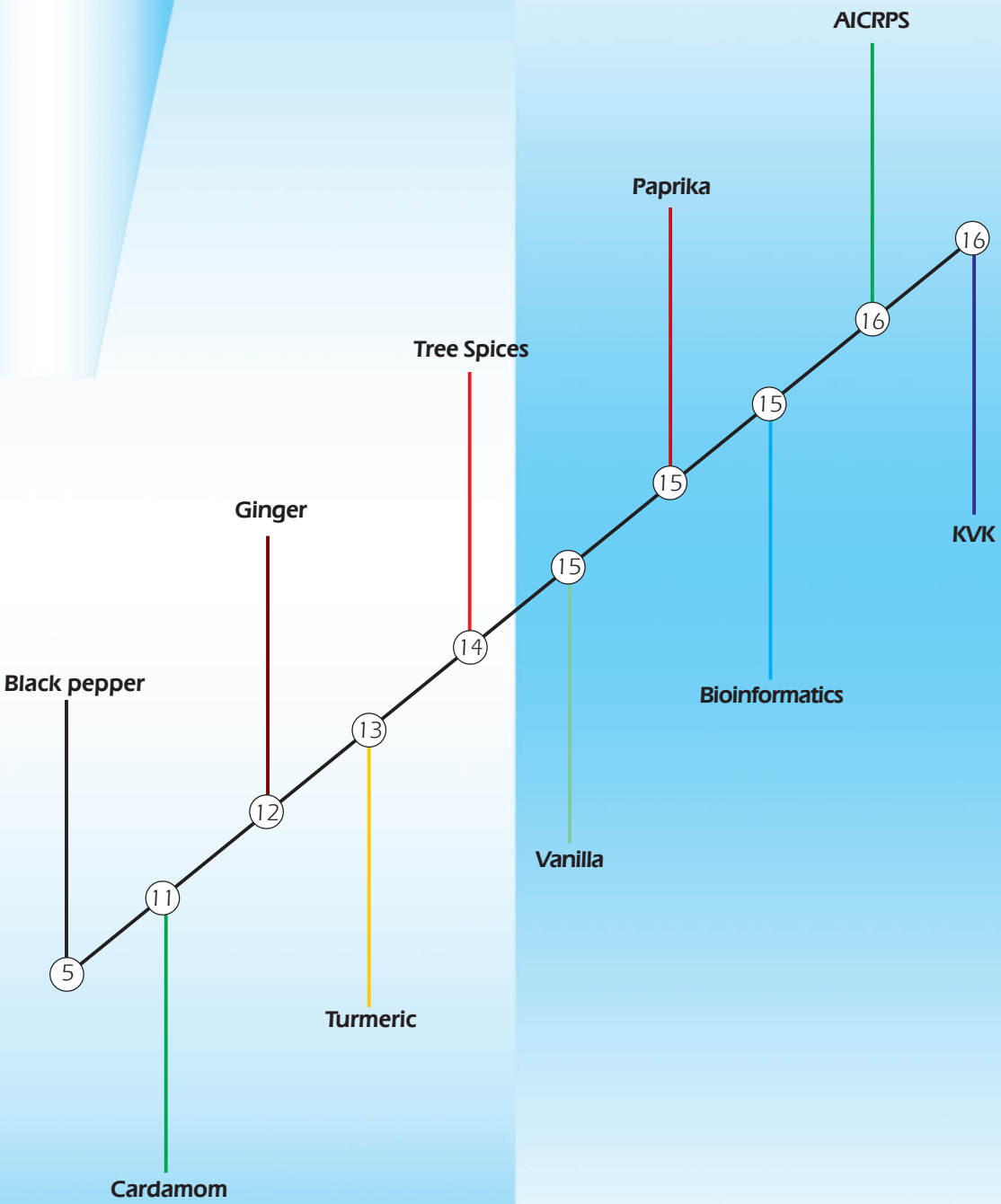
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1. Black pepper

Germplasm collection, conservation and evaluation

About101accessions (86 wild and 13 cultivated types) were collected and added to the existing germplasm collections from Attappadi, Siruvani, Wagamon, Vandiperiyar, Erumeli (Kerala); Molem, Walpoi and Conacon (Goa), Dapoli (Maharashtra) and farmers' fields. One hundred accessions were replanted at Central Plantation Crop Research Institute, Kidu as an alternate germplasm repository. Fifty accessions were characterized based on IPGRI descriptor thus making total number of characterized so far to 850. The Germplasm conservatory at IISR, Calicut has 2337 accessions (1075 wild and 1272 cultivated). A unique spike proliferating black pepper accession collected from a farmers nursery is being maintained in the pepper repository.

