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Annual Report
2004 - 05

भारतीय मसाला फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद)

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(Indian Council of Agricultural Research)

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Front cover

View of ginger field in Kerala

Back cover

From top : Black pepper, cardamom, ginger, turmeric, nutmeg, vanilla, paprika

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PREFACE

During the period 2004-05, the Indian Institute of Spices Research made commendable progress in terms of research, extension and computerization. In research front, the collections of various spices have been enriched. One hundred and seventy *Piper* accessions were added to the germplasm collection besides other spices. Use of GIS has been attempted to locate the development and extent of spread of diseases. Three black pepper hybrids, open pollinated progenies and a clone have been identified as high yielders. Use of biocontrol agents had a significant impact on the control of foot rot disease in black pepper. The critical level of micro nutrients like zinc was optimized. A large number of endophytic bacteria were isolated from black pepper, ginger and turmeric with several isolates inhibiting soilborne pathogens. The institute developed softwares for various uses, notable among them being SOILLAB and PIPERBASE. The Krishi Vigyan Kendra and Agricultural Technology Information Centre continue to render services to the farmers and the report would amply indicate the directions in which the researches are attempted. The year also saw the down-fall in the prices of various spices notably vanilla and cardamom and there was a good demand for planting materials of ginger and turmeric.

All these achievements were possible only because of the guidance received from Director General, Dr. Mangala Rai, and Deputy Director General (Hort), Dr. G. Kalloo. I place on record our gratitude to them. My friend Dr. K. V. Ramana, formerly Project Coordinator (spices) and presently Assistant Director General (PC) gave support and cooperation whenever requested. I thank him and Dr. S. N. Pandey, Assistant Director General (Hort.) for their help. To members of RAC, I express my thanks. I thank the editorial committee for the wonderful job of editing the Annual Report.

(V A PARTHASARATHY)

DIRECTOR

प्रस्तावना

वर्ष 2004-05 की अवधि में भारतीय मसाला फसल अनुसंधान संस्थान ने शोध कार्य, विस्तार एवं कंप्यू-टरीकरण में प्रशंसनीय प्रगति प्राप्त की है। शोध कार्य में विभिन्न मसालों के संकलन को प्राढा दिया। अन्य मसालों के अलावा सत्तानप्रे पाइपर अक्सशनों को जर्मप्लासम में जोड दिया। रोगों की व्याप्ति के विस्तार और विकास को समझने के लिए जी आई एस के उपयोग का उद्यम चालू किया। काली मिर्च के तीन संकरज, खुले परागित संततियां और एक क्लोन को उच्च उपजता के लिए पहचान की गयी। जैवनियन्त्रण एजेंट का उपयोग खुर गलन रोग नियन्त्रण में प्राहुत प्रभाव डालता है। जैव पोषण जैसे सिंक की सही मात्रा का प्रयोग अनुकूल एवं स्वीकृत है। अदरक एवं हल्दी से वियुक्त किये अनेक एन्डोफाइटिक प्रौक्टीरियाओं में 19 वियुक्तियों को राइसोम रोगजनक का प्रावरोध करके देख लिया। संस्थान ने विभिन्न उपयोग के लिए सोफ्टवेयर विकसित किया जिनमें प्रमुख है सोयिललाप्रा और पाइपरप्रोस। कृषि विज्ञान केन्द्र और कृषि तकनोलजी सूचना केन्द्र किसानों के लिए अपनी सेवाएं प्रस्तुत कर रहे है और रिपोर्ट में शोध कार्य को विस्तृत रूप से सूचित करते है। इस साल में वैनिला और इलायची जैसे विभिन्न मसालों के मूल्य पतन देख रहा है और अदरक एवं हल्दी की रोपण सामग्रियों के लिए प्राडी मांग भी होती है।

ये सभी देन हमने केवल डॉ मंगला राय , महा निदेशक और डॉ जी कल्लू , उप महा निदेशक (हार्टी) से प्राप्त मार्गदर्शन से अर्जित की है। मैं इस समय उन्हें अपनी कृतज्ञता प्रस्तुत करता हूँ। मेरा दोस्त डॉ के वी रमणा, पहले परियोजना समन्वयक थे अप्रा सहायक महा निदेशक (पी सी)है जिन्होंने जप्रा कभी सहायता व सहकारिता आवश्यक होता है हमें प्रदान करते थे। मैं उन्हें धन्यवाद ज्ञापित करता हूँ । इसके अलावा डॉ एस एन पांडे, सहायक महा निदेशक (हार्टी) को उनकी मदद के लिए धन्यवाद ज्ञापित करता हूँ । आर ए सी सदस्यों के लिए भी मैं अपनी कृतज्ञता प्रकट करता हूँ। मैं वार्षिक रिपोर्ट के महत्वपूर्ण संपादन कार्य के लिए संपादन समिति को धन्यवाद ज्ञापित करता हूँ।

डॉ वी ए पार्थसारथी
निदेशक

Executive Summary

SPICES GENETIC RESOURCES

One hundred and seventy *Piper* accessions including *Piper nigrum* with bold berries, *P. argyrophyllum* with long spikes and *P. hymenophyllum* with profuse hairiness were collected from the forests of Kakkayam, Tusharagiri (Calicut District) and Tirunelly (Brahmagiri and Pakshipathalam-Wyanad District) and other parts of the country. The present field cardamom clonal gene bank comprises collections, variants, hybrids and disease resistant selections. During the year, five accessions (precocious yielder- 3 and high yielder-2) were collected from Kodagu District, Karnataka. A total of nine accessions of *Zingiber* spp. and 11 accessions of *Curcuma* spp. were collected from farmer's fields of Kerala and Arunachal Pradesh. Several collections of tree spices were also made during the year from different locations in the country. Eleven accessions of indigenous and five accessions of exotic germplasm of paprika-alike- chillies and paprika were collected from Jorhat (Assam) and Dharwad (Karnataka).

BLACK PEPPER

GIS and Shannon Diversity Index studies indicated species richness in Northeast India, coastal Andhra Pradesh, Orissa and West Bengal. One *Piper nigrum* accession collected from the natural forests of Nelliampathy (Palghat District) was registered as a unique germplasm for its high oleoresin content (28.15%), and bold berries (INGR. 04111, IC-370011). Promising black pepper lines such as *OPKm*, *HP1411* and *Coll. 1041*, yielded 4.05, 3.87 and 4.14 kg fresh berries/vine respectively as compared to Sreekara (2.94 kg/vine). Inter Short Sequence Repeat (ISSR) markers were found to discriminate *Piper* species, *Piper* hybrids *HP 780* x *P. nigrum* (wild), *IISR 4176* x *IISR 430*, *Panniyur 1 x Karimunda* and their parents. Majority of black pepper accessions contained 4% oil. *Acc. 1602* contained 19% oleoresin followed by *KS-127*, *IISR 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 more than 3.6% piperine.

A regression model developed using black pepper – weather relationship indicated that rainfall had a positive association with yield. However, maximum temperature had a negative relationship and minimum temperature had a positive relationship with yield up to 25 weeks.

Organic nutrition trials indicated that soil P and Zn availability increased significantly compared to INM and chemical systems of production.

The crop loss due to foot rot disease was reduced by 8.43% when biocontrol technology was adopted, whereas the loss ranged from 40.7 to 52.3% when the technology was discontinued or not adopted. Mass multiplication technology for *Trichoderma harzianum* for control of *Phytophthora* foot rot disease in black pepper has returned an internal rate of return (IRR) of 19% and B: C ratio of 3.2:1.

Seventy-three new isolates of putative endophytic bacteria, antagonistic to nematode pest and *Phytophthora*, from black pepper were isolated, morphologically characterized and preserved in the repository of endophytes.

The incidence of stunted disease was correlated with environmental factors such as altitude, rainfall and temperature. Citrus mealybug (*Planococcus citri* Risso), commonly found associated with black pepper (*Piper nigrum* L.) was shown to transmit the *Badnavirus* associated with stunted disease. *Badnavirus* particles were purified from infected black pepper and a DAS-ELISA based method was developed for its detection in plants. Coat protein gene of *Cucumber mosaic virus* (CMV) infecting *P. longum* and *P. betle* were cloned, sequenced and sequence comparison showed that the virus belongs to subgroup 1B of CMV. Phytoplasma causing phyllody

disease in black pepper was identified and was shown to belong to Aster yellows group. A nested PCR method was developed to detect phytoplasma in phyllody affected black pepper plants.

Surveys conducted in Wyanad and Calicut Districts in Kerala indicated that in addition to an undescribed species of *Planococcus*, *P. citri* also infests basal portions of stems and roots of black pepper.

CARDAMOM

The glabrous selections of Malabar type (*MA-15*, *MA-18*, *MA-20*) were moderately resistant to leaf blight caused by *Colletotrichum gloeosporioides* whereas the compound panicle types (*CP-9*, *CP-2*) are resistant. *Amomum subulatum* and *A. microstephanum* were found clustered with *Elettaria cardamomum* indicating that *Amomum* is closest to cultivated cardamom according to RAPD profile. Three cardamom accessions *viz.*, *CP, HY-2* and *NHY-2* had high levels of essential oil (7.8, 6.8 and 6.4% respectively). Drip irrigation and sprinkler irrigation once in 12 days recorded significantly higher number of tillers/clump, more number of leaves pet tiller and more number of panicles per plant whereas the control recorded lower yield. Trench system of planting recorded less runoff and soil loss.

Investment on the technological package developed for soil-water conservation in cardamom based cropping system in Kodagu District of Karnataka yielded a net return of Rs.1,11,593/ ha as against Rs.56,186/ ha in non-adopted farms. Soil and water conservation measures suggested for cardamom based cropping systems in Kodagu District returned a net economic surplus of Rs.34.57 lakhs with IRR of 33% and B: C ratio of 2.9.

GINGER AND TURMERIC

Ginger *Acc. 578* an exotic ginger collection from Nepal recorded the highest yield (15.25 kg/ 3 m^2) with a dry recovery of 23.5% and fibre content of 1.5 %. Oil content ranged from 1.2 to 2%, oleoresin from 3 to 5.2% and fibre from 2 to 6.0%. Ginger *Acc. 41* was found free of shoot borer infestation. Among the root knot resistant turmeric and ginger accessions, *Acc. 43, 56* and *57* in turmeric and *Acc. 36* in ginger were found to be superior in yield and other characters. Cytological analysis of true turmeric seedlings of the mother line *Acc. 126* revealed a somatic chromosome number of 84 or 78.

The critical levels of Zn were found to be 2.1 mg kg^{-1} for soil and 27 mg kg^{-1} for foliar concentrations. The mean yield recorded in ginger (*var. Varada*) when grown organically was 7.5 kg/ 3 m^2 with a reduction of 26% and 22.8% rhizome yield as compared to chemical and integrated farming, respectively. Turmeric *(var. Alleppey)* recorded a mean yield of 15.5 kg/ 3 m^2 under organic cultivation with a reduction of 15.3% rhizome yield as compared to the conventional system. Phenlyalanine Ammonia Lyase, the initiating enzyme in the biosynthesis of curcuminoids could be purified to 157 fold from the crude extract of turmeric leaves

The pathogen causing soft rot of ginger and turmeric was identified as *Pythium myriotylum*. A reliable screening methodology based on soil inoculation of the pathogen was developed for large scale screening of ginger germplasm for bacterial wilt resistance. Turmeric was identified as one of the hosts of *Ralstonia solanacearum*. Among the putative endophytic bacteria isolated from ginger and turmeric rhizome, 19 isolates were found to inhibit rhizome rot pathogens such as *Fusarium oxysporum*, *Pythium myriotylum*, *P. ultimum*, *Rhizoctonia solani* and *Ralstonia solanacearum*. For large-scale disinfection of ginger seed rhizomes, the rhizome solarization methodology was modified to suit bulk requirements.

For obtaining higher number of sprouts and lesser incidence of rhizome scale, storage of rhizomes in dried leaves of *Strychnos nux-vomica* or *Glycosmis pentaphylla* or *S. nux-vomica* + saw dust (1:1) or *G. pentaphylla* + saw dust (1:1) were as promising as storage in sawdust alone.

TREE SPICES

Evaluation of clones of elite lines of nutmeg for morphological characters indicated that *A4/22* recorded the maximum height (179 cm) in the fourth year. *A9/18* recorded maximum yield of 933 fruits per tree. RAPD

based molecular profiling clearly distinguished clone number 16 of *Viswashree* from the mother, other clones and seedlings. At a similarity index of 0.96, three groups could be distinguished. Soft wood grafting of *Garcinia xanthochymus* was standardized on nine month old *G. xanthochymus* rootstocks with 90% success. In immature clove, the eugenol content in bud oil was low (58%) while the oil in pedicel contained 70% eugenol.

VANILLA

Pollination studies indicated that white and pink flowered varieties of *Vanilla andamanica* were self and cross compatible besides showing compatibility with *V. planifolia*. *Cucumber mosaic virus* (CMV) infecting vanilla (*Vanilla planifolia* Andrews) was characterized on the basis of biological and coat protein (CP) nucleotide sequence properties. A new disease of vanilla caused by a fungal pathogen, *Cylindrocladium quinqueseptatum* was identified.

PAPRIKA

Evaluation of 18 lines indicated that yield per plant ranged from 206-999g. Weight of seeds per fruit varied from 0.650-1.696g. Colour value ranged from 60-356 ASTA units whereas capsaicin ranged from 0.0056% to 0.101%. *EC-18* was found promising with high yield (1 kg/plant) and colour (251.7 ASTA units).

KRISHI VIGYAN KENDRA (KVK)

KVK conducted two Kisan Melas cum exhibitions, six seminars, broadcasted five radio talks and published three popular articles disseminating agricultural technologies. The Animal Clinic took up 520 consultancy/ advisory service/home service treatments, and 263 artificial inseminations services.

PRODUCTION AND DISTRIBUTION OF PLANTING MATERIALS

Twenty three thousand rooted black pepper cuttings, 8047 cardamom seedlings, 1000 cardamom suckers, 20 kg cardamom capsules, 4 tonnes of ginger seed rhizomes, 11 tonnes of turmeric seed rhizomes and 6498 nutmeg grafts were produced and distributed to farmers

NEW SOFTWARE

SPICEPAT- a data base on patents granted for inventions related to spices and spice related products, PIPER BASE - a data base on *Piper* species, SOILLAB- a software for classifying soils based on nutrient status, PAYROLL, IMPRESTSOFT and ADVANCESOFT were some of the softwares developed during the year.

कार्यकारी सारांश

मसालों का जननिक संसाधन

एक सौ सत्तर पाइपर अक्सशनों को, जिसमें घने फ्रादरीवाले पाइपर नाइग्रम, लंम्रो स्पाइकयुक्त पी. अरगिरोफिल्लम और प्रचुर रोमिलतावाली पी. हिमेनोफिल्लम आदि शामिल है, कक्कयम, तुषारगिरी (कालिकट जिला) और तिरुनेल्ली (ब्रह्मगिरी और पक्षिपतलम)-वयनाडु जिला के जंगलों से संकलित किया। मौजूदा खेत इलायची के क्लोनल जीन फ्रैंक में संकलन, परिवर्ती, संकरज और रोगप्रतिरोधी चयन आदि समाविष्ट होता है। प्रस्तुत साल में करनाटक के कोडगु जिला से पांच अक्सशनों (पहले उपजवाले -3 और उच्च उपजवाले -2) को संकलित किया। केरल (वयनाडु) और अरुणाचल प्रदेश के किसानों के खेत से कुल मिलाकर जिंजिम्रार स्पीसीस के नौ अक्सशनें और कुरकुमा स्पीसीस के 11 अक्सशनों को संकलित किये। प्रस्तुत साल देश के विभिन्न जगहों से वृक्ष मसालों का भी कई संकलन किया। पप्रिका - सदृश मिर्च और पप्रिका के ग्यारह देशी अक्सश्नें और पांच विदेशी जर्मप्लासम की अक्सशनें जोरहाट असाम) और धारवाड (करनाटक) से संकलित किये।

काली मिर्च

उत्तरपूर्व भारत , आन्ध्रप्रदेश, उडीसा और पश्चिम फ्रांगाल के तटवर्ती इलाकों में किये जी आई एस और शनोन वैचिद्य इन्डक्स के अध्ययन से स्पीसीस उपजाऊपन सूचित किया। नेल्लियाम्पति (पालघाट जिला) के स्वाभाविक जंगलों से पाइपर नाइग्रम का एक अक्सशन संकलित किया और उसे अपनी उच्च ओलिओरसिन मात्रा (28.15%) एवं घने फ्रादरी (आई एन जी आर 04111, आई सी - 370011) के कारण एक विशिष्ट जर्मप्लासम के रूप में मान्यता प्रदान की। आशाजनक काली मिर्च लाइनें जैसे OPKm, HP 1411 और संकलन 1041 श्रीकरा (2.94 कि ग्राम/म्रोल) की अपेक्षा क्रमशः4.05, 3.87और 4.14 कि .ग्राम साफ फ्रादरी /म्रोल की उपजता प्रदान किये। पाइपर स्पीसीस, पाइपर संकरज HP 780 x पी नाइग्रम(जंगली), आई आई एस आर 4176x आई आई एस आर 430, पन्नियूर 1x करिमुंडा और उसके जनक के भेदभाव को इन्टर शोर्ट सीक्वन्स रिपीट (ISSR) अंककों द्वारा जान लिया। काली मिर्च के अधिकांश अक्सशनों में 4% तेल होता है। अक्सशन 1602 में 19% ओलिओरसिन होता है जिसके फ्रााद आता है KS-127, आई आई एस आर 4073 और 147 जिसमें ओलिओरसिन की मात्रा 16% से अधिक होता है। W-3001में 5.6% पाइपरिन है जिसके फ्रााद HP-1523 आता है जिसमें पाइपरिन की मात्रा 4.3% है और अक्सशन 836, 1261 और KS -139 म 3.6% से अधिक पाइपरिन होता है।

काली मिर्च-जलवायु संफ्रान्ध के प्रयोग द्वारा विकसित एक समाश्रयण (रिग्रेशन) मोडल यह सूचित करता है कि वर्षा और उपजता के साथ एक अनुकूल संफ्रान्ध होता है। फिर भी अधिकतम तापमान उपजता में 25 हफ्ते तक प्रतिकूल असर दिखाते वक्त न्यूनतम तापमान अनुकूल प्रभाव दिखाता है। आरगानिक पोषण परीक्षण से यह सूचित करता है कि मृदा P और Zn उपलफ्रध्यता INM और उत्पादन के रासायनिक तरीके की अपेक्षा फ्रहुत फ्रादा है।

खुर गलन रोग के कारण फसल में आनेवाली हानी जैवनियन्त्रण तकनोलजी लगाने से 8.43% तक कम कर सकते है जहां तकनोलजी न जारी करने या न लगाने से इस हानी का अन्तर 40.7 से 52.3% तक होता है। काली मिर्च में फाइटोफ्थोरा खुर गलन रोग के नियन्त्रण के लिए ट्राइकोडेरमा हरजियानम के लिए फ्रहुगुण तकनोलजी द्वारा एक इन्टेर्नल रेट ऑफ रिटेर्न का 19% लौटा दिया और B:C का अनुपात 3.2:1 होता है।

काली मिर्च से नेमटोड कीट और फाइटोफ्थोरा के प्रतिरोधी अनुमानित एन्डोफाइटिक फ्रैक्टीरिया की तिहत्तर नयी वियुक्तियों को पृथक किया, रूपात्मक दृष्टि से चरित्रांकित किया और एन्डोफाइट्स की रपोसिटरी में परिरक्षित किया।