Spike proliferation in *Piper nigrum* L- a possible high yielder

Genetic resources of spices at IISR, Calicut

Crop	Number of Accessions
Black pepper	2347
Cardamom	436
Ginger	684
Turmeric	1040
Nutmeg	484
Cinnamon	408
Clove	233
Garcinia	86
All spice	2
Vanilla	93
Paprika	130

List of registered unique germplasm accessions

Crop	IC number	Unique character
Black pepper	IC 547018	High caryophyllene (18.2%)
Cardamom	IC 349541	Compound panicle type, high yield
Cardamom	IC 349544	Basal branching of panicle with green bold capsules
Cardamom	IC 349599	Katte resistance
Cardamom	IC 349634	Rhizome rot tolerance
Chinese cassia	IC 370425	High bark oil (4.9%); High cinnamaldehyde content (90.5%)

Varieties released

The 23rd Kerala State Variety Release Committee has approved four black pepper varieties *viz.*, IISR-Shakthi, IISR Thevam, IISR-Girimunda, and IISR Malabar Excel. Besides being suitable for cultivation at high altitudes, IISR Thevam is a high yielder with adult plant tolerant to foot rot disease. IISR Girimunda is a high yielder with resistance to anthracnose disease while IISR Malabar Excel is good yielder with high oleoresin (13.6%). IISR-Shakthi is tolerant to foot rot disease.

Evaluation of tissue cultured black pepper plants

Tissue Cultured (TC) plantlets (10,000) were field evaluated in 100 trials covering over 25 ha in the states of Kerala and Karnataka. The TC plants showed good establishment and

20% of them showed early flowering. Molecular characterization using ISSR markers indicated genetic uniformity among the TC plants.

PCR technique for the identification of traded black pepper

RAPD based molecular profiling of traded black pepper from India, Vietnam, Malaysia and Indonesia revealed a distinct clustering pattern of the traded black peppers in conformity with the country of origin.

PCR technique to detect adulterants in commercial black pepper powder

A papaya (*Carica sp*) specific band of approximately 470 bp was found in PCR based molecular method using primer OPJ 09 in the market samples of commercial black pepper powder. Earlier, a Sequence Characterized Amplified Region (SCAR) marker was developed to identify papaya seed adulteration in powdered market samples of black pepper.

Chitinase and *Phytophthora* resistance

Hydrolytic enzyme, chitinase was found to increase in *Piper colubrinum* after challenge with *Phytophthora capsici* and peak activity was found at 60 hours after inoculation. An internal fragment of 313 bp of a putative chitinase gene corresponding to 104 amino acid was cloned and showed similarity to known chitinase genes from plants.

Azospirillum and Sulphate of Potash improve black pepper productivity

In bush pepper, application of Sulphate of Potash (SOP-1.75g pot^{-1}) at bimonthly interval recorded the highest yield of 295 g pot^{-1} followed by Muriate of Potash (MOP-3.5g) and SOP (4.5g pot^{-1}). In a pepper garden, maximum yield (3.16 kg $vine^{-1}$) was obtained with SOP (500g $plant^{-1}$)+ Mg SO_4 (25g $plant^{-1}$), which was on par with recommended dose of potash (K) as SOP and significantly higher than control. Among different forms of K, water-soluble and available K had significant positive correlation with berry yield, oleoresin and piperine. Application of *Azospirillum* along with nitrogen (70g), phosphoros (55g), potash (270g) and magnesium (200g) per vine increased yield of black pepper vines (21%) compared to control and application of NPK (140:55:270g $vine^{-1}$) alone.

Nutrient solution for production of healthy plants of black pepper in nursery

Application of plant nutrient solution consisting of urea, super phosphate, potash, and magnesium sulphate in 4:3:2:1 proportion at monthly intervals along with solarized potting mixture recorded vigorous and healthy black pepper plants.

Rapid multiplication of improved varieties of *Piper nigrum* in a traditional serpentine method using improved agrotechiques

Rooted cutting of improved varieties developed though improved agrotechiques and scientific pathogen indexing

Physiological and biochemical basis of productivity

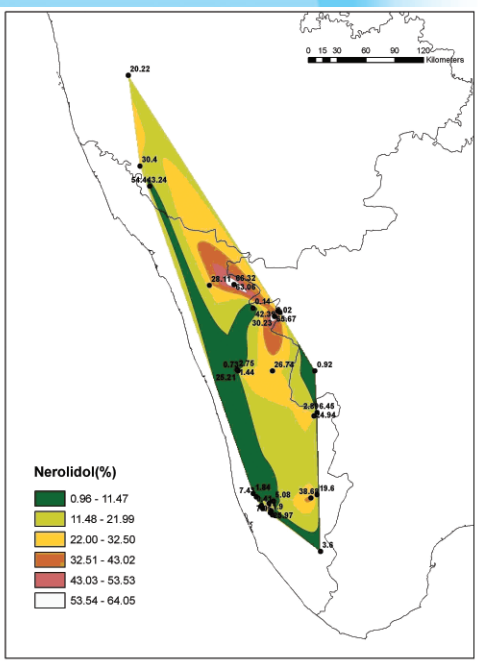
High yielders had higher photosynthetic rate (2.2-3.86μ moles m^{-2} s^{-1}) than low yielders (2.0-3.2 μ moles m^{-2} s^{-1}). High yielders recorded slightly lower leaf temperature (32.6 to 33.7 °C) than the low yielders (32.9 to 33.8°C). Nitrate reductase activity was high for high yielders during pre-bearing (429-921 m moles of NO_2 g^{-1} h^{-1}) and bearing periods (621-1183 m moles of NO_2 g^{-1} h^{-1}). Low yielders recorded comparatively low activity (453-814 NO_2 g^{-1} h^{-1}) during pre-bearing and during bearing period (612-994 m moles of NO_2 g^{-1} h^{-1})

Influence of climate changes on growth and quality

Leaf area, plant height and photosynthetic rate of pepper plants grown in plant growth chamber for four months at 3°C above ambient temperature (which is the projected temperature increase due to global warming for Calicut by 2050 based on HadCM3 model) was on par with the growth at ambient temperature.

Geographical influence on biochemical and physical quality parameters in black pepper

The total number of leaf volatile oil components of *Piper nigrum* leaf varied from 7-15 among the accessions collected from Western Ghats and the geographical effect on biochemical parameters was highly significant. The percentage of two sesqueterpenes, β-Caryophyllene (2.1-6.8%) and Nerolidol (1.4 to 66.3%) significantly varied among all germplasm accessions whereas another



Geographical distribution of Nerolidol (%) in germplasm accessions of *Piper nigrum* in Western Ghats

component, Pinene (1.53-20.3%) (a common component of berry oil) was recorded from specific latitude 9°29'-9°40'.

Pepper harvested from Ambalavayal in Wyanad district recorded high bulk density and oleoresin for Karimunda, Sreekara, Subhakara and IISR-Thevam compared to Peruvannamuzhi, Idukki, Yercaud, Dhapoli, Panniyur

Value addition in black pepper

Process for production of white pepper has been standardized. Dry recovery of about 25.0-26.0 % was achieved.

Standardization of optimum storage condition

Dried black pepper stored in polyethylene covers under vacuum, 100% N_2, and 90% N_2+ 10% CO_2 for a period of 240 days did

A. Control, B. 90% N_2+10%CO_2 C. 100% Vacuum D. 100%N_2
Ideal storage condition for black pepper

not show any significant variation for oil, oleoresin, except for a reduction of 15% moisture content.

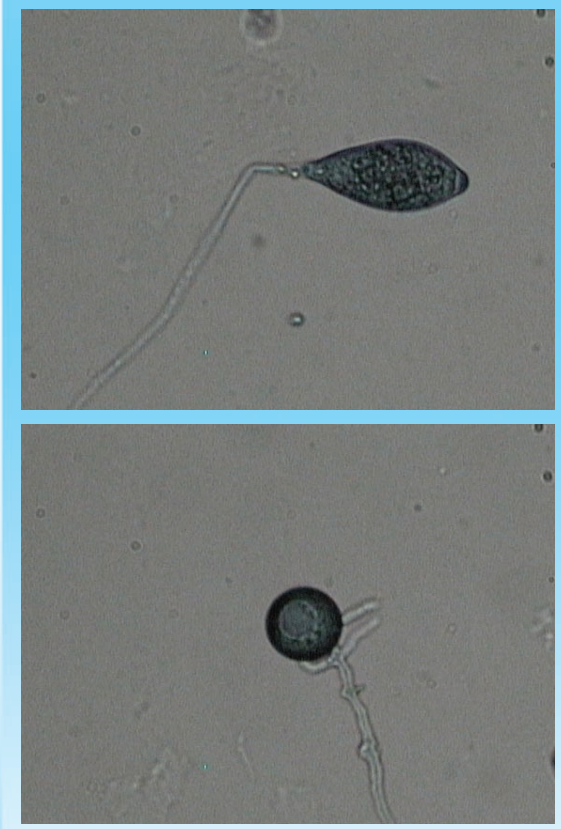
Microbial community analysis of rhizosphere soils of standards used in black pepper gardens

Greater diversity in soil microbial community was identified under *Glyricidia*-black pepper (BP) system (68), followed by *Garuga*-BP (66) and *Ailanthus*-BP systems (65) than *Erythrina*-BP *(48)* or RCC pole-BP (50) systems. Fungal population was higher under *Ailanthus*-BP (19), while the other systems registered significantly lower fungal diversity. The study indicated that the standards used as supports for black pepper caused distinctive rhizosphere effects on microbial community structure in soils of the systems studied.