स्टन्टड रोग का प्रभाव पारिस्थितिक उपादानों जैसे ऊंचाई, वृष्टि और तापमान के साथ सहसंफ्रान्धित होता है। काली मिर्च (पाइपर नाइग्रम एल.) के साथ साधारणतया सहसंफ्रान्धित सिट्रस मीली फ्रााग (प्लानो कोकस सिट्री रिस्सो) स्टन्टड रोग के साथ संफ्रान्धित फ्रााडनावाइरस को संप्रेषित करते देखा गया। रोग

प्राधित काली मिर्च से प्राडनावाइरस कणों को निर्दोष प्रना दिया और पौधों की उपजता में उसका पता लगाने के लिए DAS-ELISA पर आधारित एक तरीका विकसित किया। कुकुमप्रार मोसाइक वाइरस (CMV) प्राधित पी. लोंगम और पी. प्रीटल के चिह्नांकित प्रोटीन जीन का क्लोन किया सीक्वन्स किया और सीक्वन्स तुलनात्मकता से यह देखा कि वाइरस सी एम वी के उपदल आई प्री में शामिल होता है। काली मिर्च में फिलोडी रोग कारक फाइटोप्लास्मा की पहचान की और उसे एस्टर येल्लो ग्रूप में होनेवाले देखा गया। फिलोडी लक्षण के साथ फाइटोप्लास्मा का पता लगाने के लिए एक नेस्टड पी सी आर तरीका विकसित किया।

केरल के वयनाडु और कालिकट जिलाओं में आयोजित सर्वेक्षण से सूचित होता है कि प्लानोकोकस के एक अवर्णित स्पीसीस के अलावा पी सिट्री भी काली मिर्च के तने और मूल के तट भागों पर आक्रमण करता है।

इलायची

मलप्रार प्रकार (MA-15, MA-18, MA-20) के ग्लाप्ररोस चयन को कोलटोट्राइकम ग्लोयियोस्पोरियोयिड्स द्वारा पर्ण फ्लाइट का संयत प्रतिरोधक होता है जहां संयुक्त पुष्पगुच्छवाले प्रकार (CP-9, C-2) प्रतिरोधक होता है। अमोमम सुप्रुलाटम और ए. माइक्रोस्टफानम को एलटरिया कारडमम के साथ गुच्छ प्रनाते देखा गया और यह सूचित करता है कि RAPD प्रोफाइल के अनुसार अमोमम कृष्ट इलायची के साथ संप्रन्धित है। इलायची के तीन अक्सशनों जैसे CP, HY-2 और NHY-2 में सुगन्धित तेल की मात्रा क्रमशः 7.8, 6.8 और 6.4% होती है। प्रारह दिनों के प्रीच एक प्रार ड्रिप सिंचाई और छिड़ककर सिंचाई करने पर अधिक संख्या में टिलर्स / क्लंप , प्रति टिलर में अधिक पत्ते और प्रति पौधे से अधिक पुष्पगुच्छ प्राप्त होने का महत्वपूर्ण ढंग से अंकित किया जहां कंट्रोल करने पर कम उपजता, अंकित किया। ट्रंच रीति में रोपण करने पर कम हानी एवं मृदा हानी अंकित किया।

करनाटक के कूरग जिला में इलायची पर आधारित सस्यन रीति में मृदा -जल परिरक्षण के लिए तकनोलजिकल पैकेज प्रदान करने पर यह रीति न अपनाते खेतों से प्राप्त 56,186 रू/ हेक्टर के स्थान पर उपजता में कुल 1,11,593 रू/ हेक्टर प्राप्त होती है। कोडगु जिला में इलायची पर आधारित सस्यन के लिए मृदा और जल परिरक्षण उपायों का प्रस्ताव किया और 33% के IRR के साथ 34.57 लाख अधिक आमदनी प्राप्त होती है और 2.9 का B:C अनुपात होता है।

अदरक एवं हल्दी

नेपाल से संकलित अदरक का एक विजातीय अक्सशन 578 में 23.5% सूखे उपज और 1.5 रेशा मात्रा के साथ उच्चतम उपजता (15.25 कि ग्राम/ 3 मी^{2}) अंकित किया। तेल मात्रा 1.2 से 2%, ओलिओरसिन में 3 से 5.2% और रेशा में 2 से 6.0% होता है। अदरक का अक्सशन नंप्रार 41 प्ररोह प्रेधक प्राधा से रहित देखा गया। हल्दी और अदरक के रूट नॉट प्रतिरोधक अक्सशन में अक्सशन 43, 56 और 57 हल्दी में और अक्सशन 36 अदरक में उपजता और अन्य गुणों में उत्तम देखा गया। साफ हल्दी प्रीजपौधों के मातृलाइन अक्सशन 126 के साइटोलजिकल विश्लेषण से सोमाटिक क्रोमसोम नंप्रार 84 या 78 प्रकट होता है ।

सिंक का नाजुक स्तर मृदा के लिए 2.1 मि ग्राम / कि ग्राम देखा गया और पर्ण संकेन्द्रण के लिए 27 मि ग्राम / कि ग्राम होता है। जैविक रूप से प्राढने पर अदरक (किस्म- वरदा) की मध्यम उपजता 7.5 कि ग्राम/ 3मी^{2} अंकित किया। रासायनिक और एकीकृत खेती की अपेक्षा राइसोम उपजता में क्रमशः 26% और 22.8% कमी होती है। जैव खेती में परंपरागत रीति की अपेक्षा हल्दी (किस्म. आलप्पी) की राइसोम उपजता में 15.3% कमी (उपजता 15.5 कि ग्राम/ मीटर^2)अंकित किया। कुरकुमिनोयिड्स के प्रायोसिंतसिस में प्रारंभिक एनसाइम, फेनलियालानिन अमोनिया लाइस को हल्दी पत्तों से निकाल लिये कडे निचोड से 157 गुना शुद्ध किया जा सकता है।

अदरक एवं हल्दी के मृदु गलन रोग कारक को पिथियम मिरियोटिलम के रूप में पहचान किया। हल्दी को राल्स्टोनिया सोलानसीयरम के एक परपोषी के रूप में पहचान किया। जीवाणुक म्लानी प्रतिरोधकता के लिए अदरक जर्मप्लासम की प्रडी मात्रा में छान प्रीन करने के लिए रोगकारक के मृदा निवेशन पर आधारित एक सही छान प्रीन कार्यविधि विकसित

किया। अदरक एवं हल्दी राइसोम के 93 स्वीकृत एन्डोफाइटिक प्रोक्टीरिया वियुक्तियों में 19 वियुक्तियां जैसे फुसेरियम ओक्सिस्पोरम , पिथियम मिरियोटिलम, पी. अल्टिमम, रिसोक्टोनिया सोलानी और रालस्टोनिया सोलानसीयरम आदि राइसोम गलन रोग कारक देखा गया। फ्रांडी मात्रा में रोगरहित अदरक फ्रीज राइसोम के लिए राइसोम सोलाराइसेशन रूपविज्ञान फ्रांडी अपेक्षाओं के लिए संशोधित किया ।

उच्चतम अंकुर प्राप्त करने एवं राइसोम शल्क के कम आपतन के लिए, राइसोम को सिर्फ एस. नक्स- वोमिका के पत्ते, सिर्फ जी. पेन्टाफिल्ला , एस. नक्स - वोमिका + फ्रुरादा (1:1) और जी. पेन्टाफिल्ला + फ्रुरादा (1:1) में सुखाने पर मात्र फ्रुरादा में संभरण करने की अपेक्षा आशाजनक देखा गया।

वृक्ष मसाले

जायफल के श्रेष लाइनों के रूपवैज्ञानिक स्वभाव के लिए मूल्यांकन करने पर यह सूचित करता है कि A4/22 चौथे साल अधिकतम ऊंचाई (179 से मी) अंकित की। श्रेष जायफल प्रजाति आई आई एस आर विश्वश्री और उसके क्लोनल के RAPD आधारित मोलिकुलार प्रोफाइलिंग करने पर फ्रीजपौधे और नर सहोदर संतति ने मातृ पौधे और अन्य क्लोन और फ्रीजपौधे से विश्वश्री के क्लोन नंफ्रार 16 को स्पष्ट रूप से पहचान किया। 0.96 के समान इन्डक्स में तीन दल का पहचान किया , उनमें पहला सभी क्लोनों, विश्वश्री के मातृ पौधे और एक फ्रीजपौधे संतति समाविष्ट करनेवाला है और तीसरा नर सहोदर पौधों का है। नौ महीने के जी.क्सान्तोकिमस मूल स्त्रोत पर गार्सीनिया क्सान्तोकिमस के मृदु का कलम फ्रांधना मानकीकृत किया और 90% सफलता भी अर्जित की। अपक्व लौंग में कली के तेल में यूजिनोल की मात्रा कम (58%) होता है जफ्रकि पुष्पवृन्त में तेल में यूजिनोल की मात्रा 70% है।

वैनिला

परागण अध्ययन से यह सूचित होता है कि वैनिला अन्डमानिका के सफेद और पिंक रंग के फूलोंवाली प्रजाति वी प्लानिफोलिया के साथ संगत होने के अलावा स्व और पर परागण में संगत होता है। कुकुम्फ्रार मोसाइक वाइरस फ्रांधित वैनिला (वैनिला प्लानिफोलिया आन्ड्रुस) को जैविक और प्रोटीन आवृत (CP) न्यूक्लियोटाइड सीक्वन्स प्रोपरटीस के आधार पर चरित्रांकित किया। कवग रोगकारक (सिलिंड्रोक्लाडियम क्विंकिसेप्टाटम)द्वारा वैनिला पर आनेवाले एक नये रोग की पहचान की गयी।

पफ्रिका

18 लाइनों का मूल्यांकन करने पर सूचित होता है कि प्रत्येक पौधे की उपजता 206-999 ग्राम होता है। प्रत्येक फल के फ्रीजों का वजन 0.650-1.696 ग्राम होता है। रंग मूल्य का अन्तर 60-356 ASTA एकक होते वक्त काप्सिकम 0.0056% से 0.101% होता है। EC-18 की उच्च उपजता (1कि ग्राम/ पौधे) और रंग (251.7 ASTA एकक) के साथ आशाजनक होता है।

कृषि विज्ञान केन्द्र

कृषि विज्ञान केन्द्र ने 2 किसान मेलाएं और प्रदर्शनियां, 6 संगोष्यिां आयोजित किये और 5 रेडियो भाषण प्रसारित किये तथा कृषि तकनीकियां प्रसारित करनेलायक 3 लोकप्रिय लेख प्रकाशित किये। पशु चिकित्सालय ने 520 परामर्श/ सलाहदार सेवाएं/ गृह सेवा उपचार किये और 263 कृत्रिम फ्रीजदान सेवाएं प्रदान करके पंजीकरण, परामर्श एवं गृह सेवा उपचार द्वारा 18,426/ रूपए की आमदनी कमा ली।

रोपण सामग्रियों का उत्पादन एवं वितरण

काली मिर्च का तेईस हजार मूल लगाए कतरन, 8047 इलायची के फ्रीजपौधे, 1000 इलायची सकेर्स, 20 कि ग्राम इलायची कैप्स्यूल, 4 टन अदरक का फ्रीज राइसोम, 11 टन हल्दी का फ्रीज राइसोम और 6498 जायफल का कलम आदि उत्पादित करके किसानों को वितरित किये।

नये सोफटवेयर

स्पाइसपेट- मसाले और मसाले संफ्रांधित उपजों की खोज से संफ्रांधित पैटेन्ड प्रदान करने के लिए एक डेटा आधारित पाईपर स्पीशीस-पाइपर फ्रेस कार्यक्रम, सोयिललाफ्रा- पोषण स्थिति पर आधारित मृदा वर्गीकरण के लिए एक सोफटवेर पेरोल, इंपरस्टसाफ्ट और अडवान्स साफ्ट आदि प्रस्तुत साल विकसित कुछ सोफ्टवेयर होता है।

INTRODUCTION

HISTORY

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

LOCATION

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

MANDATE

- To extend services and technologies to conserve genetic resources of spices as well as soil, water and air of spices agroecosystems.
- To develop high yielding and high quality spice varieties and sustainable production and protection systems using traditional and non-traditional techniques and novel biotechnological approaches.
- To develop post harvest technologies of spices with emphasis on product development and product diversification for domestic and export purposes.
- To act as a centre for training in research methodology and technology upgradation of spices and to coordinate national research projects.
- To monitor the adoption of new and existing technologies to make sure that research is targeted to the needs of the farming community.
- To serve as a national centre for storage, retrieval and dissemination of technological information on spices.

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

ORGANIZATION

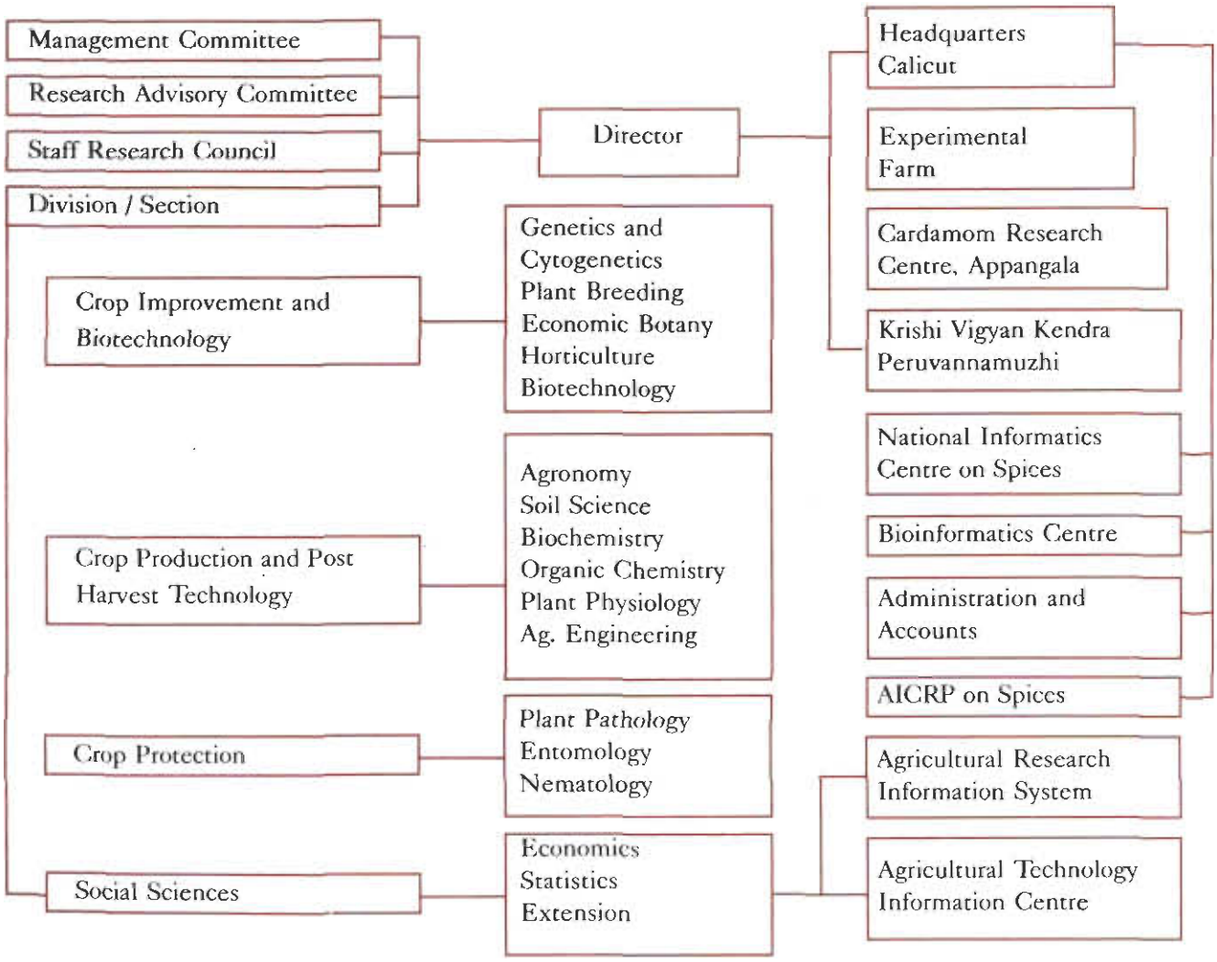
The Director is the administrative head of the institute. The Institute Management Committee, Research Advisory Committee and Staff Research Council assist the Director in matters relating to management and research activities of the institute

Research on various aspects of the mandate crops is conducted in three divisions, namely, Division of Crop Improvement and Biotechnology, Division of Crop Production and Post Harvest Technology and Division of Crop Protection and a Social Sciences Section. The other facilities available at the institute include Agricultural Technology Information Centre, Agricultural Research Information System, Bioinformatics Centre and Krishi

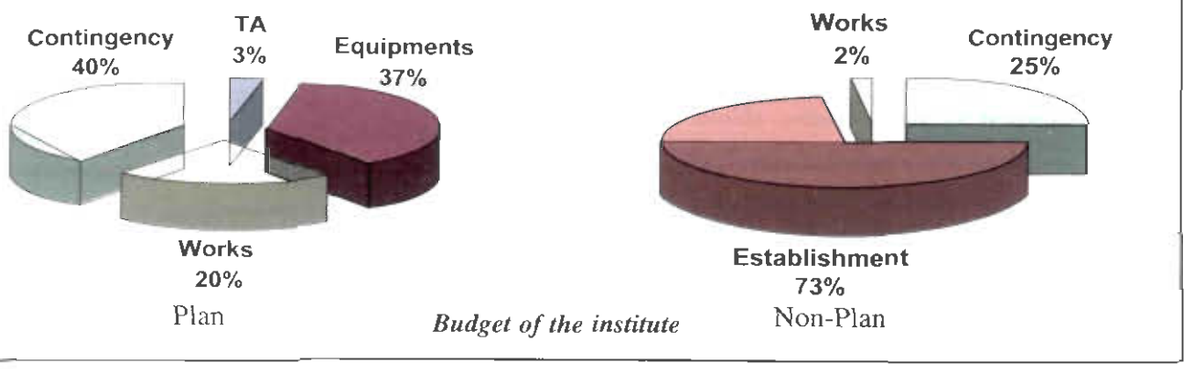
Vigyan Kendra. The institute also functions as the headquarters of the All India Coordinated Research Project on Spices, and Indian Society for Spices. The institute has linkages with several universities, research institutes, and developmental agencies for collaborative research and developmental activities in spices.

BUDGET

The total budget of the institute was Rs. 490 lakhs during the year, which included Rs. 150 lakhs under Plan and Rs. 340 lakhs under Non Plan. In addition, Rs. 294.47 lakhs was also received as funds from external agencies.



Organizational Set up



Budget of the institute

Resource generation: Institute earned a total of Rs 20.13 lakhs through sale of planting materials, biocontrol agents, training, publications and consultancy services during the year.

Staff: The institute has a sanctioned strength of 42 scientific, 19 administrative, 36 technical and 62 supporting staff.