Phytophthora foot rot

Etiology

Morphological and molecular characterization of black pepper isolates of *Phytophthora* revealed that isolates shared the characters of both *P. capsici* and *P. tropicalis*. Characters like production of chlamydospores, growth at 30°C matched with *P. tropicalis* whereas the sporangial characters and pathogenicity on capsicum was similar to that of *P. capsici*. The rDNA sequence shared 98% identity with *P. tropicalis* or *P. capsici*. Interestingly the isolate showed 100% identity with *P. tropicalis* based secondary structure of ribosomal RNA



P. tropicalis or *P.capsici*?
Black Pepper isolate shares the characteristic of both *P. tropicalis* and *P. capsici*

Further PCR-RFLP analysis revealed high levels of intraspecific and interspecific variability in the ITS regions among the *Phytophthora* isolates from Black pepper.

Resistance

Two promising foot rot resistant black pepper hybrids namely, HP-490 and HP-521 were identified which survived pathogen inoculation in controlled green house trials.

Development of bioconsortia against foot rot

A five-year field trial conducted at Peruvannamuzhi revealed the potential of bioconsortia consisting of IISR 6, 8, 13, 51, 151 and 853 for management of foot rot and slow wilt in cv. Karimunda variety of black pepper.

Anthracnose

Resistance

Eleven accessions/varieties comprising of Panniyur-5, IISR Girimunda, HP-780, Panchami, Aimpriyan, Subhakara, Karimunda (Idukki), Kottanadan, Jerakamunda (Gudalur), Arakalamunda, and Chomala showed resistance to *Colletotrichum gloeosporioides.*

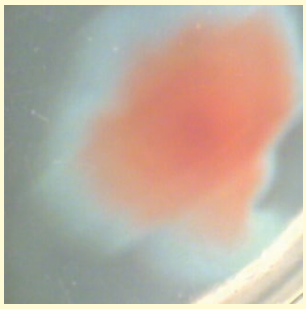
Stunted Disease

Variability in *Piper yellow mottle virus* (PYMoV) isolates

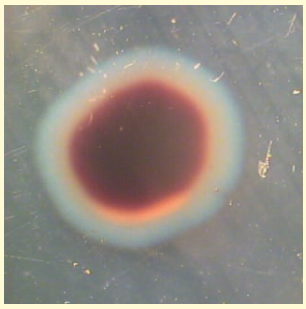
Sequence analysis of portion of ORF I and ORF III from Kozhikode, Idukki and Wyanad

Bacterial endophytes against *Phytophthora capsici*

Endophytic bacteria found effective against *Phytophthora capsici* in black pepper were identified as *Pseudomonas aeruginosa* (BP-35) and *P. putida* (BP-25) by analyzing the nucleotide sequence of 16s rDNA. *Pseudomonas aeruginosa* was found to induce density dependent systemic resistance in excised single nodal shoots. The 16s rDNA sequences of these have been deposited with GenBank



Pseudomonas aeruginosa IISR-BP35



Pseudomonas putida IISR-BP25

Promising endophytic bacteria against *P. capsici* infection in *Piper nigrum* L.

Density dependent induction of systemic resistance in shoots of *Piper nigrum* against *P. capsici* by endophytic bacteria, *Pseudomonas aeruginosa* IISRBP35

districts of Kerala and Kodagu district of Karnataka revealed variable nature of ORF I sequences and highly conserved ORF-III among isolates. The *Badnavirus* infecting *Piper longum* and *P. betle* were also identified as strains of PYMoV

Distribution of viruses in black pepper plants during different seasons

DAS-ELISA based tracking of PYMoV and CMV in black pepper varieties at monthly intervals indicated that concentration of both the viruses was higher during October to January

Nematodes

Characterization

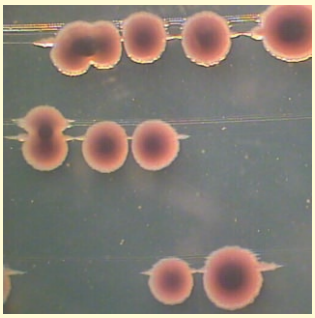
Sequence analysis of ITS region (398bp) of rDNA of burrowing nematode (*Radopholus similis*) population infesting black pepper in India revealed 98% sequence similarity with known *R. similis* populations across the world. This is the first report of molecular characterization of an Indian isolate of *R. similis*.

Host resistance

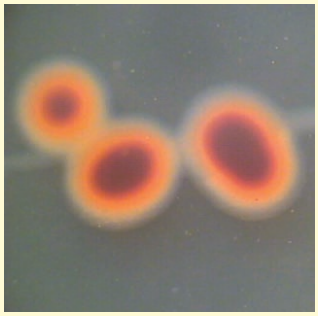
Six black pepper lines tolerant to *P. capsici* were screened against *R. similis* and *M. incognita*. All these lines were susceptible to *R. similis* while two lines *viz* Acc.1578 and OP progeny 04/1533(2) showed resistant reaction to *M. incognita* in the preliminary screening. Among the four *Piper* spp. screened, only *P. colubrinum* showed resistance to both the nematodes. The field performance of two *R. similis* resistant black pepper lines, HP-39 and C-820, was far superior to other lines even four years of planting.

Nematode suppressing endophytic bacterial strains for black pepper

The species identity of two promising endophytic bacteria was confirmed through 16S rDNA sequencing. The two *R. similis* inhibiting endophytes were identified as *Curtobacterium luteum* (TC-10) and *Bacillus megaterium* (BP-17). The bacterial endophytes *Curtobacterium luteum* IISR TC-10 significantly improved black pepper growth characters such as number of leaves, root weight and total biomass of plants besides suppressing the *similis*. When used as a chitin based formulation, besides sustaining the population at 10^7 cfu g^{-1} after 90 days of storage at 28°C, it successfully reduced the nematode infestation in pepper nurseries. The improvement of vigour of black pepper is an additional benefit of this strain



Bacillus megaterium IISR-BP17



Curtobacterium l uteum IISR-TC10

Promising endophytic bacteria against *R. similis* infection in *Piper nigrum* L.

Root mealybug

Integrated Management

An integrated pest management schedule involving, use of root mealybug-free rooted cuttings, removal of weeds in interspaces of black pepper vines during summer especially when intercropped with coffee, drenching imidacloprid 0.0125% or acetamaprid 0.0125% or carbosulfan 0.075% or chlorpyriphos 0.075% on severely affected vines or drenching tobacco extract 3% on mildly affected vines and adoption of control measures against *Phytophthora* and nematode infections, was developed for the management of root mealybug, based on studies conducted for the past 3 years.

Screening against 'pollu' beetle

Screening of 66 cultivars and 76 hybrids of black pepper available in the Germplasm Conservatory against pollu beetle (*Longitarsus nigripennis*) indicated that all the accessions were susceptible to the pest. The percentage of berries infested in the cultivars ranged from 1.6% to 30.6% and in the hybrids from 3.3% to 52.6.

2. Cardamom

Fifteen accessions were collected from two explorations in Kerala (Attappadi and Wagamon), including a variant of green gold with pubescent leaves. Twenty-six compound panicle accessions were characterized based on IPGRI descriptor.

High quality cardamom

The accessions with high husk to seed ratio are NHY-1, CCS-1 self & NHY-35. The oil content ranged from 3.9 to 6%. Some of the high oil accessions are NHY-3, NHY-14, NHY-15, NHY-35, RR-1 x MB-3, VA-1, AMB-2, MA-7, CCS-1 OP.

Chemistry of Indian Cardamom

GC-MS study confirmed the superior intrinsic quality of Indian cardamom over Guatemalan and Sri Lankan cardamom. The essential oil yield of Indian, Guatemalan and Sri Lankan cardamom was found to be 10%, 5% and 14% respectively. Chemical profiling has shown a total of 33 compounds in Indian, 26 in Guatemalan and 35 in Sri Lankan, and 22 of them are common among all three samples. GC profiling of oil indicated that Indian cardamom is rich in 1, 8-cineole and α-terpinyl acetate. Indian cardamom recorded comparatively low quantity of linalool as compared to Guatemalan and Sri Lankan. At low concentration the linalool gives pleasant taste to the cardamom. Linalyl acetate, octyl acetate and trans α caryophyllene were not identified in Indian and Guatemalan cardamom whereas Z citral, methyl cinnamate, nerol, and 2-decenoic acid were present only in Indian cardamom.

Indigenous nutrient mobilizing bacteria for cardamom

Application of *Azospirillum* (Caz3) and Phosphobacteria (Cpb2) recorded maximum number of leaves, dry weight, total NPK uptake, root colonization and lower disease incidence. The N-fixation capacity of the isolates Caz3 was 7.39 mg g^{-1} malate whereas the phosphobacterial strains Cpb2 recorded higher solubilisation efficiency of up to 220 mg L^{-1}

Drought Tolerance

IISR Avinash, Green gold and CL-893 were relatively tolerant to moisture stress while CCS-1 was susceptible. CL-893 and its cross combinations recorded better growth and yield characters.

Screening of cardamom germplasm for leaf blight resistance

Natural infection of leaf blight on 72 accessions was recorded using 0 to 6 disease rating scale and 21 accessions were found resistant to *Colletotrichum gloeosporioides*.

3. Ginger

Germplasm collection, conservation and evaluation

Among the low fibre type accession, Acc. 164, 558, 246 and 537 had more than 2% oil and above 6.5% oleoresin, with below 3% fibre. Among the high oil types, Acc. 162, 50, 57, 411, 225, 201 and 197 are with above 2% oil. Acc. 50 and 57 contained above 6.5% oleoresin. Acc. 197, 217, 228, 411 contained below 3% fibre. Among the exotic ginger collections, accession from Nepal (Acc.581) performed superior to other varieties for yield whereas the accession 420 performed well for high oil.