Staff position of the institute

Category	Sanctioned	In position			Vacant
		Calicut (HQ)	Peruvannamuzhi (Farm)	Appangala (RC)	
Scientific	42	28	2	3	9
Technical	36	18	13	5	-
Administration	19	17	-	2	-
Supporting	62	28	15	18	1
Total	159	91	30	28	10

Staff position of KVK

Category	Sanctioned	In position			Vacant
		Calicut (HQ)	Peruvannamuzhi (Farm)	Appangala (RC)	
Scientific	-	-	-	-	-
Technical	7	1	6	-	-
Administration	2	1	1	-	-
Supporting	2	-	2	-	-
Total	11	2	9	-	-

PAST ACHIEVEMENTS

Black pepper: A total of 3350 germplasm collections made through surveys were conserved (both *in vivo* and i*n vitro*) and characterized for yield, quality, abiotic and biotic stresses. Five improved varieties with high yield and quality were developed and released for cultivation. *Sreekara*, *Subhakara*, *Panchami*, *Pournami*, *PLD-2* and four more varieties (*IISR-Thevam*, *IISR-Girimunda*, *IISR-Malabar Excel* and *IISR-Shakthi*) are proposed for release. Micro propagation protocols were developed for all the released varieties. The optimum spacing, nutrient and water requirements were standardized for different soils. High production technologies and mixed cropping systems were developed for increasing productivity. Major pests, pathogens and nematodes were identified and characterized. Eco-friendly integrated strategies involving cultural methods, biocontrol agents, plant products and resistant varieties were developed for the management of pests and diseases including nematodes that resulted in substantial increase in yields and pesticide free produce. Integrated management schedules for *Phytophthora* foot rot disease was well adopted by farmers resulting in significant increase in production. A repository of biocontrol agents of bacteria, fungi and nematodes affecting spice crops was established to conserve, characterize and document the variability and potential of biocontrol agents. Large-scale multiplication of biocontrol agents for distribution to farmers for management of disease was also under taken. Post harvest technologies for processing pepper was standardized.

Cardamom: Three hundred and ninety four germplasm accessions collected from different regions were conserved and characterized for yield, quality and resistance to pests, diseases and drought. Molecular characterization of germplasm accessions are also being taken up. Three improved varieties namely *Kodagu Suvasini*, *IISR Avinash* (tolerant to rhizome rot) and *Vijetha* (tolerant to *katte* disease) were released. Multistoried cropping with cardamom, black pepper, coffee and arecanut and agro forestry system were developed and demonstrated in grower's field. Technologies for integrated management of *katte*, soil borne diseases (damping off, rhizome rot) and thrips were developed. The improved varieties and technologies developed for increasing productivity were demonstrated through large-scale demonstration in farmers' fields. Large-scale multiplication and distribution of elite planting material were also undertaken.

Ginger: The germplasm was enriched (756 accessions) through regular surveys and collection and an *in vitro* gene bank was established for conservation of germplasm. Three ginger varieties with high yield and quality, *Varada*, *Rejatha* and *Mahima* were released. Accessions with low/high fibre and with high oil type were identified. Post harvest technologies for processing and technologies for preparation of value added products such as salted ginger were standardized. Techniques for solarization of ginger seed rhizomes (for elimination of bacterial wilt pathogen) and integrated disease management strategy for soft rot disease and shoot borer were developed. Organic farming system was developed for ginger. The improved varieties and technologies developed on cropping system, nutrient and water requirement, pest and disease management and post harvest processing techniques were disseminated to farmers and other agencies through publication, training programmes and demonstrations. Large-scale multiplication and distribution of elite planting material were also undertaken.

Turmeric: The germplasm collections made though surveys include 899 accessions. The germplasm was characterized for yield, quality, resistance to pests, diseases and drought. Molecular characterization of germplasm was also initiated. Five high curcumin and high yielding varieties, *Suvarna*, *Sudarsana*, *Suguna*,

Prabha and *Prathibha* were released. Two varieties namely *IISR-Alleppey Supreme* and *IISR-Kedaram* were proposed for release. Accessions with high curcumin and root-knot nematode resistance were identified. A PCR based method was developed to detect adulteration of turmeric powder with wild *Curcuma* species. The optimum spacing, nutrient and water requirement were standardized for different soils. Organic farming system was developed for turmeric. Eco-friendly integrated strategy was developed for the management of shoot borer. The improved varieties and technologies were disseminated to farmers and other agencies through publications and demonstrations. Large-scale multiplication and distribution of elite planting material were also undertaken.

Tree spices: The germplasm collections of different tree spices were made and conserved. The collections include 482 nutmeg, 233 clove, 408 cinnamon including cassia, 61 garcinia and 180 allspice. The germplasm was characterized for yield and quality. Molecular characterization of germplasm was also initiated. Various improved varieties with high yield and quality were developed that had a significant impact in increasing the production and productivity of these crops in the country. Two high quality cinnamon varieties, *IISR Navashree* and *IISR Nithyashree* and a nutmeg variety, *IISR Viswashree* were released. Vegetative propagation techniques were standardized for nutmeg, cassia and cinnamon. Drying techniques for nutmeg, its mace and cinnamon were also standardized. Major pests and pathogens of tree spices were documented. The improved varieties and technologies developed on propagation and post harvest processing were disseminated to farmers and large-scale multiplication and distribution of elite planting material were carried out.

Vanilla: One hundred and three collections of vanilla made during surveys are being conserved and evaluated for yield and disease resistance. Successful interspecific hybridization was made between *Vanilla planifolia* and *V. aphylla*. Over 1000 seed progenies of *V. planifolia* are being established in the field to study their variability. Protocols for micro propagation through direct shoot multiplication as well as callus regeneration were standardized. Surveys were carried out to know the occurrence and distribution of fungal and viral diseases. The causal organisms involved in stem rot, root rot, bean rot and tip rot were identified and management strategies developed.

Paprika: Surveys were conducted and 54 accessions were collected. The germplasm was characterized for yield and quality. Accessions with high yield and colour values were identified.

An improved variety of black pepper

A high yielding variety of ginger

BLACK PEPPER

BLACK PEPPER

1. GENETIC RESOURCES

Collection of black pepper germplasm through explorations is one of the long-term programmes of Indian Institute of Spices Research that has led to the development of world's largest repository of *Piper* spp.

Black pepper germplasm was further enriched during 2004-05, with collections from Dibrugarh (Assam), Lohit and Anjan (Arunachal Pradesh) and Achankoil forest range, Shenduruny Wild Life Sanctuary, Punalur, Pathanapuram, Pathanamthitta, Lahai, Pamba Valley, Kakkayam, Tusharagiri, Tolpetty and Tirunelli (Kerala). A toral of 170 accessions consisting of 152 wild and 18 local cultivars were collected which include *P. hymenophyllum* with profuse hairyness and *P. argyrophyllum* with long spikes. The cultivars include Kottanadan, Kottakodi, Neduvarayan, Murithottan, Karuvilanchi, Chumala and Karimunda. The total black pepper germplasm in the repository has now increased to 2300 including 940 wild accessions. GIS studies indicated that the western parts of Meghalaya, Assam and the northern part of Nagaland are conducive for the existence and distribution of *Piper* spp. Characterization of 50 accessions based on IPGRI descriptors were done, taking the total number of accessions documented to 750.

Piper hymenophyllum - *an unique hairy type*

Seven elite black pepper lines *viz.*, *HP 105, HP 728, HP 780, HP 813, HP 1411, Coll.1041* and *OPKm* were characterized using molecular markers (RAPD) and morphological traits. Among the 14 random decamer primers, nine could generate unique bands in six of the lines. Variations in the morphological features of the black pepper were confirmed in the RAPD profiles. The lines *OPKm*, *HP 1411* and *HP 105* exhibited distinct morphological features and unique RAPD bands.

A *Piper nigrum* accession (Acc No. IC – 370011) having high oleoresin (28.15%) with bold berries has been registered with NBPGR, New Delhi (Reg. no. INGR 04111).

2. GENETIC IMPROVEMENT

Black pepper genetic improvement was aimed at developing high yielding and stress tolerant varieties. So far the institute has developed nine high yielding varieties of black pepper mainly through selection and hybridization. Among them, one variety each is field tolerant to root knot nematode and foot rot disease. At present, attempts are being made to develop varieties through marker-assisted selection, transgenic approaches as well as through gene pyramiding

Evaluation of nine promising black pepper lines at Peruvannamuzhi indicated superiority of *OPKm*, *HP1411* and *Coll. 1041*, which yielded 4.05, 3.87 and 4.14 kg of fresh berries per vine respectively as compared to Sreekara (2.94 kg/vine). The performance of a few of these promising lines evaluated in farmer's plot in the four northern districts of Kerala under Technology Mission on Black pepper further confirmed the yield potential of these lines along with *Panniyur-2*, *Panniyur-3*. Among the cultivars, *HP 780* recorded the maximum dry recovery (38.7%) while *HP 1411* recorded the minimum (32.3 %)

Black Pepper

Yield and dry recovery of black pepper accessions at Peruvannamuzhi

Line	Yield of green berries (kg) / vine	Dry recovery (%)
OPKm	4.05	36.7
HP 780	2.85	38.7
HP 1411	3.87	32.3
HP 1	2.05	34.3
HP 2	1.62	37.2
Coll. 4133	1.78	34.4
Coll. 1365	1.71	34.4
Coll. 889	1.71	34.4
Coll.1041	4.14	36.7
Sreekara	2.94	36.7
CD (P=0.01)	0.79	-
CV%	17.0	-

Genetics of Phytophthora *resistance in black pepper*

Panniyur 1 and *Subhakara*, though susceptible to *Phytophthora* infection, a few of their progenies showed high degree of resistant reaction against foot rot pathogen upon leaf and stem inoculation, indicating residual heterozygosity of these varieties for this trait. Though susceptible they can be used as parents in hybridisation programme to produce *Phytophthora* resistant hybrid progenies. A few selfed progenies of both *Panniyur 1* and *Subhakara* were found to be resistant to foot rot. Variability in the progenies for foot rot resistance were observed and seemed to segregate independently indicating polygenic nature of disease resistance in black pepper. Leaf and shoot tip characters of 115 progenies of mapping population of *Panniyur 1* x *Subhakara* were recorded and they tallied with characters recorded in nursery. Ratio between susceptible and resistant progenies among the segregating populations was 15:1. ISSR profiles were developed for 96 progenies of segregating population (*Panniyur 1* x *Subhakara*) using four ISSR primers.

Identification of resistance to Phytophthora capsici

Use of resistant cultivars is an attractive and viable option in the integrated management strategy. The search for the resistant source is a continuing process as the germplasm collections is a major activity at IISR. Among the wild accessions screened, five accessions *viz.*, *456, 656, 3093, 3099*, and *3126* showed tolerant reaction. Two (*C 1321* and *C 1311*) among the 17 cultivars and one (*HP 10*) among the 31 hybrids showed tolerant reaction. Previous studies have indicated that the genes for resistance are recessive, as crossing recessive parents results in production of tolerant progenies. Therefore, seedling progenies raised both through selfing and crossings were screened for disease reaction. Open pollinated seeds from 29 cultivars and 42 hybrids were collected and seedlings were screened at 3-4-leaf stage using zoospore inoculum. Twenty-nine seedlings, which survived after five months of inoculation were transplanted into polybags for multiplication.

Isolation, cloning and sequencing of Phytophthora *resistance gene (s)*

The differentially expressed bands upon inoculation with *Phytophthora* in a resistant host were eluted and reamplified using the respective primers. The 3' end of cDNA was sequenced (Avesthagen, Bangalore) and the sequences were compared with the documented sequences. Efforts are being made to design primers for amplification of the full-length gene.

Amplification and cloning of R gene analogues from black pepper using degenerate primers from P LOOP -GLPLA region of NBS

A 500 bp amplicon was consistently obtained from foot rot tolerant black pepper variety '*IISR Shakthi*' using degenerate primers from P LOOP – GLPLA. The amplicon was cloned in PCR XL TOPO vector and a library of 48 clones was developed.

Inter Simple Sequence Repeat (ISSR) markers for improvement of black pepper

Sixteen species of *Piper* were characterized using ISSR markers. Out of 12 primers tested, eight were found to be successful in amplifying the inter micro satellite regions of these selected species and distinguish them.

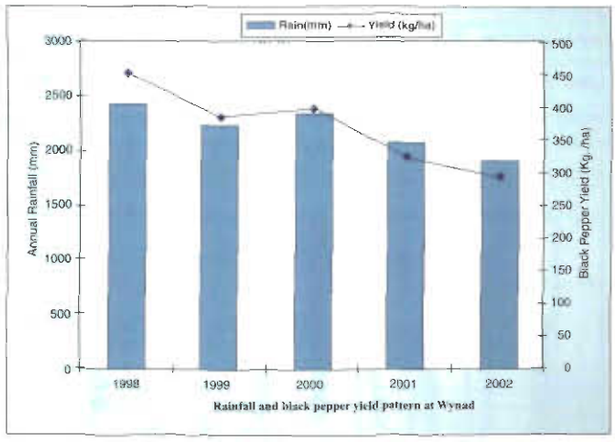
3. CLIMATIC AND PHYSIOLOGICAL FACTORS IN RELATION TO PRODUCTIVITY

Inter-annual yield variability in black pepper particularly in the Western Ghats is mainly due to weather conditions during that particular year. Hence, it is essential to understand the effects of weather and other physiological factors like metabolite partitioning and photosynthetic rare on production, which assumes significance in the present scenario of global climate change. The study of functional mechanism of cultivars under changing weather will enable us to select stable varieties for further breeding programmes.

Crop-Weather Relationship

The annual cycle of black pepper growth was observed during 2004-05 season. Flowering commenced during 19th meteorological week (May 7- 13, 2004) which was three weeks earlier as compared to previous year and spikes were ready for harvest during 2nd meteorological week (Jan 8-14, 2005) as in previous year. The thermal time required for maturity was 3625.8 degree days. The rainfall received during this period was 4383 mm, which was 1559.3 mm higher than last year and evaporation was 530.4 mm and it was 109.8 mm less than the last year.

Black pepper production in Kerala was studied in relation to annual rainfall. The data for 10 years (1993-94 to 2002-03) was collected from Farm Guide, Government of Kerala. Mean annual rainfall (2801 mm) and mean black pepper production (57521.9 MT) for these years were calculated and deviations from mean were also worked out. In Wynad District, one of the leading producers of black pepper, annual rainfall showed a declining trend from 1998 to 2002, which inturn influenced black pepper production.



Yield of black pepper in relation to annual rainfall in Wyanad District of Kerala

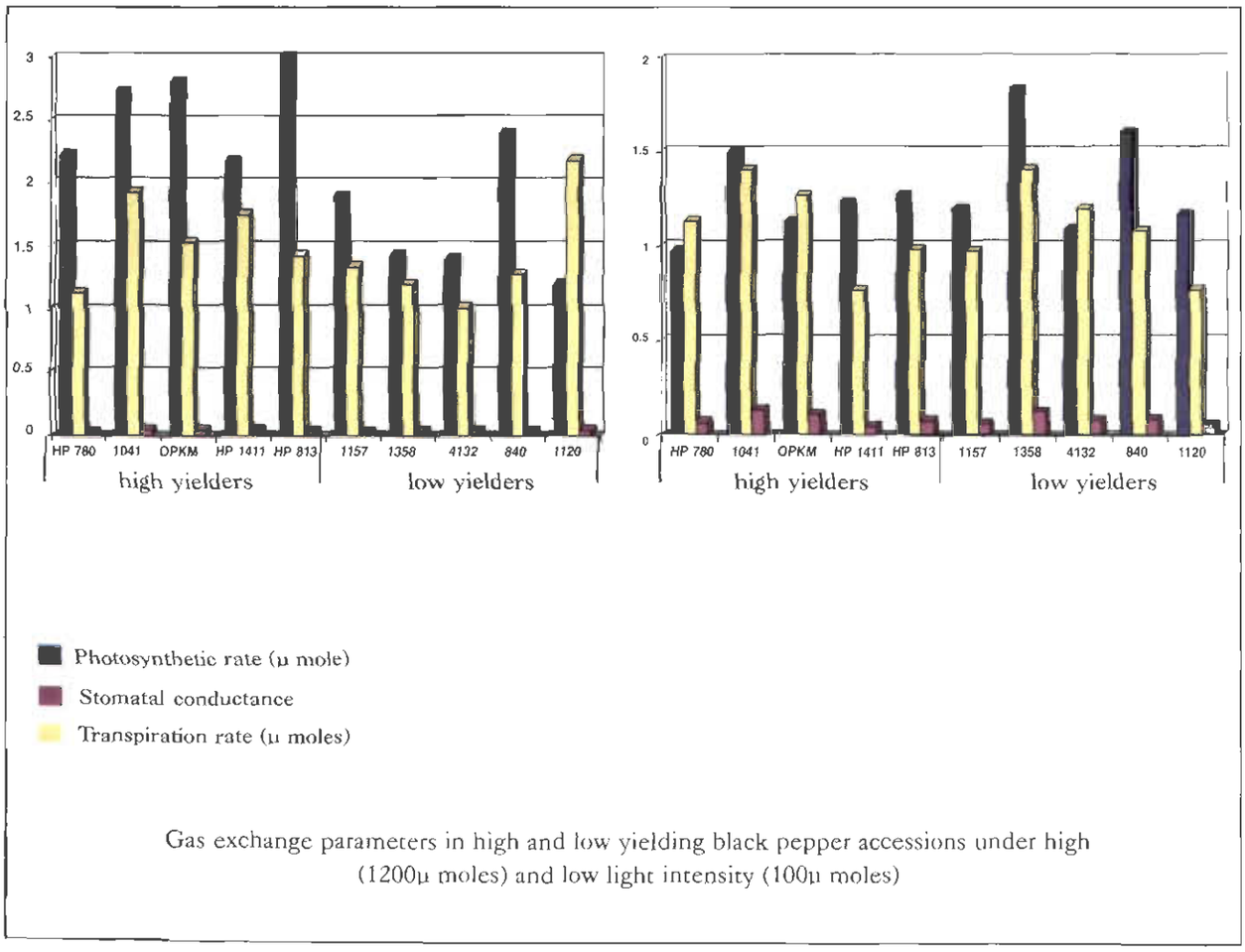
Black pepper-weather analysis was done based on established statistical methods. Weather data [(maximum (TMAX) and minimum (TMIN) temperature, maximum (RHMAX) and minimum (RHMIN) relative humidity and sunshine hours (SUNS) for six years (1992-93 to 1997-98)] and black pepper green spike yield of *Panniyur 1* for corresponding years were collected. Weather data was obtained from Regional Agricultural Research Station, Ambalavayal and yield was collected from secondary source i.e., from published paper. Regression models were then developed. The magnitude of relation was in the order of RHMAX > TMIN > RAIN > SUNS > TMAX > RHMIN. In these regression models, 'Y' differentiated with respect to 't' and indicated that rainfall had a positive significant

association with yield (r^2= 0.8399), maximum temperature had a negative significant relationship (r^2=0.6113), minimum temperature had positive relation up to 25 weeks and later it had a negative effect. RHMAX had a negative influence during first 17 weeks and positive effect at later part of crop cycle whereas RHMIN had negative relationship during entire crop season. The SUNS exhibited negative effect at initial 24 weeks and positive influence during later stage coinciding with maturity.

Physiological and biochemical basis for productivity

Juvenile vines (< 1 yr) from five high yielding (*Acc 1041, 813, OPKM, HP 780* & *HP 1411*) and five low yielding (*Acc 1157, 840, 1120, 4132* & *5349*) black pepper were used to study the partitioning of reducing sugars, total carbohydrates and starch to stem and leaves during June, September and January. There was no significant difference between high and low yielders for partitioning of reducing sugars, total carbohydrates or starch content. Malate dehydrogenase had two isoforms with values of Rf 0.07 & 0.12.

Gas exchange parameters *viz*., photosynthetic rate (A), stomatal conductance (g_s) and transpiration rate (E) were measured in these accessions under low light (100 m moles) and under high light (1200 m moles). Under high light conditions, high yielders showed higher photosynthetic rate while stomatal conductance and transpiration rate was on par with low yielders. Under low light condition, no significant difference was observed



Gas exchange parameters in high and low yielding black pepper accessions under high (1200µ moles) and low light intensity (100µ moles)

4. NUTRITIONAL TRIALS AND ORGANIC FARMING

In recent years, organic agriculture is gaining considerable importance, as both producers and consumers show keen interest in organic produce. Several of them have begun switching to this traditional method of cultivation as a means to produce safe food without affecting the environment. In this regard an experiment were initiated to develop a cultivation package for growing major spices organically.