Phosphorus -Zinc ratio on ginger yield

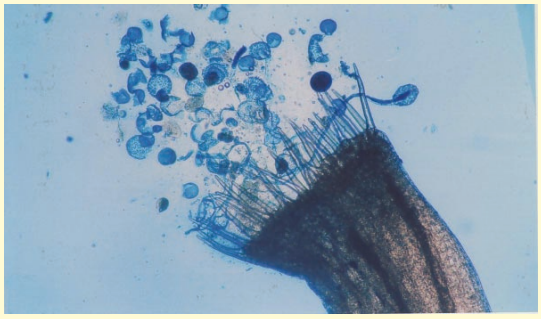
The threshold value of leaf P/Zn ratio was found to be 90 through second order response function. On validating the same under field conditions, the initial leaf P/Zn ratio at 60 DAP in the range of 145-223 could be brought to the threshold range of 69-150 after foliar spray of Zn (0.5%) twice during August and October. By lowering the ratio below 108, increased rhizome yield up to 20% could be achieved.

Nutrient optimization for targeted yield in ginger

Based on the initial soil fertility levels of N, P, K and Zn, the fertilizer doses for obtaining yields of 10, 15 and 20 kg^{-1} bed were applied. Zinc was supplemented as foliar spray. The

Pollen germination

Ginger accession-12 (Erattupetta) was found to be unique for its colour pattern of the floral labellum, high pollen stainability (27.5%), high *in vitro* germination of pollen grains (10.44), better pollen tube growth (mean length of 1209 µm after 24 h of culture) and germination of pollen grains on the stigma on self-pollination. This cultivar appears to be suitable for future studies to induce seed set.



In vivo pollen germination of ginger accession 12

Variation in colour pattern on ginger flower

Nutrient Optimization for targeted yield

Target yield *(kg bed^{-1})	N	P	K	Realized yield kg bed^{-1}	Deviation (%)
		g bed^{-1}			
10	97	24	-	10.8	0.5
15	175	54	30	12.4	-17
20	250	83	60	11.4	-43
Control	37	25	24	8.3	—

*Bed= 3.0 square meter

achieved ginger rhizome yield was 10.8, 12.4 and 11.4 kg^{-1} bed with a deviation of +0.5%, -17% and -43% from the target. Through targeted nutrient application increased yield of 14-26% over recommended dose could be achieved in IISR Varada with reduced fertilizer application

Phenology of ginger

First tiller appeared at 646-degree days with a total 11 tillers and the plant attained maturity at 3096.8-degree days. Leaf growth along the main stem followed the quadratic pattern in ginger. Total leaf area of 4092 cm^2 per clump was noted for ginger.

Microbial community structure in soils under various management regimes

The effects of nutrient management system in ginger such as Integrated, Organic or Chemical treatments on soil microbial community structure revealed that the prokaryotic population was highest under integrated system whereas the eukaryotic population was high in both integrated and fully organic treatments. Interestingly the fungal population was high in chemical treatment.

Soft rot

Integrated management

Rhizobacteria (IISR-51, IISR-6), endophytic bacteria (BP35), *T. harzianum* (P-26), Metalaxyl-mancozeb 0.125% and mancozeb 0.2% were evaluated for the management of rhizome rot disease. The incidence of the disease was less in the chemical treatments when compared to biological treatments. Besides chemical treatment recorded maximum yield.

4. Turmeric

Varieties released

The 23rd Kerala State Variety Release Committee has approved two high quality turmeric varieties *viz.*, IISR-Alleppey Supreme and IISR-Kedaram for cultivation. Both the varieties are high yielding with more than 5% curcumin and resistance to leaf blotch disease.

Phenology of turmeric

First tiller appeared at 1106-degree days with a total 6 tillers and the plant attained maturity at 3571-degree days. Leaf growth along the main stem followed the linear pattern. Total leaf area of 11867 cm^2 per clump were noted for turmeric

Chemical analysis of *Curcuma* species

GC and MS based qualitative analysis of essential oils *Curcuma* species revealed highest oil percentage in *C. aromatica* (4.8 %) followed by *C. caesia* and *C. sylvatica* (3.6 %) and the lowest percentage of oil were recorded in *C. haritha* (2.4 %).

Diversity analysis of *Curcuma* species

Genetic diversity analysis of 36 popular varieties revealed that the improved varieties clustered distinctly from the land races/ cultivars based on Jaccards similarity Index. Most of the land races from one geographical region clustered together with a few released varieties, which were evolved through germplasm selection of material collected from these region.

Soft rot

Pythium aphanidermatum was found to be the causal organism of soft rot of turmeric in the states of Andhra Pradesh, Tamil Nadu, Kerala and Karnataka. Though frequented in the isolations along with *Pythium*, the fungi *Fusarium* and *Rhizoctonia* failed to cause the disease in turmeric.

Shoot Borer

Distribution and crop loss

The incidence of the shoot borer (*Conogethes punctiferalis*) was serious (above 25% incidence) in Wyanad and Kozhikode districts in Kerala whereas in other states surveyed (Tamil Nadu, Karnataka and Andhra Pradesh) the incidence was negligible. The yield obtained was only 262 g $clump^{-1}$ when 75%–100% of shoots were damaged when compared to 378 g $clump^{-1}$ when the damage was 0% - 25% of shoots.

Bioecology

Studies on seasonal population of shoot borer in the field at Peruvannamuzhi indicated that the symptoms of pest infestation were first observed during August and maximum new infestations occurred during October to November. Though the mermithid nematode, the natural enemy of shoot borer was observed throughout the crop season, their parasitisation was higher during August and September.

Nutrient optimization for targeted yield in turmeric

Based on the initial fertility levels of N, P, K and Zn, the fertilizer doses for obtaining 15, 20, 25 kg bed^{-1} yield in turmeric were worked out and applied. Zinc was supplemented as foliar spray. The achieved turmeric rhizome yield was 14.8, 15.8 and 16.3 kg bed^{-1} with a deviation of -1%, -20% and -34% from the fixed target. Through targeted nutrient application 12-20% increased yield over recommended dose could be achieved in Prathiba with reduced fertilizer application.

5. Tree spices

Germplasm collection, conservation and evaluation

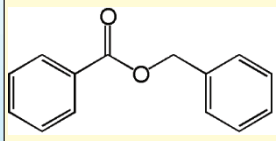
A total of 20 *Garcinia gummigutta* and 32 *indica* wild collections were made from forest areas in Western Ghats. Out of 94 nutmeg accessions evaluated A9/53 performed better yielding 714 fruits and fruit weight was maximum (120g)

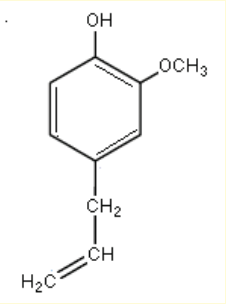
Marker Assisted Selection in *Myristica*

Molecular profiling of elite accessions of *Myristica fragrans* revealed unique amplicon in the accessions such as A9/4 (a very high yielding epicotyl graft with plagiotropic shoots), A9/150, possessing very thick mace and apple shaped bold fruits and A4/22 with unique character of high number of erect shoots. The study further revealed two major clusters with all *Myristica* species and *Knema andamanica* forming a separate cluster distant from *Gymnocranthera*, a related genera of *Myristica*. Similarity coefficient ranged from 0.58-0.80. *M. malabarica* and *M. beddomei* showed the highest similarity of 80%. Unique markers were identified in some of the wild species.

Chemotypes identified

Based on leaf oil analysis using GC-MS, two chemotypes of *Cinnamomum veerum* viz., *eugenol* and *benzyl benzoate* types were identified in *C. veerum*. The related species *C. sulphuratum* also contained benzyl benzoate as a major constituent.





C. veerum- Benzyl Benzoate type

C. veerum - Eugenol typ

Morphologically indistinguishable chemotypes of *Cinnamomum* based on GC-MS analysis

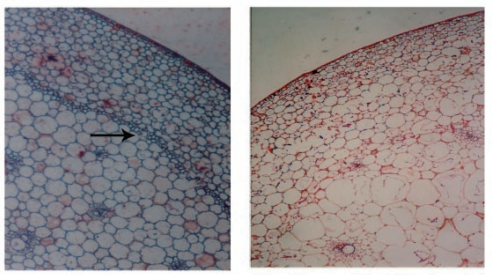
Chemistry of *Garcinia*

Method for quantification of a major organic acid, hydroxy citric acid, using HPLC from rinds of *Garcinia indica* was standardized. HCA showed significant variations among the four species of *Garcinia* whereas lycopene did not show significant variation. HCA content varied in various species of *Garcinia viz. Garcinia gummigutta* (2.6), *G. mangostana* (0.27), *G. indica* (5.21), *G.tinctoria* (3.3). Lycopene in *Garcinia* fruits was found to be *Garcinia gummigutta* (0.123), *G. mangostana* (0.098), *G. indica* (0.093), and *G. tinctoria* (0.156).

6. Vanilla

Comparative anatomical analysis of vanilla

Comparative anatomical analysis of internodal region of *Vanilla* sp. from Andaman and Nicobar Islands and *V. planifolia* revealed the distinct absence of schlerenchymatous band separating the cortex and ground tissue in the former, which further indicates that *Vanilla* sp. from Andaman and Nicobar Islands, is closer to the leafless species of *Vanilla.*



Vanilla planifolia *Vanilla sp.* (A&N islands)

Occurrence of *Bean common mosaic virus* (BCMV) on vanilla.