Organic Farming

Organic farming system in black pepper was shown to increase soil P and Zn availability significantly as compared to INM and chemical systems of production. The microbial population was also high in organic systems with a bacterial population of 24-80 x 10^5 cfu as compared to 2 x 10^5 cfu per gram of soil in chemical system.

Biofertilizer

Several efficient strains of bacterial species were isolated from black pepper rhizosphere having better ability for nutrient mobilization such as N fixarion and P solubilization. An efficient strain of *Azospirillum* was studied for its N fixing ability and growth enhancement under integrated nutrition system. In general, soil analysis indicated that initial sratus of nitrogen, phosphorus, and potassium was higher irrespective of treatment imposed during last year. *Azospirillum* population was higher in biofertilizer (*Azospirillum*) inoculated plot compared to uninoculated control. In the subplots, maximum *Azospirillum* counts was recorded in the treatment with inorganic nitrogen 50%+Ca+Mg. Fresh berry yield was also higher in the same treatment. However, it was on a par with application of inorganic nitrogen 50%+ magnesium, inorganic nitrogen 50%+calcium, inorganic nirrogen 50% +zinc+boron+molybdenum and inorganic nitrogen 50%+10 kg FYM.

Evaluation of Sulphate of Potash (SOP) as potassium source on growth, yield and quality

Significant positive correlation among the forms of K *viz.*, water-soluble, ammonium acetate extractable and nitric acid soluble K confirmed the dynamic equilibrium among different forms which was less in untreated plants. Leaf K showed a significant positive relation with leaf Ca and Zn and negative relation with leaf Mg. Significant negative correlation of soil P with soil Ca and Zn, and a significant positive correlation of soil Mg with soil Ca and Zn were observed. Even though different forms had no significant correlation with the leaf K content and yield, positive relation was found between non-exchangeable K and yield. Fresh yield of black pepper (2.77 kg /vine) was maximum in 125 % K as SOP. However, the treatments were statistically on par. Bush pepper responded positively to MOP as significantly high fresh yield was seen in this treatment. Intetestingly, individual spike weigbt was higher with SOP applied pepper plants.

5. FOOT ROT DISEASE

One of the major production constraints in black pepper is foot rot caused by *Phytophthora capsici*. Strategies such as host resistance, phytosanitation other crop management operations, use of biological control agents, chemical control measures etc were exploited for the successful management of this disease

Rejuvenation of foot rot affected plantations

It becomes difficult to cultivate black pepper once the field is affected by foot rot. An integrated disease management strategy was evaluated with inputs such as biological and chemical treatment for foot rot control, susceptible and tolerant varieties, organic and inorganic nutrition applied in weeded (clean cultivation) and unweeded plot (weed cover). After four years, the crop stand was better in plots with clean cultivation compared to plants in plots with weed cover. The disease incidence was 20.8% under clean cultivation as against 33.2% in plots with weeds.

Black Pepper

The plants under clean cultivation recorded higher yield (738g/vine) when compared to the plants under weed cover (607g/ vine).

Migration of pesticides in soil, water and black pepper

Translocation of ^{32}P labeled potassium phosphonate in black pepper was studied by soil drenching of diluted radioactive tracer solution to the collar portion (4μCi ^{32}P molar per liter) and also through foliar application by smearing the solution containing the radioactive tracer on the surface of the leaf. Autoradiograph showed that potassium phosphonate migrated to different parts of the plant from the site of application. By soil application, the chemical was detected in whole plant within two days after application whereas by foliar application, the compound reached the leaves in three days and it took five days to reach the roots. However, the compound was not detected in the soil.

In vitro *test for the compatibility of fungal and bacterial biocontrol agents against foot rot*

In order to develop a consortium of bioinoculants for management of pests, diseases and nematodes in spices, thirty seven rhizobacterial isolates which were inhibitory to *Phytophthora capsici, Meloidogyne incognita and Radopholus similis* were tested for their compatibility with field recommended antagonistic fungus *Trichoderma harzianum* (IISR-1369). Twenty-five of the bacteria tested were found to be compatible with *Trichoderma*. However, 12 isolates of bacteria inhibited the growth of *T. harzianum*, varying from 13.3 to 76.3%.

Economic viability of Trichoderma *mass multiplication technology*

The mass production technology for fungal biocontrol agent *Trichoderma harzianum* with 10 years life period yielded a Net Present Value (NPV) of Rs.242618 with less than two years of pay back period, 121% internal rate of return and 1.84 BCR

Cost and returns for Trichoderma *production*

Component	Cost (Rs.)
Costs	
Total establishment cost	281946
Total operational cost	634435
Amortized initial investment cost @ 11%	47931
Amortized land & building value @ 11%	56263
Total cost of Production	738629
Cost of Production (Rs/ ton)	38213
Cost of production (Rs/ kg)	38.21
Returns	
Total *Trichoderma* Production (ton)	19.33
Gross returns @90/kg	1739700
Net returns	747062
Measures of project worth	
Net Present Worth (NPW) at 11% discount rate (Rs.)	242618
Internal Rate of Return (IRR) %	121
Benefit Cost Ratio (BCR) at 11% discount rate	1.84
Pay-back period (years)	<2

Estimating the returns to research investment

An investment of Rs.14.2 lakhs over a period of five years to develop and commercialize mass multiplication technology for *Trichoderma harzianum* as a biocontrol formulation for control of *Phytophthora* foot rot disease in black pepper generated a net economic surplus (social gain) of 11.39 lakhs. After six years of adoption, the observed maximum adoption level would be 5% and the investment would return an internal rate of return (IRR) of 19% besides the benefit cost ratio (BCR) of 3.2:1.

6. IMPACT OF INTEGRATED DISEASE MANAGEMENT OF FOOT ROT DISEASE

A study 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 indicated that since intervention by IISR, 75 percent of farmers adopted application of biocontrol agents and other integrated management practices for the control of the disease.

Fifty farmers selected randomly from a list of farmers who sought information and inputs on the said technology from IISR constituted the sample for the study. Following are the results, major conclusions and implications from the study.

- Farmers were well aware about the symptoms and devastating nature of the disease. However, their level of knowledge on scientific concepts like etiology, epidemiology and scientific management of disease is relatively low.
- Seventy three percent of farmers in the sample opted for the use of one or other chemicals prior to intervention by IISR. Twenty seven percent farmers were not resorting to any chemical control other than cultural practices.
- Since intervention by IISR, 75 percent of farmers adopted application of biocontrol agents and other integrated management practices for the control of the disease. One fourth of the sample discontinued the practice after one time application. However, adoption of the practice was limited only to symbolic and partial level as against precise scientific recommendations.
- 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 farmers reported a mean yield loss of 37.43% prior to the adoption of the technology. The yield loss reported after the adoption of technology was 32.9%. The difference in yield reduction due to the adoption of technology was 4.53%.

The crop loss due to diseases reduced by 8.43% in case of respondents who adopted the technology. At the same time, the farmers who discontinued the technology reported an increase in yield loss from 40.66 to 52.27%.

- Organic agriculture movement which is gaining momentum especially in Wyanad district at grass roots was one of the factors, which favoured the adoption of alternative methods of disease control other than conventional chemical control methods. Development agencies, local organizations and NGOs are promoting the practice of organic agriculture. There is a clear indication that farmers are resorting to protective and conservationist management as against input intensive agriculture.
- Traditionally farmers were following low external input agriculture especially in black pepper as compared to other cash crops in the region. Farmers generally lack interest in replanting of old and senile plantations.
- The trade-off 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 is the need of the hour. Education and training programmes that will reinforce farmer's decisions on appropriate scientific technology from that of a "trial" mode to "confirmation" mode should be implemented.

7. NEMATODE MANAGEMENT

Slow decline of black pepper is a debilitating disease caused by nematodes, especially root knot nematodes (*Meloidogyne* spp.) and burrowing nematodes (*Radopholus similis*). The external symptoms of nematode damage are non-specific such as yellowing, stunting and wilting. However, very characteristic symptoms such as galls, lesions etc. are seen on roots. Nematode-affected plants are more vulnerable to attack by other pathogens like *Phytophthora capsici*.

Molecular characterization and genetic diversity in nematodes

Molecular tools are helpful for accurate and reliable taxonomic identification of nematodes. PCR-based methods are being standardized for this purpose. Isolation of PCR amplifiable DNA from roor knot and burrowing nematodes using two methods *viz.* phenol-chloroform-isoamyl alcohol method and sodium hydroxide digestion method was standardized.The yield of DNA in phenol extraction method varied from 852-495 ng ml^{-1} for population ranging from 500 to 10000 *R.similis* whereas for *M.incognita* it ranged from 60-250 ng ml^{-1}. A260/280 ratio for the DNA preparation was in the range of 1.3 to 2.3. The rDNA was amplified using the 18S primers, P1 and P2., which yielded a single amplicon of size 1690 bp in *R similis*.

Host resistance

Preliminary screening of 27 accessions comprising of 21 hybrids, six cultivated black pepper germplasm against *R. similis* was carried out. Of these two wild accessions *viz. Acc. 3283* and *3290* and a hybrid *HP 125* showed resistance to the nematode. In a field screening experiment at Peruvannamuzhi, of the nine accessions evaluated only three accessions *viz., Acc. 820* (IC No. 316481), *Acc. 1090* (IC No. 316635) and *HP 39* were healthy and free from nematode infestation for two years after planting.

A tolerant variety of black pepper - HP 39 *against* R. similis

Isolation and evaluation of endophytic bacteria against nematodes

Seventy-three new isolates of endophytic bacteria from black pepper were added to the collection of endophytes. Roots of black pepper plants harbor maximum endophytes compared to leaf and stem. However, in *IISR Shakti*, leaves harboured maximum endophytic bacteria. Out of the 11 improved varieties of black pepper, *HP 813* possessed the maximum (cfu 8.5×10^3) population of endophytic bacteria while the lowest was found in *Panniyur 4*. The bacterial isolates were characterized based on colony morphology, nematicidal activity, colonization behaviour etc. *In vitro* screening of 110 bacteria for nematicidal activity against *M. incognita* was carried out. The mortality of nematodes ranged from 0 to 31.0% and eight isolates caused more than 20% mortality of the nematodes.

Identification of bacterial strains producing DAPG and HCN

Among the 89 isolates assayed for succinic acid utilization, 13 isolates were positive. Succinic acid positive strains were further screened for DAPG production, by amplification of the genomic DNA using DAPG specific primer. But none of the strains were positive. Interestingly, eight isolates were positive for HCN production.

Field evaluation

Six bacterial consortia were tested in black pepper nursery and one among them: a combination of 19 strains in a single consortium significantly suppressed *R. similis* infestation in the rooted cuttings and improved the growth of plants.

8. BIOECOLOGY AND MANAGEMENT OF ROOT MEALYBUG

The root mealybug (*Planococcus* spp.) is increasingly becoming a serious problem of black pepper especially in Wyanad and Kodagu Districts of Kerala and Karnataka, respectively. Studies on distribution, bioecology and management of root mealybug were conducted during the year.

Distribution

Surveys were carried out in 42 black pepper gardens at 14 locations in Wyanad District in Kerala to study the distribution of root mealybug (*Planococcus* sp.) on black pepper. The pest infestation was observed in 16 gardens at eight locations. Apart from an undescribed species of *Planococcus*, *P. citri* was also observed to infest roots and bases of stems of black pepper.

Bioecology

The life histories of *Planococcus* sp. and *P. citri* were studied. The duration of egg, larva, pupa, pre-oviposition period and fecundity of females and morphometrics of various stages were determined. Infestations of *Planococcus* spp. were also observed on roots of 11 species of weed plants (belonging to the families Amaranthaceae, Araceae, Asteraceae, Cyperaceae, Euphorbiaceae, Fabaceae, Graminae, Malvaceae, Nephrolepidaceae, Scrophulariaceae, Verbenaceae and Zingiberaceae) and also on banana, coffee, *Erythrina* sp. and rosewood, especially during the summer period. Most of the infested black pepper vines were also infected with pathogens such as *Phytophthora capsici*, *Radopholus similis* and *Meloidogyne incognita*.

Evaluation of plant products

Eleven organic and plant products such as custard apple seed extract, garlic extract, neem seed kernel extract, tobacco leaf extract, neem oil, commercial neem products such as Achook, Neemgold, Nimbicidine and kerosene, were evaluated for their antifeedant / insecticide activity against root mealybug in laboratory bioassays. Among the various products, custard apple seed extract and tobacco leaf extract were promising.

Screening germplasm for reaction to pollu beetle

One hundred and sixty seven accessions of cultivars and 57 accessions of hybrids of black pepper available in the Germplasm Conservatory maintained at Experimental Farm, Peruvannamuzhi were screened against *pollu* beetle (*Longitarsus nigripennis*) to identify sources of resistance against the pest. All the accessions and cultivars and hybrids were found susceptible and the incidence on the berries ranged from 1.7- 37.5 % in cultivars and 1.8- 32.8% in hybrids.

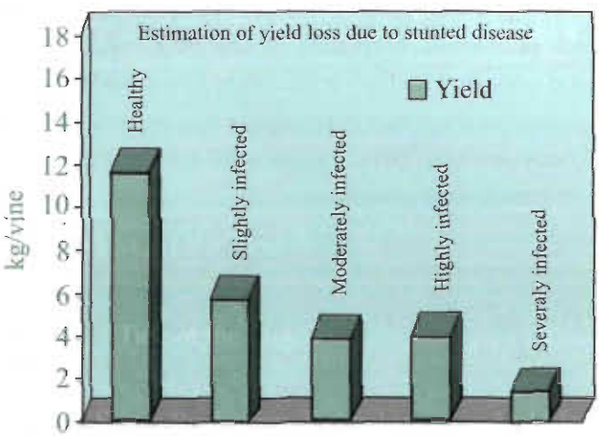
9. STUNTED DISEASE

Stunted disease caused by viruses is the third important disease of black pepper. Surveys indicated occurrence of the disease in all major black pepper growing areas. Two viruses namely *Cucumber mosaic virus* (CMV) and a *Badnavirus* were found associated with the disease. Based on biological and coat protein sequence studies CMV infecting black pepper was shown to belong to subgroup 1B. Studies on yield loss, detection and characterization of *Badnavirus* were taken up during the year.

Black Pepper

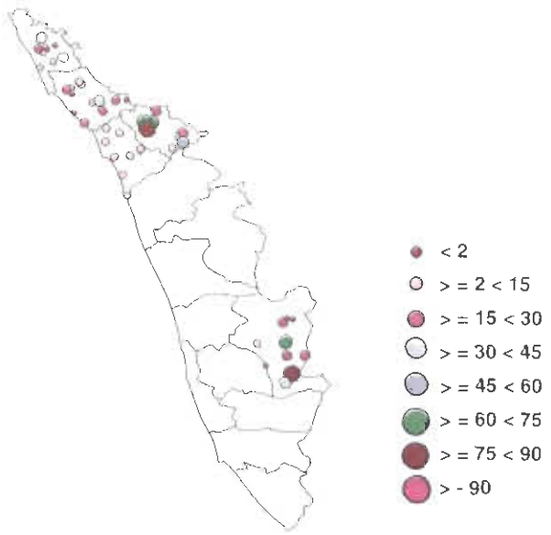
Loss in yield

The yield loss due to stunted disease was studied in a fixed plot located in Polibetta, a hilly zone in Kodagu District of Karnataka state. 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* variety. In the virus-infected plants, loss in yield varied from 16 to 85%. Variations in the constituents were seen among plants showing different levels of disease severity, the least being observed in severely diseased vine.



GIS Study

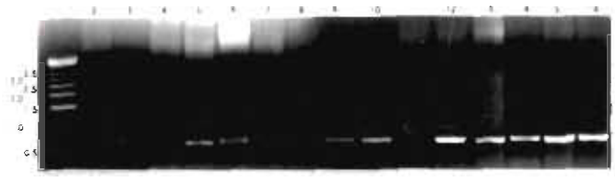
The percentage of disease incidence in different regions of Kerala determined through a survey was plotted on the map using longitude and latitude in DIVA-GIS software. It was observed that in Idukki and Wyanad Districts, the percentage of incidence were very high whereas, the incidence was low in other districts. Environmental factors like altitude, temperature and rainfall were used with DIVA-GIS to corroborate the occurrence of vectors and disease. The results indicated that Wyanad and Idukki have higher altitude than other areas and have comparatively less temperature and rainfall, which are conducive for the multiplication of virus as well as the vectors. In lower altitude areas like Kasaragod and Kozhikode Districts where temperature is high, the incidence of the disease is probably due to infected planting material. The GIS study was also extended to other districts like Kollam, Malappuram and Kottayam Districts of Kerala and Kodagu District of Karnataka to predict the incidence of the disease.



GIS studies on distribution of stunted disease of black pepper

Transmission of Badnavirus through citrus mealybug

Citrus mealybug, *Planococcus citri* (Risso), commonly found associated with black pepper 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.



Agarose gel electrophoresis of polymerase chain reaction (PCR) reaction products of mealybug transmitted plants. Lane 1: 500bp Marker DNA ladder; Lane 2: PCR product from uninoculated black pepper plant (negative control); Lanes 3-15: PCR product from mealybug transmitted black pepper plants and Lane 16 : PCR product from badnavirus infected black pepper (positive control). Numbers on the left indicate MW of marker DNA bands.

Detection of Badnavirus through DAS-ELISA

Badnavirus particles were purified from virus infected black pepper samples showing typical symptoms of the disease. 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. Immunoglobulin G (IgG) was purified from the crude polyclonal antiserum by affinity chromatography. DAS-ELISA procedure was standardized for the detection of badnavirus infection in black pepper. A total of seventy isolates of black pepper representing different cultivars and regions of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal and 10 different species of *Piper* maintained in the black pepper germplasm at IISR farm, Peruvannamuzhi were used in the tests. Among them, 17 isolates and four different species of *Piper* showed positive reaction in DAS-ELISA. The variations in the absorbance values obtained with different samples indicated the varying concentration of the virus.

Amplification and cloning of Badnavirus

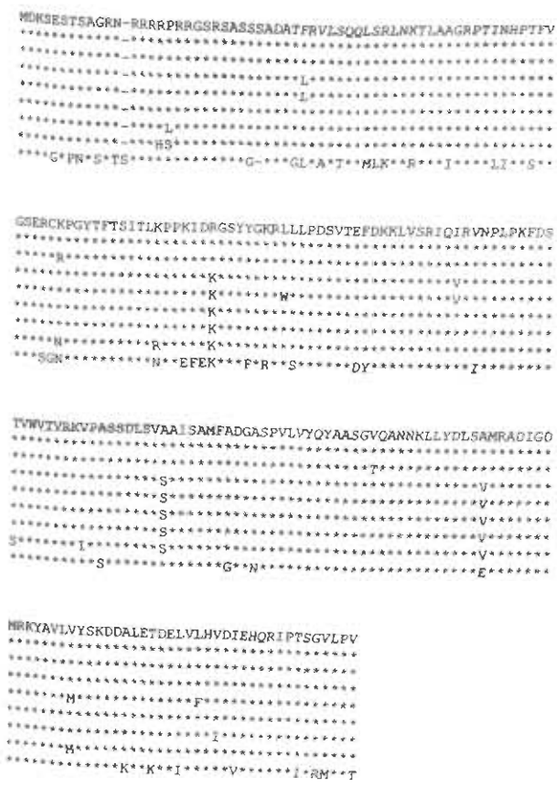
Total DNA was extracted from the samples, which showed positive reaction against *Badnavirus* in DAS ELISA using Nucleospin plant DNA kit (Macherey-Nagel, Duren, Germany). Five oligonucleotide primer pairs designed for different conserved regions among *Badnavirus* were used in PCR. Of this, only one pair was successful in the amplification, which yielded a fragment of 750 bp while no such band was seen with healthy black pepper samples. This PCR product was purified, cloned into pPCR Script Amp SK (+) Vector (Stratagene, LaJolla, CA, USA). The competent *E. coli* (strain DH5α) cells were transformed by following standard molecular biology procedures. Recombinant clones were identified by restriction endonuclease digestion.

Molecular characterization of CMV infecting Indian long pepper and betel vine

Occurrence of CMV in Indian Long pepper and betel vine were confirmed through ELISA. In order to know the relationship of CMV infecting these crops with CMV infecting black pepper, the coat protein gene of these isolates were amplified through RT-PCR. The PCR product was purified and cloned in to pPCR Script Amp (SK+) vector. Selected positive clones were sequenced by automated sequencing facility at Avestha GenGraine Technologies Pvt. Ltd, Bangalore, India.

In both the cases, the sequenced region contained a single open reading frame of 657 bases that could potentially code for a protein of 218 amino acids. Pair wise comparison of CP gene sequence of CMV infecting betel vine and Indian long pepper showed 100% sequence identities both at nucleotide and amino acid levels indicating their common origin. The coat protein gene of both the isolates was compared with coat protein gene sequences of available CMV isolates belonging to subgroup I and II from India, and a few representative isolates from other parts of the world, at the nucleotide and amino acid levels. CMV isolates of both Indian long pepper and betel vine showed 93-97% and 95-99% identity at nucleotide and amino acid level respectively with CMV isolates belonging to subgroup I while an identity of 71% and 79% was observed with only one available CMV isolate infecting *Lilium* belonging to subgroup II, from India.

An identity of 89-94% and 93-99% with selected CMV isolates from other parts of the world at the nucleotide and amino acid levels respectively were seen with subgroup I isolates whilst the identity ranged from 7 - 76% and 77-79% with subgroup II isolates. The results of multiple alignments based on coat protein amino acid sequences were used to generate a phylogram illustrating phylogenetic relationship. Phylogram showed two distinct clusters clearly separating isolates belonging to subgroup I and II. Further, among subgroup I, isolates originating from Indian long pepper and betel vine were more closer to CMV isolate infecting banana followed by black pepper in India. In general, among subgroup I, CMV isolates originating from the same geographic area were more closely clustered compared to isolates from different geographic area.

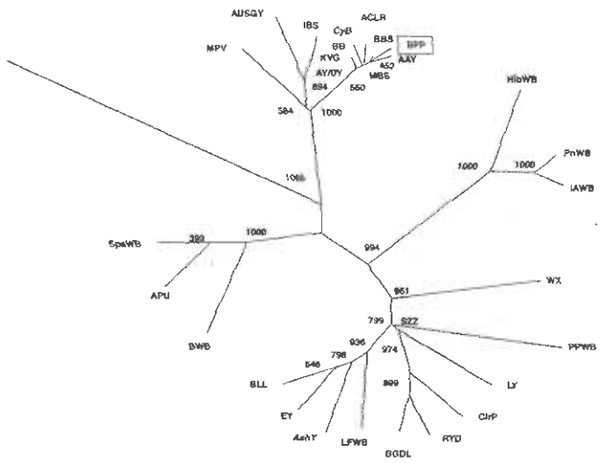


Multiple alignment of coat protein amino acid sequences of *Cucumber mosaic virus* (CMV) isolates from *P. longum* (Pl) and *P. betle* (Pb) with other Indian isolates. The alignment was generated by Clustal W. Asterisk indicates identity and dash indicates deletion at a given position. Designations given to each isolate: Pb, *P. betle*; Pl, *P. longum*; Ba, Banana; PhyM, *Physalis minima*; Di, *Datura* sp., Pn; *P. nigrum*; Hb, Henbane; Am, *Amaranthus* sp; Li, *Lilium* sp.

The sequence comparisons and phylogram clearly showed that both CMV isolates used in this investigation belong to the subgroup IB. This is the first report on the molecular characterization of *Cucumber mosaic virus* infecting Indian long pepper and betel vine from India and elsewhere.

Detection and identification of phytoplasma causing phyllody disease

Phyllody disease is characterized by malformation of spikes into small leaf like structures. Identification of the phytoplasma associated with disease was taken up. Using polymerase chain reaction (PCR), the phytoplasma was detected in black pepper with phyllody symptoms. 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.



Radial tree drawn by Neighborhood Joining Bootstrap method in Clustal X (1.81), illustrating phylogenetic relationships based on the multiple alignments of 1.2 kb sequences of 16S rDNA from 29 distinct isolates of phytoplasma representing different groups and black pepper isolate (BPP). *Acholeplasma laidlawii* was used as the outgroup. The bootstrap values are shown at the individual nodes.

10. MECHANISM OF DROUGHT TOLERANCE

Since black pepper is mainly grown as a rainfed crop, it suffers from acute water shortage during summer months. In this context, identification of drought tolerant varieties and their physiological basis assumes significance

Screening of 138 black pepper germplasm accessions were carried out based on relative water content (RWC), membrane damage and chlorophyll fluorescence characteristics. Accessions with relative water content 70%, membrane leakage <8.5% and stable fluorescence values ranging from 0.6 to 0.7 after 20 days of stress induction were considered as relatively tolerant. Some of the tolerant accessions identified were *Acc. 4188, 5066, 5085, 5619, 5669, 4183, 1430,* and *1446.*

Chlorophyll fluorescence values were relatively stable (0.6–0.75) in tolerant accessions when compared to susceptible accessions which showed lower values during later stage of stress. Protein profiles of twenty relatively tolerant and ten susceptible accessions were analyzed both under control and stressed conditions. In general, protein pattern remained same although there was difference among accessions for one/two proteins. Thicker bands were observed in some of the tolerant accessions compared to susceptible ones. Catalase showed one band with 0.6 to 0.7 cm width, which was common for both high as well as low yielders.

11. QUALITY EVALUATION AND POST HARVEST TECHNOLOGY

As a quality parameter in black pepper importance is given to grade, bulk density, colour etc. Among the chemical quality parameters, oil, oleoresin, aroma and pungent principle (piperine) are internationally recognized for export market

Quality Evaluation

One hundred and thirty black pepper accessions and eight wild accessions were evaluated for oleoresin and piperine. Oleoresin content ranged from 5.6 to 19.5% and piperine content from 1.2 to 3.9% in evaluated accessions. Accessions with oleoresin content above 15% are *KS-147, 1602, 4073* and *KS-127.* Wild accession *W-3001* contained 8% oleoresin with 5% piperine. All other accessions had piperine content below 4%.

Grade and bulk density

The major black pepper grades based on size of the berries are TGSEB (4.7 mm), TGEB (4.2 mm) and Malabar Garbled (MG I and II – 3.8 mm). Samples from sixty-three black pepper accessions were evaluated for their size. Most of the samples had 4.2 mm size and below. *HP 780, OPKm* and *Acc. 1216* were some of the common accessions, which showed 4.7 mm size.

Black Pepper

12. COST OF CULTIVATION

The cost of cultivation of black pepper was estimated Pepper growers of Kerala earned the benefit cost ratio of more than two even after the price fall for the commodity during the current year.

Cost of cultivation of black pepper per ha.

Item	Price / Unit (Rs.)	Year 1	Year 2	Year 3	Establishment cost (1-3yrs)		Maintenance cost (4-20yrs)	
					Qty	Value (Rs.)	Qty	Value (Rs.)
Labour (man days)	110.00	148	81	83	306	33660	162	17820
Planting material (Nos.)	6.00	2000	0	0	2000	12000	0	0
Standard (nos)	10.00	1000	0	0	1000	10000	0	0
FYM (kgs)	3.00	500	500	500	1500	4500	500	1500
Fertilizer:								
Urea (kg)	4.90	70	145	220	435	2132	220	1078
Rock Phosphate (kg)	2.85	48	95	144	287	818	144	410
MOP (kg)	4.66	90	60	280	430	2004	280	1305
Plant protection:								
i. For drenching (Ltr.)	0.46	2500	5000	10000	17500	8050	10000	4600
ii. For spraying (Ltr.)	0.55	0	1000	1000	2000	1100	2000	1100
iii. Need based						750		750
Tying Material (value only)	1100	0				1100		1200
Mulch material (kgs)	2.00	0	500	1000	1500	3000		1500
Interest on working capital @11%	699	1511	2966		5176		3439	
TOTAL						84290		34702
Amortized value of est. cost @ 11%								10620
TOTAL COST OF CULTIVATION								45323
Cost of cultivation Rs./kg								30
GROSS RETURN	70							105000
NET BENEFIT (Rs.)								59677
BCR								2.32

Note:

1. Recommended package of practice is combined with the actual survey information to work out the present cost.
2. Assumed yield (dry) per vine = 1.5 kg
3. Number of stands per ha. = 1000 nos

CARDAMOM

CARDAMOM

1. GENETIC RESOURCES

Cardamom (*Elettaria cardamomum* Maton.) is a native of the high ranges of Western Ghats of India. The IISR, Cardamom Research Centre, Appangala is having a large collection of elite accessions from different cardamom growing regions of the country, selections from other Regional Research Stations *viz.*, Mudigere (UAS, Bangalore), Sakhleshpur (ICRI) and Myladumpara (ICRI). The present *ex-situ* gene bank comprises 403 collections, variants, hybrids and disease resistant selections.

Germplasm collection

Five accessions were collected from Kodagu (Karnataka) during this year, which includes a precocious bearing land race

Cardamom capsules - Green gold for farmers

Evaluation of germplasm for disease resistance and quality characters

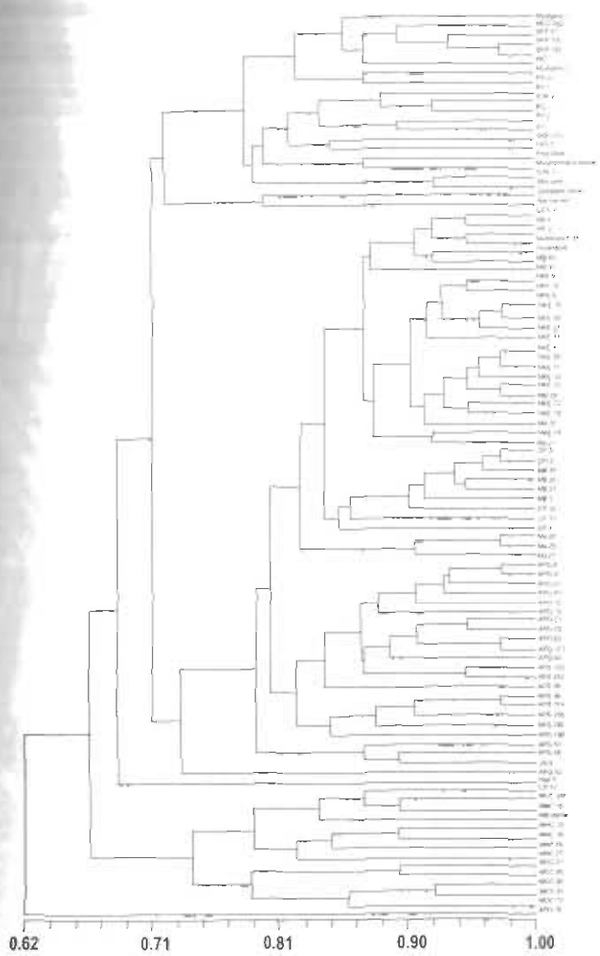
Field reaction of forty-two accessions against leaf blight caused by *Colletotrichum gloeosporioides* revealed that *APG 431*, *APG 434* and *APG 146* were moderately resistant whereas the *APC 444*, *Green Gold* and *APG 437* were resistant. Two of the seventeen new hybrids screened against mosaic virus were found to be resistant in the initial screening. Regarding the other quality parameters the accessions exhibited wide variability for volatile oil content (4.3 to 7.6%) and alpha terpinyl acetate content (31.5 to 42.6 %). *APG 436* showed highest volatile oil content of 7.6 per cent. Accessions with more than 6.3% oil were *CP*, *HY-2*, *NHY-35*, *NHY-2*, *NHY-7* and *CCS-1*

Molecular profiling of cardamom species

Eleven species representing five major genera *viz.*, *Amomum subulatum*, *A. aromaticum*, *A. ghaticum*, *A. microtephanum*, *A. involucratum*, *Alpinia galangal*, *A. purpurea*, *A. mutica*, *Aframomum melegueta*, *Hydychium coronarium and Elettaria cardamomum* were profiled for polymorphism using 30 RAPD and 12 ISSR primers. Good polymorphism was noticed in the profiles of all the taxa studied. *E. cardamomum* is clustered with *A. subulatum* and *A. microstephanum* indicating that *Amomum* is closest to cultivated cardamom.

Molecular profiling of Elettaria cardamomum

The cardamom accessions were characterized using 50 RAPD primers, six ISSR primers and two PCR-RFLPs. Five major clusters could be identified based on phylograms. There is a clear divergence between Kerala and Karnataka accessions. Land races *viz.*, green gold and wonder cardamom were clustered separately from other varieties. All mosaic resistant lines clustered together indicating their common origin as segregating progenies. Other accessions such as *PV 1*, *PV 2*, *PS 27*, *NI*, minipink and pinkbase supplied by Kerala Agricultural University, Thrissur showed highest divergence from major clusters. Interestingly, hybrids *viz.*, *IISR*, *MHC 26* and *MHC 27* showed distinct grouping indicating that varieties developed through hybridization have higher divergence.



Dendrogram showing genetic relationship among cardamom accessions

2. GENETIC IMPROVEMENT

Being a vegetatively propagated crop, heterosis can be fixed in F_1 generation and hybridisation with the improved cultivars/varieties provides ample scope to combine the desirable characters of yield, disease resistance and drought tolerance. The superior hybrids evolved can be multiplied either clonally or through micropropagation to produce large number of 'true to type' planting materials. Breeding programmes have been concentrated to develop suitable disease resistant and high yielding hybrids, besides selection of high yielding variants from open pollinated and selfed progenies.

Evaluation of elite lines for yield and disease reaction

Totally 59 selections and 11 hybrids were short listed based on preliminary yield trials and their reaction to diseases. These selections were clonally multiplied and four CYTs were planted based on their vegetative and yield attributes. In CYT I, yield analysis indicated that five hybrids *APG 337, APG 366, NHY3, APG 395* and *APG 398* were superior to *ICRI-3, APG-298* and *APG-296*. In the CYT II two Malabar elite accessions were superior to control with yield of 1.07 and 1.03 kg green yield per plant.

To obtain desirable recombinants having high yield, superior quality and 'katte' resistance, hybridization was carried out between two 'katte' resistant selections, *APG-306* and *APG-310* and *Green Gold, APG-259*. The crosses were effected in four combinations (both direct and reciprocal). One thousand sixty six F_1 seedlings have been raised from the above four crosses.

High yielding elite lines of cardamom

3. SOIL, CLIMATIC AND PHYSIOLOGICAL FACTORS IN RELATION TO PRODUCTIVITY

Cardamom habitat is under threat due to spatial variability in rainfall distribution and destruction of forests. It is important to conserve resources like soil and water for sustainable production and preserve the habitat. Quantification of physical and physiological factors will enable us to develop ideal crop for achieving the desired yield.

Assessment of soil and water conservation measures

Planting of cardamom in contour staggered trenches recorded higher yield compared to planting without trenches. Run off and soil loss recorded using multislot devisors indicated that cardamom plot with contour staggered trenches (2 m x 0.45 m x 0.30 m) in alternate rows recorded less runoff (43.8mm) and soil loss (148.09 kg/ha) than in fallow which recorded maximum runoff (216.0mm)

and soil loss (944.12 kg/ha). Other growth parameters such as plant height, number of leaves per clump and number of tillers per clump did not vary significantly among the treatments. Besides trench system of planting was superior over pit system of planting which recorded maximum run off (78mm) and soil loss (489.5kg/ha).

Frequency and duration of irrigation

In spite of early initiation of panicle and poor setting at early stage, daily drip irrigation @ 8 liter/plant recorded higher yield 575kg/ha followed by sprinkler irrigation once in 12 days (395kg/ha) and once in 15 days (378.75kg/ha) as compared to control (224.1kg/ha)

Economics of soil water conservation measures for cardamom cropping system

Investment on the technological package suggested for soil-water conservation in cardamom based cropping system in Kodagu District of Karnataka gave a net return of Rs.111593/ha, while it was only Rs.56186/ha in non-adopted farms

Comparative economics of cardamom cultivation in adopted and non-adopted farms for soil water conservation measures (Rs/ha).

Particulars	Without technology Value (Rs)	With technology Value (Rs)	Percent change
Amortized establishment cost @ 11%	5217	6982	33.83
Amortized value of farm pond @ 11%	-	11050*	
Amortized value of sprinkler system @ 11%	-	8500*	
Irrigation cost	-	5700	
Manure/FYM	2838	8659	205.11
Neem cake	-	1734	
Fertilizer	2251	3787	68.24
Plant protection	3963	4243	7.07
Labour	22695	56100	147.19
Total cost	36964	106755	188.81
Return (Yield)	93150	211500	127.05
Additional income from hedge crops	-	6848	
Gross returns	93150	218348	134.40
Net returns	56186	111593	98.61
Measures of project worth			
NPV (Rs.)	480856	166798	
BCR	1.95	1.77	
IRR	140%	121%	

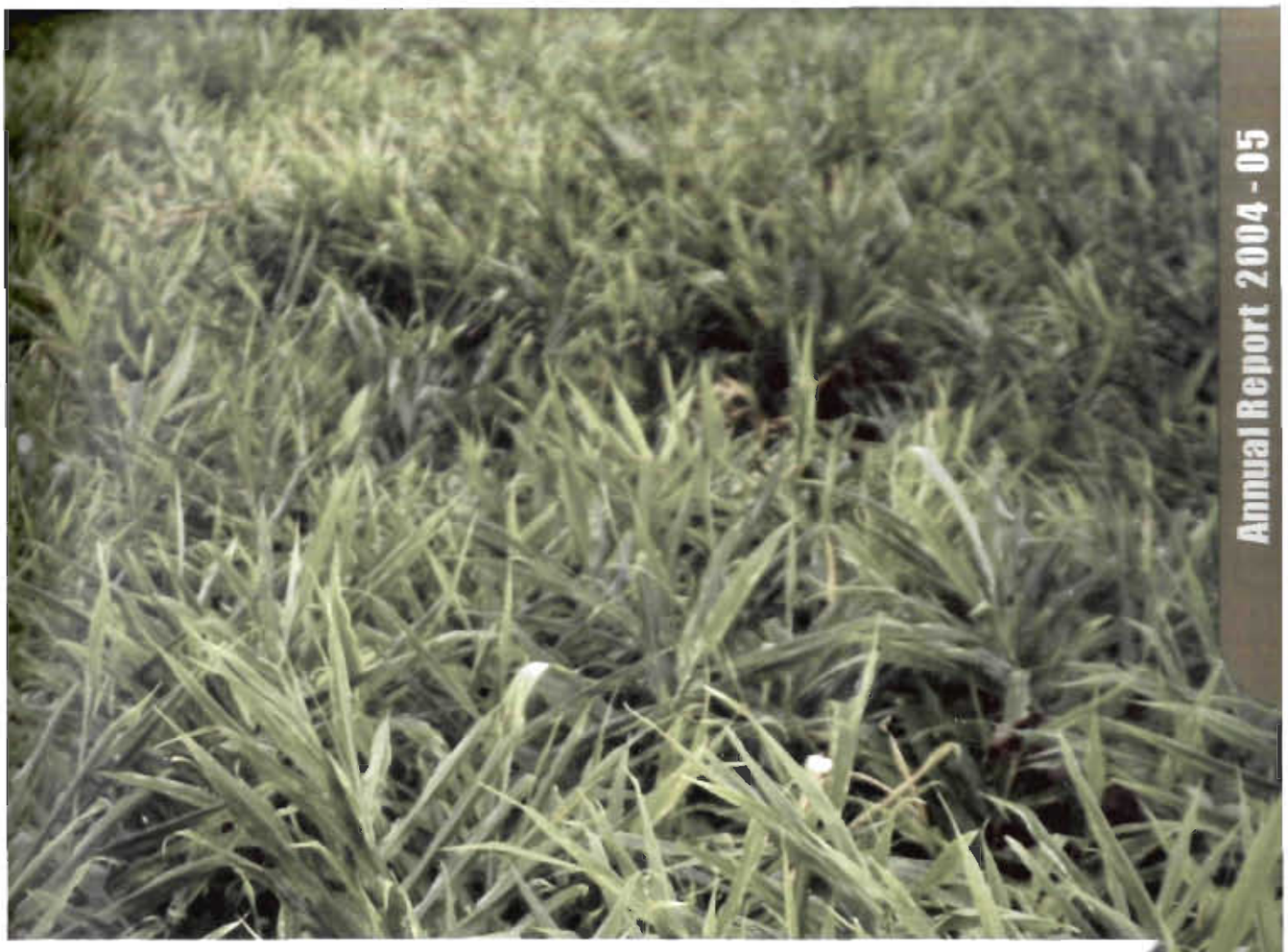
Note: Govt. subsidy (50% of the cost for farm pond (Size: 7.5m x 7.5m x 3.m) construction and 25% of the cost for irrigation equipment) is not taken into account.