A virus associated with necrosis and mosaic on vanilla was identified as a strain of *Bean common mosaic virus* (BCMV) based coat protein gene sequence comparison and phylogenetic studies.

7. Paprika

Zero pungency paprika

The color value of selected germplasm ranged from 100 to 216 ASTA units. The highest color value of 216 ASTA units was registered with ICBD-17, followed by EC-31 (193 ASTA units). The oleoresin content varied from 9.0-22.0 %, the highest being with ICBD-15 (22.39 %). The pungency (Capsaicin content) varied from 0.0-1.34 %. The accessions with zero pungency were EC-71 and LCA-422.

PCR technique to detect adulterants in commercial chilli powder

A *Ziziphus nummularia* specific band of approximately 350 bp could be detected in a molecular detection using primer OPJ 10 in the market samples of chilli powder

8. Influence of socio-economic and agro-ecological changes on spice production

Since last decade, the average size of operational farm holdings reduced from 3.7 to 3.0 in district of Wayanad in Kerala owing to reduction in size of marginal and small farm holdings and diversion of agricultural land for non-agricultural purpose. The estimated Markov's transition matrix indicates that, there was a transition of area under coffee and black pepper to non-traditional crops like arecanut, coconut, banana and other vegetable crops due to the change in socio-economic and agro-ecological factors in the region.

9. Bioinformatics Center

New database/software

PhyDisH, a new database of *Phytophthora* diseases of horticultural crops which includes information on all the *Phytophthora* isolates conserved in the National Repository of *Phytophthora* at the institute.

Sign-O-Bacteria, a tool for identifying the species-specific signatures in plant-associated bacteria was also developed

A digital Institutional Repository has also been implemented at IISR using the DSpace open source platform. DSpice@IISR holds the full

text of research articles published from IISR, summary of theses, project reports etc.

New websites

Bioinformatics center has developed new websites for various organizations such as IISR library (SpicE-Lib), All India Coordinated Research Project on Spices (www.aicrps.res.in), NRC for Seed Spices, Ajmer and AICRP on Potato, Shimla.

Office Automation

ARISoft, the new office automation software developed jointly by IISR and M/s Focuz Infotech, Kochi was launched by Dr. G. Kalloo, former DDG (Hort & CS) on 22 November 2006.

10. All India Coordinated Research Project on Spices

Germplasm

Genetic resources of spice crops have been enhanced with the germplasm holdings of 680 accessions in black pepper, 273 in cardamom, 63 in ginger, 1326 in turmeric, 77 tree spices and 2540 in seed spices.

Black pepper

Management of scale insect

Research conducted AICRP spices center at Pampadumpara revealed that the biorationals such as Neem Gold (0.5%) and Neem oil (0.5%) were found to be superior to Fish Oil insecticidal soap (2.5%) in reducing the population of scale insects.

Cardamom

Germplasm

Pampadumpara center has obtained IC numbers (547920 to 547992) for 73 cardamom accessions (CRSP 1-CRSP 73) from NBPGR, New Delhi

Root grub management

Root grub management trials conducted AICRP spices center at Pampadumpara confirmed the potential of entomopathogenic nematodes, *Heterorhabditis indicus* (100 IJ/grub) applied as drenching for control of root grub in cardamom.

Ginger

Disease management

In an integrated management of *Pythium*, *Fusarium* and *Ralstonia* of ginger, rhizome solarization (45min) reduced the disease incidence and increased the yield significantly, followed by hot water treatment. Solarization recorded increased sprouting (92.2%), decreased *Pythium* rot by 5.3%, *Fusarium* yellows by 4.4% and *Ralstonia* wilt by 3.1% at Solan center

Turmeric

Promising turmeric lines

In a screening trial at Pundibari center, TCP 198, 93, 104, 43, 115, 118, 19, 53, 70, were found to be tolerant to both leaf blotch and leaf spot diseases

11. Krishi Vigyan Kendra

The Kendra has conducted 100 training programmes on various subjects, which had benefited a total of 2710 farmers. The Kendra has also conducted two long duration vocational training programmes for rural youth on Repair and maintenance of farm implements, which had benefited 39 unemployed rural youth. A total of 1575 farmers visited KVK during the period for consultation, purchase of planting materials and other inputs. During the period an amount of Rs. 6.62 lakhs has been realised through sale of planting materials, mushroom spawn, *Trichoderma*, chicks and the activities of Plant & Animal Health Centre.

Kisan Mela and exhibitions

KVK had participated in the exhibitions/Kisan melas conducted at IISR, Calicut during the AICRP (Spices) Workshop from 24th to 27th May 06, at Acharya Ranga Agricultural University, Hyderabad during 2nd national Conference on KVKs from 26th and 27th November 06, at Calicut during Calicut flower show from 8th –14th February 07.