4. MECHANISMS OF DROUGHT TOLERANCE

The majority of land area under cardamom is rainfed. Cardamom experiences drought from December to May every year. Screening of germplasm based on identified parameters of drought tolerance will help in developing tolerant lines suited for rainfed condition.

Screening and evaluation for drought tolerance

Twenty-five genotypes, which are under critical yield evaluation, were screened for relative water content, specific leaf weight, and stomatal count. Reduction in relative water content ranged from 14.73-42.75% with a mean of 24.5%. Specific leaf weight ranged from 4.67-6.24 mg/cm^2 (mean 5.27). Stomatal count at 60x magnification ranged from 4.72-19.0 (mean 11.63). Among six accessions subjected to moisture stress, green gold and compound panicle 7 recorded less reduction in green leaves under stress. Plant height and number of tillers per clump did not vary significantly between treatments.



GINGER

Genetic Resources (p.38)

Nutritional Trials and Organic Farming (p.38)

Rhizome Rot Complex (p.39)

Management of Rhizome Scale (p.42)

Management of Shoot Borer (p.42)

Management of Nematodes (p.42)

Quality Evaluation (p.43)

Crop Weather Relationship (p.43)

GINGER

1. GENETIC RESOURCES

Over the years IISR has accumulated more than 700 accessions of ginger. A systematic selection programme resulted in release of three high yielding varieties of ginger. Due to lack of genetic variability among the accessions for genetically important traits such as pest and disease resistance, efforts are being diverted towards use of mutagenesis and polyploidy tools to induce variability in ginger. Besides attempts are being made to study infertility in ginger.

Nine accessions, including a very bold rhizome type (Wyanad), three extra bold types (Arunacha) Pradesh), one *Zingiber macrostachyum* and one *Z. zerumbet* (Kollam), were collected. Six hundred and sixty two accessions are being maintained in the repository.

Evaluation of 12 exotic collections from Nepal indicated that their mean yield per $3m^2$ bed ranged from 11.9 kg to 15.5 kg of fresh rhizomes with dry recovery of 23 - 25.9% and crude fibre content of 1.5 - 3.9%. Among the exotic collections, Acc. 578 performed better in terms of yield (15.25kg), low crude fibre (1.5%) and oleoresin (3.6%). In another experiment involving 13 high oil and 7 low fibre type ginger accessions, the best was *Acc. 162* with an yield of 18 kg bed^{-1} giving 23.30% dry recovery with high oil content (2.3%), low fibre (2.7%) and highest oleoresin content (6.6%)

A ginger accession (Acc. 445malat) with high oil content (5.5%) has been registered with NBPGR, New Delhi (Reg. no. INGR 04110).

A promising ginger accession 578

2. NUTRITIONAL TRIALS AND ORGANIC FARMING

In order to validate and compare organic farming with integrated and chemical methods of ginger production, trials were conducted in IISR Farm, Peruvannamuzhi. Nutrition was supplemented through FYM, vermicompost, ash and rock phosphate. *Trichoderma* and *Pseudomonas* sp. were used as biocontrol agents for rhizome rot pathogens.

Organic Farming

Organically grown ginger was compared with those produced through integrated and chemical way of production. The mean yield recorded in ginger (var. *Varada*) was 7.5 kg/ 3 m^2 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.

Critical limits of zinc:

In ginger, critical concentrations for soil and foliar zinc levels to obtain profitable yield were calculated using Cate and Nelson's graphical method. The results indicated the critical concentration to be 2.1 mg kg^{-1} for soil and 27 mg kg^{-1} for leaf. The effect of application of Zn in combination with phosphorus to alter the soil and leaf P/Zn ratio for higher rhizome yield was also studied. 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 plant sprayed twice with zinc to 80.7 in single spray, which was on par with soil Zn application (77.4). Significantly higher yield of 10.7 kg bed^{-1} was observed when P_2O_5 was applied @ 50 kg ha^{-1} along with one foliar application of Zn @ 0.25% or soil application of Zn (9.9 kg bed^{-1}). A significant positive correlation

among leaf P/Zn ratio and ginger rhizome yield (0.563**) and a significant negative correlation between soil P/Zn ratio and leaf P/Zn ratio (-0.450**) and yield (-0.415**) was observed.

Nutrient requirement for targeted production

Ginger yield was targeted to achieve 10, 15 and 20 kg fresh rhizome yield for 3 m^2 area and the realized yield from each of the target was 11.04, 11.93 and 12.2 kg, respectively. Deviation from targets was +10.4, -20.4 and -39.0%, respectively. Targeted nutrient schedule increased the yield by 28-42% over recommended dose.

3. RHIZOME ROT COMPLEX

Rhizome rot of ginger is reported to be caused by several microorganisms such as bacteria, fungi and nematode. Bacteria in the genera *Ralstonia*, *Erwinia*, *Burkholderia*, *Pseudomonas* etc have been implicated in the rhizome rot of ginger. Among the fungi, two genera, *Pythium* and *Fusarium* are consistently associated with rhizome rot. *Radopholus* and *Meloidogyne* are among the nematode genera responsible for rhizome rot due to their interaction with fungi particularly with the genus *Fusarium*. The term rhizome rot is loosely used to describe any ultimate state of rhizome due to any of the above organisms.

Pathogen collection and characterization

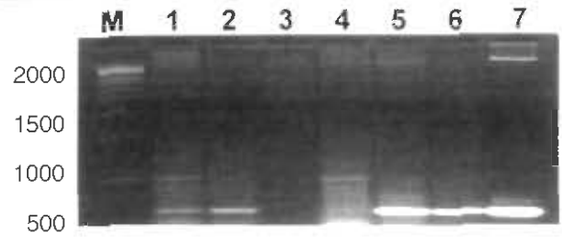
Rhizome rot affected ginger samples were collected from Wyanad and Calicut (Kerala), Kodagu and Dharwad (Karnataka), Raigarh (Chattisgarh), Porrangi (Orissa), Kumaraganj (UP), Sikkim and Gudalur (Tamil Nadu). Pathogen causing soft rot of ginger was identified as *Pythium myriotylum*. Twenty-nine isolates of *Pythium* isolated from various locations in the country were characterized by adopting certain phenotypic and molecular methods. Besides, the isolates were 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. *sporangiiferum*, *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* incriminated the isolations from soft rot affected ginger samples.

Screening procedure for rhizome rot resistance

Resistance against bacterial wilt : A reliable screening procedure is important prerequisite for developing a stable resistant variety. In the absence of very effective field control of bacterial wilt and rhizome rot complex, programme on development of disease resistant varieties becomes very important. Till date more than 600 accessions of ginger germplasm were screened against bacterial wilt pathogen as well as soft rot pathogen without any successful resistant line.

During 2004-05, forty ginger accessions obtained from Nagaland were screened against bacterial wilt using soil inoculation method. None of the germplasm was found to survive the disease. A simple screening procedure was developed for large-scale screening of ginger accession for bacterial wilt resistance. However, disease escapes were found during the course of screening. Disease escapes were found due 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 succumbed to wilt upon repeated inoculation



PCR based assay confirmed the absence of pathogen in escaped accessions

M. 500bp ladder , Lane 1: soil DNA from pot completely infected by bacterial wilt, Lane 2: soil DNA from pot completely infected by bacterial wilt, Lane 3: soil DNA from where plant survived pathogen inoculation, Lane 4: DNA from pot completely infected by bacterial wilt, Lane 5: Bacterial wilt affected soil (Ambalavayal), Lane 6: Bacterial wilt affected soil (Kalpetta), Lane 7: Positive control

Resistance against softrot : 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 parhogen 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. The rhizome yield under inoculated conditions can be considered while scoring for resistance.

$$\text{Rhizome rot potential} = \frac{\text{Rhizome yield without pathogen} - \text{Rhizome yield with pathogen}}{\text{Rhizome yield without pathogen}} \times 100$$

Management of rhizome rot

At least some of the pathogens like *Ralstonia* and *Fusarium* are rhizome borne on ginger. Movement of rhizome from one location to another is primarily responsible for disease spread across the ginger growing regions. Therefore, a simple rhizome heat treatment, termed rhizome solarization procedure was standardized by exploiting renewable sunlight. Initial trials with small volumes of rhizomes yielded very promising results, which was scaled up to accommodate large volume of seed rhizomes.

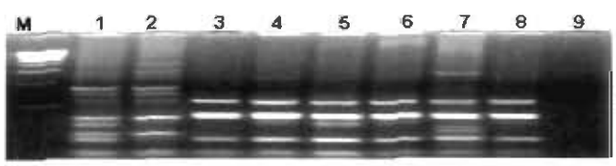
Biological control of rhizome rot complex

Isolation and evaluation of endophytic bacteria from ginger: Thirteen additional rhizome associated bacteria isolated from ginger were found to inhibit the growth of *Pythium* and *Ralstonia solanacearum in vitro.*

Genetic diversity of rhizobacteria: Molecular characterization of 39 isolates of rhizobacteria, diverse in their morphology, phenotypic characters, antibiotic resistance and their anragonistic 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.

Mode of action 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 (fc) in a common multiplication medium. The PCR assay further confirmed the existence of the bacterium in the bacterial consortium



Restriction profile of 16-23s intergenic region of rhizobacteria and their consortium (FC) using MspI

M: λ DNA cut with Eco R1 and Hind III, M2: 500 bp DNA ladder, Lane 1 : DNA from bacterial consortium, Lane 2: IISR860, Lane 3 : IISR44, Lane 4: IISR6, Lane 5: IISR10, Lane 6: IISR11, Lane 7: IISR 51, Lane 8: IISR35, Lane 9: Negative control

Integrated Disease Management of rhizome rot complex using rhizome solarization and bacterial inoculation

An integrated disease management trial involving rhizome solarization as well as bacterial consortium resulted in higher yield of rhizomes with less of soft rot incidence. In order to meet the requirement of bulk treatment of rhizomes for disinfection, rhizome solarization methodology was modified wherein the bulk of the rhizome material was spread on to the polythene sheet (100-200kg) directly under sunlight. The rhizomes were covered with another sheet of polythene sheet and the borders were sealed with wet soil or mud. The lethal temperature for *Ralstonia solanacearum* was achieved within 60 minutes when the rhizomes were exposed from 12:00 noon onwards which recorded a temperature of 46-47°C for about 30 minutes. This methodology is easy and can accommodate large volume of rhizome material for heat treatment at a time. Hence the large-scale adoption of rhizome solarization by the farming community was made possible. The solarized rhizome recorded higher germination and yield when compared to unsolarized rhizomes. With regard to disease, bacterial wilt was very negligible in the field where only one clump in the untreated control recorded bacterial wilt.

Effect of integrated rhizome solarization and bacterial treatment on germination and yield of ginger.

Treatment	Germination (%)			Yield (kg/bed of 3x1m²)		
	Solarized (45-47°C/ 30min)	Unsolarized (29°C)	Mean	Solarized (45-47°C/ 30min)	Unsolarized (29°C)	Mean
Bacterial consortium 1	94.0	88.3	91.2b	9.1	10.1	9.6a
Bacterial consortium 2	96.1	91.6	93.8ab	9.9	8.8	9.3ab
Bacterial consortium 3	86.7	88.3	87.5c	7.7	7.2	7.5c
Bacterial consortium 4	93.8	96.7	95.2a	8.3	8.7	8.5ab
Bacterial consortium 5	92.9	92.0	92.5ab	8.9	7.8	8.3b
Trichoderma harzianum as soil drench	94.0	88.3	91.2b	10.1	8.2	9.2ab
Mean	92.9	90.9	91.9	9.0	8.5	8.7

- Data with same letter designation are not different according to posthoc test at 95% confidence level
- Bacterial consortium was applied three times at monthly interval from planting onwards.
- Only one clump in the untreated plot recorded bacterial wilt during the entire season
- In general, incidence of soft rot was very meagre. Stray incidence of leaf spot and high incidence of shoot borer was recorded.

Rhizome solarization for bulk of seed rhizomes

*Rhizomes covered with the polythene sheet and edges sealed. After achieving 48°C the rhizomes are to be removed from polythene sheet quickly

4. MANAGEMENT OF RHIZOME SCALE

The rhizome scale *Aspidiella hartii* is the most serious insect pest of ginger during storage. Efforts are on to develop an integrated strategy for the management of the pest adopting chemical methods besides use of plant products as storage materials.

Development of IPM schedules

Dried leaves of *Strychnos nux-vomica* and *Glycosmis cochinsinensis* that were promising as storage materials for the management of rhizome scale of ginger were evaluated alone and along with sawdust (1:1 proportion) after dipping of seed rhizomes in quinalphos 0.075%. The trials indicated that storage of seed rhizomes in S. nux-vomica and sawdust in 1:1 proportion was more effective for obtaining a higher recovery of rhizomes (74.5%), whereas, storage in *S. nux-vomica* alone resulted in higher number of sprouts (60.5 sprouts per 1000 g) and lower population of rhizome scale (0 rhizome scale population).

5. MANAGEMENT OF SHOOT BORER

The shoot borer *Conogethes punctiferalis* is the most serious insect pest of ginger in the field. Efforts are in progress to identify sources of resistance against the pest and to validate the integrated technology developed for the management of the pest.

Identification of sources of resistance

Five hundred and fifty five accessions of ginger available in the Germplasm Conservatory maintained at Experimental Farm, Peruvannamuzhi, were screened to identify sources of resistance against the shoot borer. One accession was free of pest infestation on the pseudostems; four accessions had less than 5% infestation on the pseudostems and the percentage of incidence on the pseudostems in the remaining accessions ranged from 5.1% to 35.3%.

Validation of IPM technology

An integrated technology developed earlier for the management of shoot borer of ginger involving pruning and destruction of infested shoots at fortnightly intervals during June-July and spraying of malathion 0.1% at monthly intervals during August-September was validated at IISR Farm, Peruvannamuzhi. The trials indicated that the incidence of shoot borer was lower in the integrated and chemical methods of management (4.7% and 4.6%, respectively) when compared to control (11.9%). However, the yields were only marginally higher in the plots where the integrated method (4.8 kg/bed of 3 x 1 m) and chemical method (4.6 kg/bed of 3 x 1 m) was adopted compared to control (4.5 kg/bed of 3 x 1 m)

6. MANAGEMENT OF NEMATODES

Root knot nematodes are prevalent in all ginger growing tracts. Being an annual cash crop, application of pesticides is not advisable, which necessitates development of alternate ecologically sound nematodes control.

Host resistance

Forty-eight ginger 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. However, none of these accessions were superior to the control in yield in spite of their resistance to root knot nematodes

Biological control of nematodes

Ten promising isolates of rhizobacteria (IISR 6, IISR 13, IISR 51, IISR 522, IISR 658, IISR 853, IISR 859 &

IISR 866; LS 149 & LS 151) were evaluated in a field trial using ginger (*cv. Himachal*). The bacterial suspension ($1x10^{10}$ cfu/ml) multiplied on nutrient broth, was drenched @ 2.5 l / bed twice, immediately after sowing and after two months. None of the isolates significantly improved the yield of ginger.

7. QUALITY EVALUATION

Among the nineteen ginger accessions evaluated, oil content ranged from 1.3 to 3%, oleoresin 3.4 to 8.7% and crude fibre 2.4 to 7.0 %. *Acc. 694, 695, 633, 632* and *630* had oleoresin above 8.0 % and crude fibre above 5.0%. Statistical analysis indicated a positive correlation between oleoresin and crude fibre content and negative correlation between crude fibre, carbohydrate and starch.

Simple correlation coefficients between ginger quality parameters

	Oil	Oleoresin	Crude fibre	Carbohydrate
Oleoresin	0.817**			
Crude fibre	0.459*	0.746**		
Carbohydrate	-0.401	-0.656**	-0.784**	
Starch	-0.206	-0.397	-0.640**	0.807**

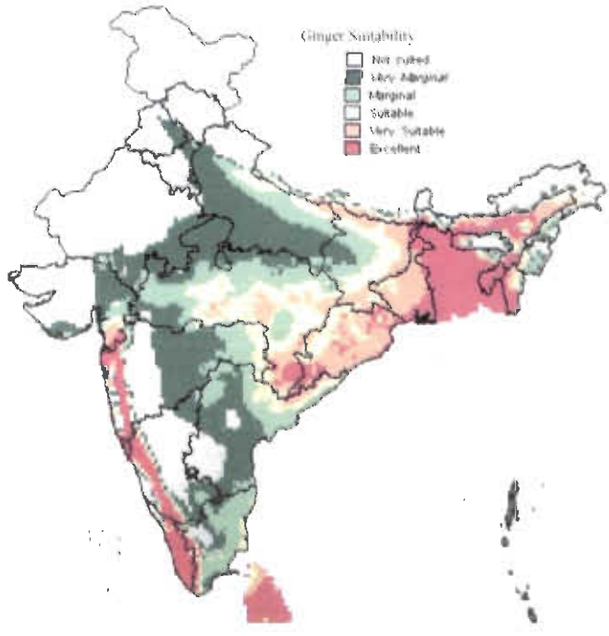
** P< 0.01; * P< 0.05

8. CROP-WEATHER RELATIONSHIP

GIS studies

GIS methodology helps to interpolate areas with the highest probability of varietal diversity or suitability of cultivation.

When rainfall is considered, the whole Kerala, Mizoram, Nagaland, Meghalaya, Sikkim and North Bengal and Orissa are very suitable but Karnataka, Maharastra and Arunachal Pradesh are only partly suitable. The Eco-crop model for crop suitability drawn with DIVA-GIS showed that Kerala, Mizoram, Manipur, western part of Karnataka and Maharashtra are excellent for ginger cultivation whereas Orissa, West Bengal, Meghalaya, Assam are very suitable. Suitability is marginal in case of Tamil Nadu and Gujarat.



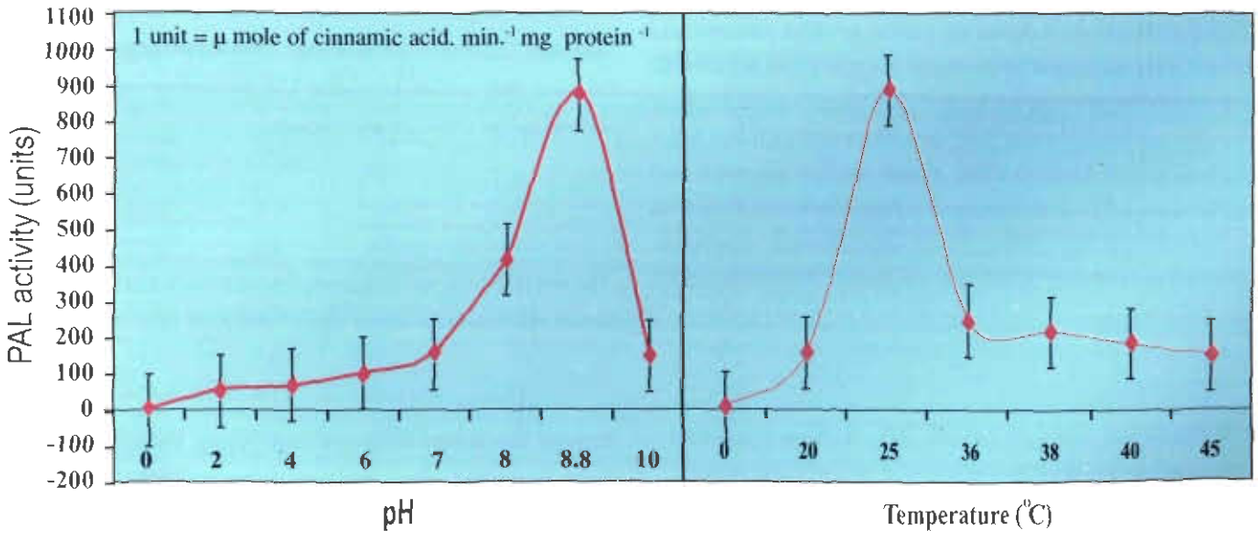
Eco-crop model of ginger showing environmental suitability of ginger cultivation drawn with DIVA-GIS.

C. haritha. Turmeric DNA bank with 232 samples was established at IISR. Forty-five turmeric samples were evaluated for oil, oleoresin and curcumin content. Oil content ranged from 2.8 to 8%, oleoresin 8.5 to 14.4% and curcumin 1 to 5.9%.

Density gradient centrifugation using sucrose could locate PAL in the different sub fractions of microsomal particles *viz*., endoplasmic reticulum and plasma membrane. PAL could be purified to 157 fold from the crude extract of turmeric leaves after $(NH_4)_2SO_4$ precipitation and two chromatographic steps followed by column chromatography

Eleven accessions from Arunachal Pradesh and Kerala were added to the germplasm repository, increasing the total number of accessions to 936. The ones from Kerala were identified as *Curcuma aromatica* and

Substrate concentration: K_m value for the reaction-involving PAL was estimated to be 0.33 by drawing a double reciprocal plot with 1/v versus 1/s, as the slope of tangents to the curve.



Effect of temperature and pH on PAL activity

Temperature and pH: Effect of temperature on the activity of enzyme showed maximum activity at 25°C ambient (888.9 x 10^{-2} units). Regarding pH, the maximum activity of PAL was seen at pH 8.8, with 876 x 10^{-2} units.

Effect of inhibitors: Phenolic acids and their analogues could inhibit PAL activity with molarities ranging from 0.03 to 1.0. Trans- cinnamic acid (1M) reduced the activity to near zero levels. Partial inhibition in enzyme activity was seen at lower concentrations. In contrast to cinnamic acid, ferulic acid and coumaric acid did not completely abolish the activity. However, exogenous addition of chlorogenic acid gave complete inhibition at all moralities tested.

Turmeric was grown organically and compared with integrated and chemical method of production. In organic farming, nutrition was supplemented by applying FYM, vermi-compost, ash and rock phosphate. Disease management was attempted by *Trichoderma* and *Pseudomonas* sp. as bio control agents for rhizome rot. Turmeric (var. *Alleppey*) has recorded a mean yield of 15.5 kg/ 3 m^2 under organic cultivation with a reduction of 15.3% and 22.7% rhizome yield as compared to the conventional and integrated systems, respectively.

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 turmeric. The soil and leaf P/Zn ratios observed in turmeric ranged from 0.7 to 6.87 and leaf P/Zn ratio from 63.2 to 129.4. Significantly highest rhizome yield of 21.6 kg bed^{-1} was observed with one foliar application of Zn @ 0.25%, which was on par with soil application of Zn (20.9 kg bed^{-1}). Application of P had no influence on the yield. Yield also showed a positive correlation with leaf P/Zn and a negative correlation with soil P/Zn ratio.

Rhizome rot affected turmeric samples were collected from Kumaraganj (UP), Medak (Andhra Pradesh) Sikkim, Gudalur (Tamil Nadu), Satara (Maharashtra). Pathogen causing soft rot of turmeric (Maharashtra sample) was identified as *Pythium myriotylum*.

Turmeric (*Curruma longa*) was found to be a host for ginger strain of *R. solanacearum* under artificial inoculation.

Among the seven different endophytic bacteria isolated from turmeric, four isolates namely TEB (Turmeric Endophytic Bacteria) 19, TEB 45, TEB 46, and TEB 48 were found to have antagonistic effect against *Pythium*, *Fusarium* and *Rhizoctonia*.

Note

Turmeric was targeted with 15, 20 and 25 kg fresh yield for 3 m^2 area and yield realized was 26, 24.2 and 26.6 kg, respectively. The deviation from the fixed targets was +73, +21 and +6.3% respectively, with 34-48% increased yield over recommended fertilizer schedule.

Evaluation of rhizome rot part

The field trial on evaluation of rhizobacterial consortium for rhizome rot management of turmeric showed that the bacterial consortium 1 (19.3 kg/bed of 3x1m) and 4 (19.7 kg/bed of 3x1) are significantly superior to other combinations (15.1 - 17.6 kg/bed of 3x1m)with regard to yield. No rhizome rot incidence (except leaf spot disease) could be noticed during the period in the experimental farm.

5. NEMATODE MANAGEMENT

Root knot
growing
pesticide
development
control

Host resistance

Among the 51-germplasms accessions screened against *M. incognita*, 18 were resistant in the preliminary screening. Acc. 31, 35, 43, 54, 56 & 57 were subjected to final round of screening in microplots against root-knot nematodes. However, none of these accessions were superior to control in yield in spite of their resistance to root knot nematodes

Evaluation of nematode resistant turmeric germplasm accessions in micro plots

Acc. No.	Height (cm)	No. of Tillers	Yield (g/plant)	EMI**
Acc. 31	82.7^{b}	3.7^{b}	549.7^{a}	1.2
Acc. 35	89.4^{b}	4.6^{b}	542.2^{a}	0.2
Acc. 43	114.1^{cd}	4.4^{b}	637.5^{a}	0.2
Acc. 54	58.7^{e}	2.4^{e}	518.7^{a}	0.0
Acc. 56	106.9^{c}	4.4^{b}	646.9^{a}	1.0
Acc. 57	122.5^{d}	4.2^{b}	696.9^{a}	0.7
Prathibha (control)	113.0^{cd}	4.3^{b}	601.6^{a}	2.3

**EMI – Egg mass index (0 – 5 scale); Data with the same letter designation are not different according to DMRT at p=0.05%

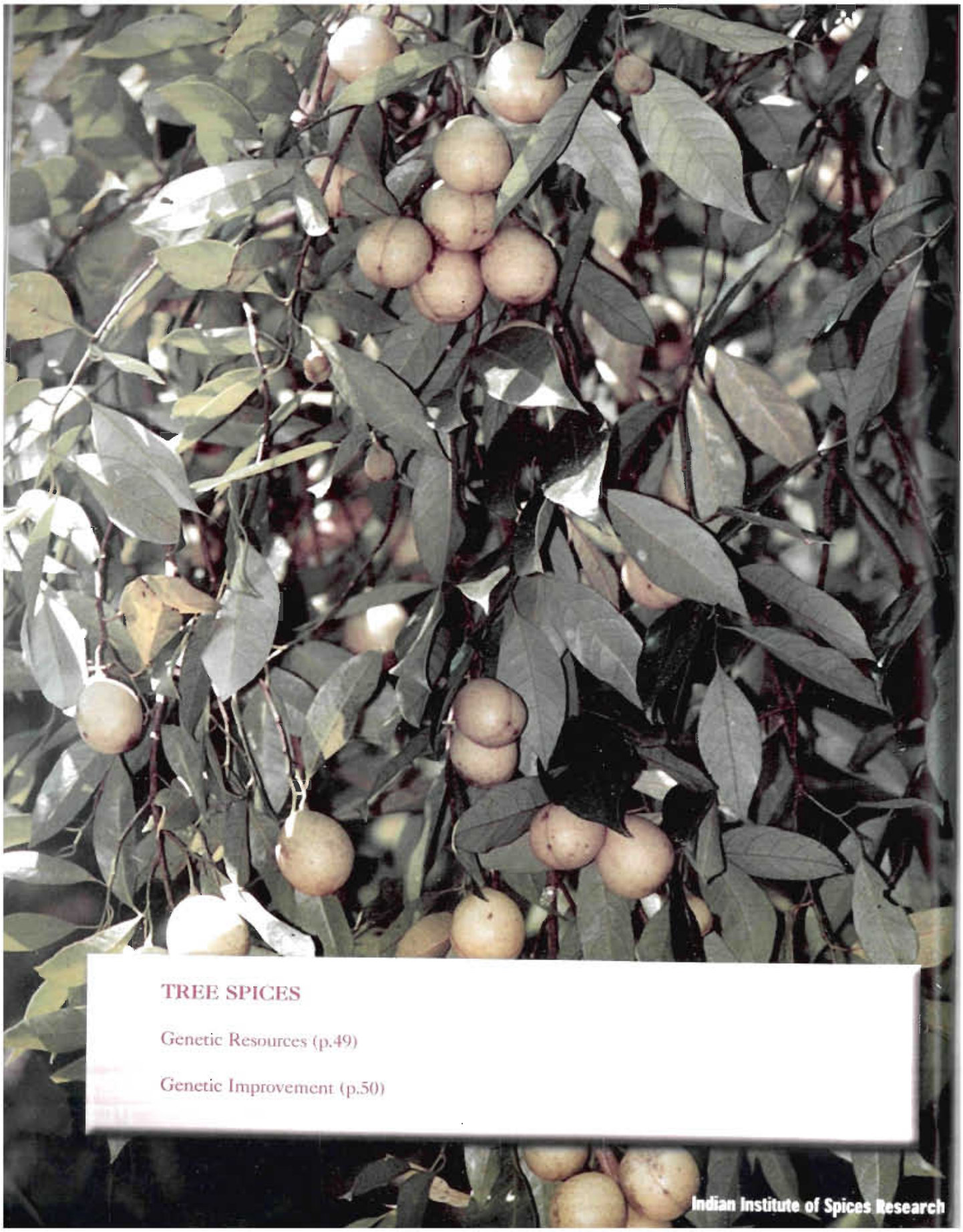
Nematodes

Ten promising isolates of rhizobacteria (IISR 6, IISR 13, IISR 51, IISR 522, IISR 658, IISR 853, IISR 859, IISR 866, LS 149 & LS 151) were evaluated in a field trial. The bacterial suspension ($1x10^{11}$ cfu/ml) multiplied on nutrient broth, was drenched @ 2.5 l / bed twice, immediately after sowing and after 2 months. Results showed that IISR 853 followed by LS.151 and IISR 6 gave the maximum yield.

Field evaluation of rhizobacteria in turmeric

Treatment	Germination (%)	Height (cm)	Tillers	Yield ($kg/3m^2$)
IISR 6	99.0^{ab}	1.55^{ab}	2.4^{b}	17.45^{ab}
IISR 13	100.0^{b}	1.55^{ab}	2.1^{a}	16.83^{ab}
IISR 51	100.0^{b}	1.70^{ab}	2.1^{a}	15.26^{a}
LS 149	100.0^{b}	1.68^{ab}	2.2^{ab}	16.70^{ab}
LS 151	99.5^{ab}	1.66^{ab}	2.1^{a}	17.66^{ab}
IISR 853	98.1^{a}	1.80^{b}	2.3^{ab}	20.25^{b}
IISR 859	99.5^{ab}	1.47^{ab}	2.1^{a}	16.30^{ab}
IISR 866	99.5^{ab}	1.44^{ab}	2.2^{ab}	15.72^{ab}
IISR 522	99.5^{ab}	1.38^{a}	2.3^{ab}	16.66^{ab}
IISR 658	100.0^{b}	1.50^{ab}	2.2^{ab}	15.72^{ab}
Control	99.4^{ab}	1.55^{ab}	2.3^{ab}	16.00^{ab}

Data with the same letter are not different according to DMRT at p=0.05%



TREE SPICES

Indian Institute of Spices Research

TREE SPICES

1. GENETIC RESOURCES

Tree spices are unique group of spices that can be grown along with other spice crops in a mixed cropping system. The major tree spices growing areas in India were surveyed and collections of cinnamon, clove, nutmeg, garcinia and allspice were made to conserve the biodiversity in these crops. At present the germplasm holdings of tree spices consists of 484 *Myristica*, 408 *Cinnamomun*, 233 *Syzygium*, 86 *Garcinia* and 2 *Pimenta* accessions. The germplasm collection include high yielding, high quality indigenous and exotic germplasm, wild and related species, endangered species and accessions with unique characteristics.

During the year, twenty-five accessions belonging to *Garcinia*, *Cinnamomum* and *Myristica beddomeii* were collected from Karnataka and Kerala. A clove (*Acc. 197*) with dwarf and bushy canopy has been registered (Reg. number INGR 04112) with NBPGR, New Delhi.

CASSIA

Among the four elite lines evaluated for plant height, number of main, harvestable and side branches, canopy size, stem thickness at 30 cm above ground level, yield per plant and percentage recovery of bark, the line C_1 showed significant difference for number of main and harvestable shoots whereas D_3 recorded the highest fresh (694g/ plant) and dry bark yield (219 g/plant). In another trial at Calicut, 10 accessions when coppiced after five years of growth revealed that fresh bark yield/plant ranged from 208-1078g; dry bark yield/plant from 82.5-475 g; bark oil from 3.0- 5.0%, leaf oil from 0.09-0.39% and bark oleoresin from 6.8-10.7%. *C-5* was the best among these with good yield (475 g of dry bark/plant), oleoresin (10.7%) and bark oil (5.0 %).

NUTMEG

Nine of the 106 accessions of nutmeg evaluated were found promising. The fruit yield per plant was in the range of 558-933. Among the accessions *A9/18* with 933 fruits per tree was found to be the best. Evaluation of clones of elite lines for morphological characters indicated that *A4/22* recorded the maximum height (179 cm) in the fourth year.

A promising nutmeg Acc. A9/18

GARCINIA

Soft wood grafting was standardized on 9-month-old *G. xanthochymus* rootstocks with 90% success. Grafts have a compact plant type and bear fruits at an early age. Preliminary field evaluation revealed that grafted plants flowered within two to three years after grafting, while seedling trees did not flower even seven years after planting.

Growth observations of seven year old Garcinia xanthochymus *seedlings* and in situ grafts*

Character	Plant type	Mean (cm)	Standard Deviation	Standard Error	Coefficient of Variation (%)
Height	Seedling	276.0	72.06	29.42	26.11
	Graft	184.0	17.72	7.23	9.63
Width	Seedling	195.0	49.89	20.37	25.58
	Graft	164.0	28.53	11.64	17.39
Girth	Seedling	6.0	1.53	0.62	25.58
	Graft	3.9	1.35	0.55	34.45

*Seedlings from District Agricultural Farm, Taliparamba

Fruit and seed characters G. xanthochymus

Character	Minimum	Maximum	Mean	Standard Deviation
Weight of fruit (g)	35.0	54.0	47.25	8.381
Length of fruit (cm)	3.9	4.7	4.42	0.359
Width of fruit (cm)	4.0	5.0	4.62	0.478
Number of sepals	5.0	5.0	5.00	0.000
Length of peduncle (cm)	3.9	4.5	4.17	0.275
Length of seeds (cm)	2.4	2.7	2.52	0.150
Width of seeds (cm)	1.3	1.8	1.52	0 .263

2. GENETIC IMPROVEMENT

Improved varieties of tree spices are mainly developed through selection from the germplasm accessions. IISR, has developed and released two varieties of cinnamon and one variety of nutmeg.

NUTMEG

Budding and grafting in nutmeg

Since *Myristica fragrans* is not compatible with *Knema andamanica*, bridge-grafting method was adopted using *K. andamanica* as rootstock on which *M. beddomeii* or *M. malabarica* were grafted by 'approach grafting', where 80 to 90% union was observed after one month. The successful graft union will be used for grafting *M. fragrans*. Chip and patch budding of nutmeg on three different rootstocks *viz*., *M. fragrans*, *M. malabarica* and *M. beddomeii* using buds from orthotropic shoots gave about 30-40% success.

Evaluation of grafts

A field trial involving three different rootstocks viz; *M. fragrans*, *M. malabarica* and *M. beddomeii* grafted with two different scions (*A9-4* and *A9-69*) at a spacing of 4.5 m x 4.5m was laid out for evaluating them for drought tolerance. The vegetative growth of the two-year-old grafts was relatively better on *M. beddomeii* rootstocks as compared to other rootstocks. Morphological and yield attributes of four year old grafts indicated higher rare of growth in grafts on *M. beddomeii* root stock, while early flowering was observed in grafts on *M. malabarica* rootstock. Among the scions, vegetative growth was more on *A9-69* scions and flowering was observed on *A9-4* scion.

Tissue culture in nutmeg

Callus induction could be achieved in nutmeg from mace explants. However, the bud break could be observed only with nodal explants.

Molecular profiling of IISR Viswashree and its progenies

RAPD based molecular profiling of elite nutmeg variety *IISR Viswashree* and its clonal, seedling and male sibling progenies could clearly distinguish clone number 16 of *Viswashree* from the mother and other clones and seedlings. Several amplicons (16) could clearly distinguish clones and seedlings. The JSI values ranged from 0.73 to 1.00, which showed close relatedness among the plants since the group consisted of clones and seedling progenies of the same mother plant. At a similarity index of 0.96 three groups could be distinguished, the first comprising of all the clones, mother and a seedling progeny, the second comprising of four seedling progenies and third consisting of the male sibling. Male associated loci of 200 bp with primer OPA 05 and another 276 bp with primer OPC 16 was observed in the study.

CLOVE

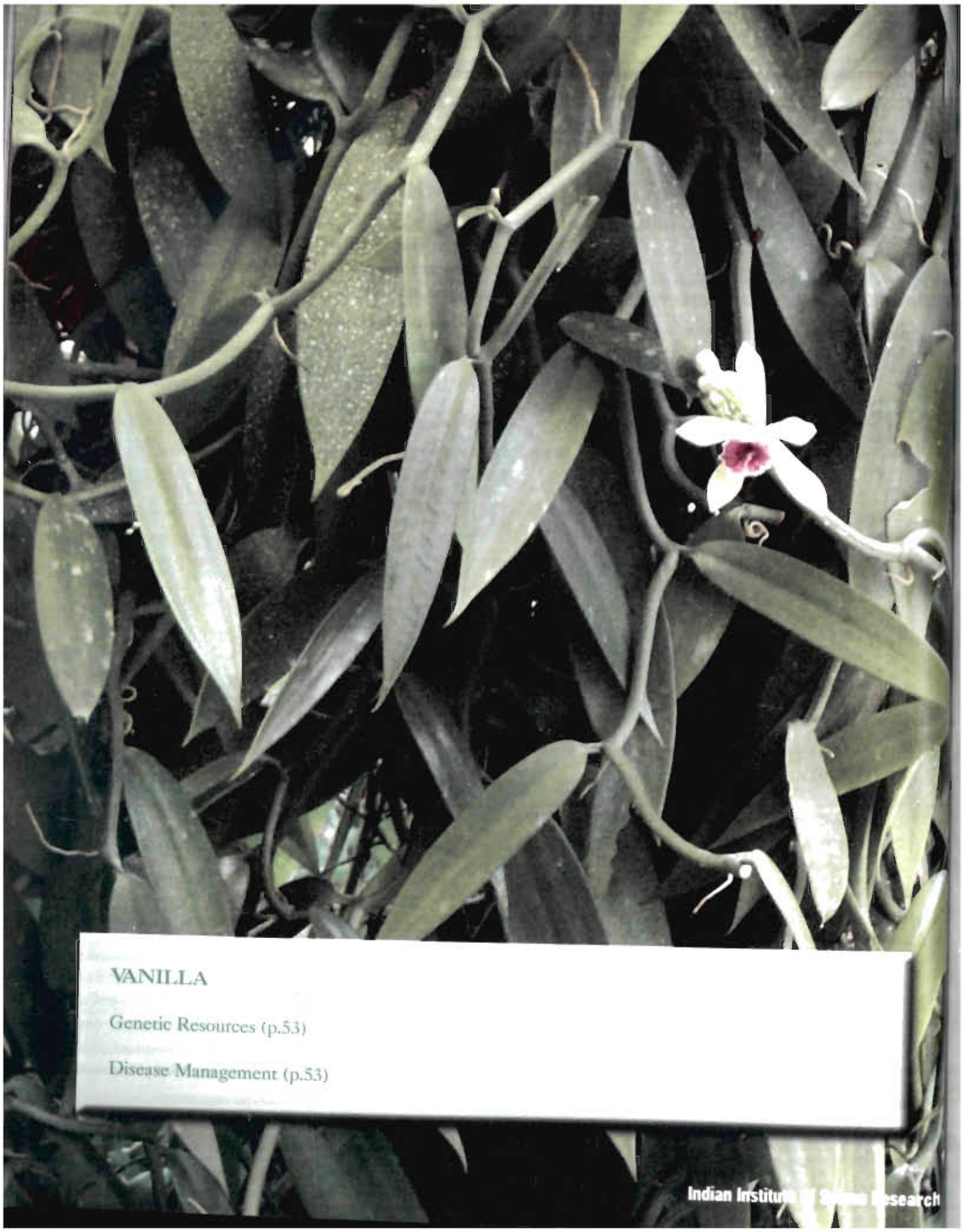
Grafting in clove

Bridge grafting was adopted to circumvent the incompatibility of *Syzygium caryophylllatum* and *S. aromaticum*, where *S. heynianum* was used as a compatible interstock for clove. Zanzibar clove, a high quality exotic accession, has been approach-grafted onto normal clove and *S. heynianum* for multiplication. Forty-three clove samples were evaluated for oil. Some of the accessions with more than 18% oil content are *K-7*, *K-9*, *B-2* and *B-95*.

GARCINIA

Preliminary studies on softwood grafting of *G.gummi-gutta* and *G indica* on *G.cowa* gave 95% and 45% union after three months.

Nut and Mace : Twin products from nutmeg



VANILLA

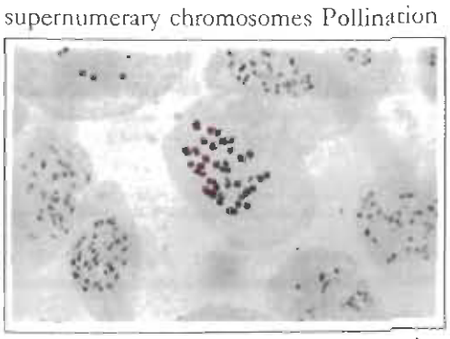
Indian Institute of Spices Research

VANILLA

1. GENETIC RESOURCES

Vanilla (*Vanilla planifolia* Andrews), the 'Prince of spices' has gained importance in the recent years. Vanilla is highly suitable for cultivation as an intercrop in heavily shaded plantations and is widely cultivated in southern states such as Karnataka, Kerala and Tamil Nadu. Genetic variability of this crop is very limited. The crop improvement research aims at conserving the existing variability through collections as well as inducing new variability through seedling progenies and *in vitro* mutagensis.

Ten accessions were collected after surveying Sakhleshpur, Mudigere (Karnataka) and Calicut (Kerala). Eighty-two accessions comprising seven species are being maintained. Cytological studies of *V. andamanica* (collection no. *4708*) revealed 2n=40, but chromosome number differs in different cells of the same accession with occasional presence of supernumerary chromosomes Pollination studies indicated that white and pink flowered varieties of *Vanilla andamanica* were self and cross compatible besides showing compatibility with *V. planifolia*.



Mitotic metaphase of V.andamanica showing 2n = 40

2. DISEASE MANAGEMENT

The area under vanilla is on the increase and it is being cultivated in various ecological conditions. New diseases such as immature bean shedding, brown spots, anthracnose and few viral diseases are taking heavy toll in many farm holdings.

Etiology of brown spot of vanilla

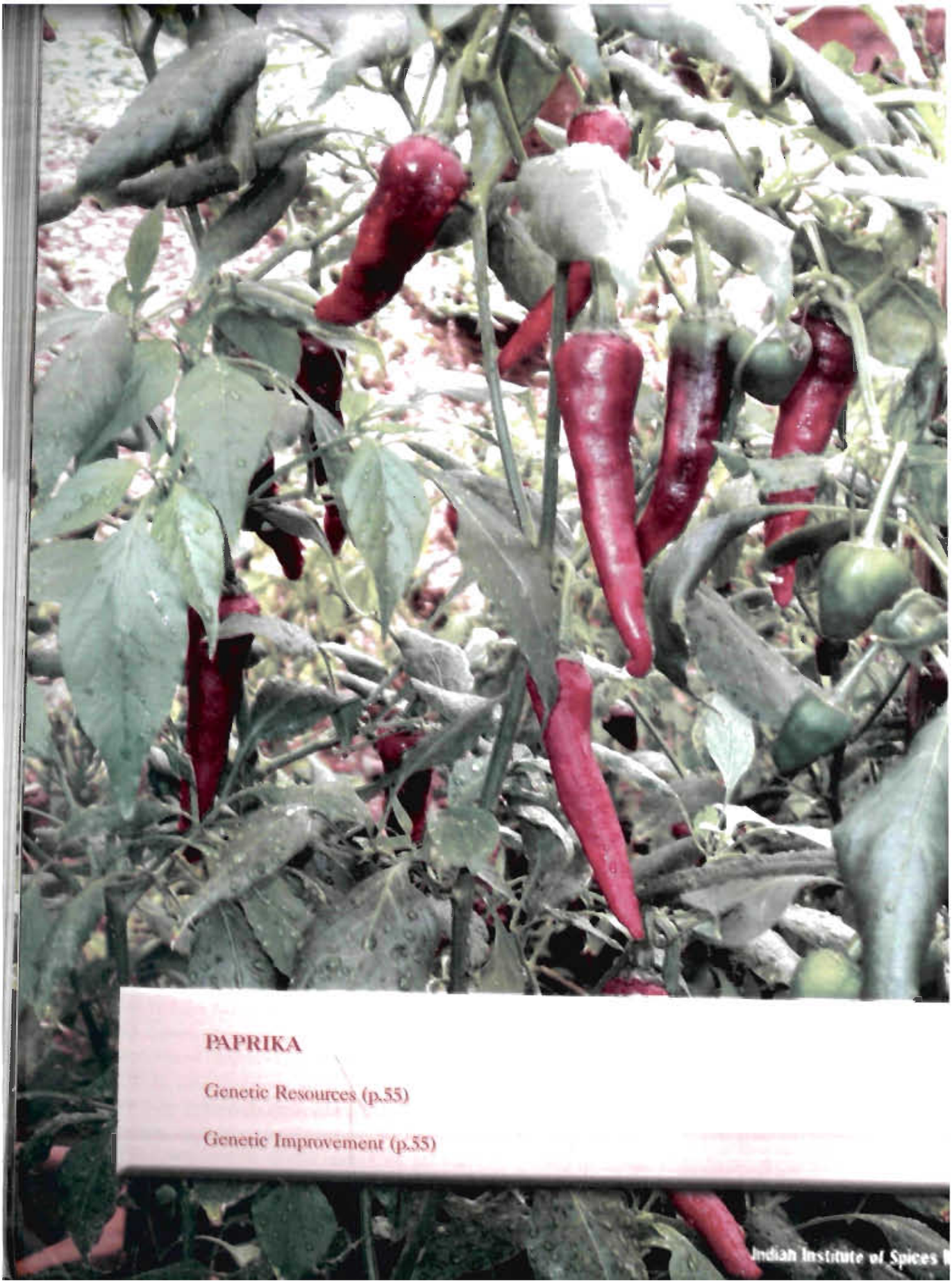
A new disease on vanilla characterized by brown spot on the bean was identified as caused by *Cylindrocladium quinqueseptatum*.

Immature bean shedding

The major predisposing factors in bean shedding appear to be temperature and humidity. In order to develop a management strategy a field trial was laid out in three vanilla plantations in Calicut district to study the effect of fungicides in controlling diseases under two irrigation systems *viz.* mist and sprinkler. Six fungicides *viz.* Carbendazim (Bavistin-0.2%), Mancozeb (Indofil M45, 0.2%), Zineb (Indofil Z-78, 0.2%), Thiophanate methyl (Roko ,0.2%), Bordeaux mixture 1% and Carbendazim-mancozeb (Staff, 0.2%) were used. Quinalphos 0.05% was sprayed to all the treatments uniformly. Two sprays were given at one month interval in February and March. The disease incidence was observed before and after spraying fungicides. The results indicated that bean shedding was comparatively less under sprinkler irrigation.

Identification and characterization of Cucumber mosaic virus

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.



PAPRIKA

PAPRIKA

GENETIC RESOURCES

Paprika is the most sought after spice for its colour components, capsorubin and capsanthin, which has industrial potential as natural coloring agents. Varieties with high colour with low pungency are being developed through introduction of exotic lines besides breeding efforts

Sixteen accessions including 11 indigenous and five exotic types were collected and 63 accessions consisting 36 indigenous and 27 exotic types are being maintained in the germplasm collection.

Evaluation of exotic paprika accessions

Yield of exotic accessions varied from 203-1112g. Weight of seeds per fruit ranged from 0.35-1.72 g. Colour value ranged from 94 to 331 ASTA units and capsaicin ranged from 0.0065% to 0.103%. *ICBD-10* and *Kt-Pl-19* were found promising for yield and quality.

Evaluation of indigenous accessions

Evaluation of 18 lines indicated that yield per plant ranged from 206-999g. Weight of seeds per fruit varied from 0.650-1.696g. Colour value ranged from 60-356 ASTA units, whereas capsaicin ranged from 0.0056% to 0.101%. *EC-18* was found promising with high yield (1 kg/plant) and colour (251.7 ASTA units).

GENETIC IMPROVEMENT

Identification of paprika for quality.

The programme is aimed to identify paprika lines with high colour and low pungency and also to study the effect of storage on colour value. Among the chilli samples from *Srinagar* and *Bydagi*, *SH- KC-19* contained 343 ASTA followed by *SH-KC-20* with 306 ASTA units. Pungency value ranged from 0.4 to 1.15%.

SOIL QUALITY IN SPICE BASED CROPPING SYSTEMS

A yardstick to quantify the extent of deterioration of soils under spice based cropping systems is not available. This is important to determine the physico-chemical, biochemical and microbial characteristics of soils associated with spice based cropping systems and to integrate the most sensitive parameters into an index for rapid and precise estimation of soil quality.

Soils were collected from different cropping systems involving spices at 0-15 and 15-30 cm depths from Kerala and Karnataka and analyzed for their physico-chemical characteristics (pH, OC, N, P, K, Ca, Mg, Zn, Cu, Fe, Mn) and biochemical characteristics (Acid-phosphatase, Alkaline-phosphatase, Inorganic pyrophosphatase, CM-cellulase and BAA-protease). Soil pH showed little variation (4.36-5.73) between the sites and depths while the levels of macro-, secondary- and micronutrients 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} respecrively. 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 levels of organic C were relatively higher in the 0-15 cm layer compared to the 15-30 cm layer. The levels of both secondary (Ca and Mg) and micro-nutrients (Zn, Cu, Fe, Mn) also followed a similar trend. The 0-15cm layer exhibited consistently higher levels of acid-phosphatase, alkaline-phosphatase, inorganic pyrophosphatase and BAA-protease as compared to the 15-30 cm layer, possibility reflecting the concomitant changes occurring in the levels of available soil organic matter, nutrients and substrates.

KRISHI VIGYAN KENDRA

TRAINING PROGRAMMES

The Kendra has conducted 112 training programmes on various subjects during the period under report. A total of 3271 persons have benefited out of the programmes. The details of the training programmes are furnished below.

Training programmes conducted during the year 2004-'05

Category	No. of courses	No. of participants			No. of SC/ST
		Male	Female	Total	participants
Practising farmers	96	1704	979	2683	214
Rural youth	12	348	154	502	81
Extension functionaries	4	65	21	86	10
Total	**112**	**2117**	**1154**	**3271**	**305**

Discipline-wise training programmes conducted

Category	No. of courses	No. of participants			No. of SC/ST
		Male	Female	Total	participants
Crop Production	54	961	530	1491	78
Horticulture	19	356	166	522	44
Plant Protection	2	56	16	72	2
Animal Science	23	473	290	763	114
Fisheries	2	58	12	70	7
Home Science	2	-	47	47	29
Others	10	213	93	306	31
Total	**112**	**2117**	**1154**	**3271**	**305**

A training programme in progress

Long duration vocational training programmes

The Kendra has conducted two long duration vocational training programmes for rural youth in two topics: 'Repair and maintenance of farm implements' and 'Tailoring'. The programmes were of three months duration. The programmes were organised in collaboration with the Government Community Polytechnic College, West Hill, Calicut. A total of 90 unemployed rural youth have benefited out of the trainings.

Revolving fund programme

The Kendra has a strong revolving fund programme to generate income for productive uses. Under this programme, quality planting materials of various crops were produced and made available to public at affordable

rates. At present, allspice seedlings, coconut seedlings, Japan wood *(pathimukam)* seedlings, bush pepper plants, garcinia graft, mango graft, guava layer, arecanut seedlings etc. are available for sale.

During the period an amount of Rs. 2.44 lakh has been realised through sale of planting materials, mushroom spawn, *Trichoderma*, chicks and the activities of Plant & Animal Health Centre.

The Kendra operated a Plant and Animal clinic offering various services to the farmers. An artificial insemination facility is also maintained at the centre to upgrade the genetic stock of livestock. The centre offered consultation, treatment and doorstep services charging nominal fee. In addition to the various treatments, the centre also provided vaccination facility and organised animal health camps in association with the state animal husbandry department. The various activities taken up by the Clinic during the period are as follows:

1) Consultancy/advisory/home service carried out : 477
2) Artificial insemination carried out : 264
3) No. of Animal health campaign/infertility camp : 6
4) Vaccination of poultry birds and animals : 700

Other extension activities

1. KISAN MELA AND EXHIBITIONS

During the period under report, KVK has participated in the following exhibitions/Kisan melas.

a) at Chelari, Calicut from 20.11.04 to 22.11.04 in connection with Kudumbasree Vilpana Mela.
b) at Pune from 15.12.04 to 19.12.04 in connection with Kisan 2004 Exhibition.
c) at Calicut from 9.2.05 to 14.2.05 in connection with Calicut Flower show 2005.
d) at Bangalore from 22.3.04 to 23.3.04 in connection with Regional Kisan Mela cum Exhibition on horticulture 2005.

2. FARMERS' STUDY TOURS

Six study tours were arranged for the farmers during the period. As many as 135 famers participated in this programme

3. SEMINARS ORGANISED

The Kendra has conducted 6 district level seminars. The details are furnished below:

Sl. No.	Title	Date	Place	No. of participants
1.	Vanilla cultivation and processing	19.08.04	KVK, Peruvannamuhi	75
2.	Bee keeping	25.08.04	KVK, Peruvannamuhi	95
3.	Organic farming	15.09.04	Calicut	257
4.	Block rubber production technology	18.09.04	KVK, Peruvannamuhi	87
5.	Organic farming	18.12.04	KVK, Peruvannamuhi	76
6.	Anthurium cultivation and marketing	22.12.04	IISR, Calicut	125

Demonstration units:

The following demonstration units are maintained by the KVK.

a) Medicinal plant unit
b) Model Homestead garden
c) Demonstration plot of improved varieties in black pepper
d) Model arecanut seed garden
e) Cashew scion bank
f) Nutmeg scion bank
g) Guava block
h) Sapota block
i) Vanilla block
j) Poultry demonstration unit
k) Mushroom spawn production unit
l) Mango scion bank

KVK

OTHER ACTIVITIES

i) **Establishment of soil, plant and water testing laboratory:** A soil, plant and water testing laboratory at a total cost of Rs. 11.8 lakhs was established at KVK.

ii) **Collaborative activities:** KVK is conducting its many mandatory activities in association with NGO's such as Centre for Overall Development (COD), The Vikas Volunteer Vahini club (VVV), INFAM etc.

TECHNOLOGIES TRANSFERRED

a) FLD Programme

This is a new concept of field demonstration and the main objective is to demonstrate newly released crop production and protection technologies and its management practices in farmer's fields under different agro-climatic regions and farming situations. In this programme, technologies were demonstrated for the first time by the scientists themselves, before being fed into the main extension system of State Department of Agriculture. These programmes were carried out with the co-operation and complete participation of progressive farmers under the direct supervision of KVK scientists. A part of the expenditure of this demonstration is met by KVK. The various FLD programmes conducted by the Kendra during the period are detailed below:

1. Drought management in coconut gardens
2. High density planting of tissue culture Banana (var. Nendran)
3. Backyard poultry with commercial hybrid layer chicken, *Gramasree*

b) OFT Programmes

These programmes aim at testing the new technologies developed at research stations in the field of crop husbandry, horticulture, animal husbandry, fisheries, etc. to ensure their suitability and sustainability to the specific locations and to suggest or modify or refine the technology accordingly. This is done by testing a released technology in real farm situation with the participation of farmer. The problems faced by the farmer in the adoption of new technologies can also be fed back to the research stations by this programme. KVK bears the cost of critical inputs in this programme. The majot OFT programmes carried out during the period are listed below:

1. Effectiveness of *Pseudomonas fluorescens* in the management of fungal diseases of vanilla
2. Effectiveness of Paclobutrazol and pruning treatments in inducing flowering in clove.
3. Control of ectoparasite infestations in livestock and poultry

VISITORS

- A total of 747 farmers visited KVK during the period for consultation, purchase of planting materials and other inputs.
- Dr. Tsedeke Abate, Director General, Ethiopian Agricultural Research Organisation along with three senior officers visited KVK on 27.5.04.

Agricultural Technology Information Centre (ATIC)

The ATIC at IISR started functio-ning in the year 1999. As per mandate, the centre is involved in technology dissemination functions through a single window coordina ting with various divisions of IISR. The major activities of centre are summarized below.

- 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
- Organizing technology dissemination services like exhibitions, seminars to farmers and other users

Milestones and Achievements

The sale of technology inputs has been strengthened by distributing planting material, farm produce and bio inputs produced from all the centres under the institute including KVK. The pamphlets on package of practices of seven major spice crops have been up dated in line with the research achievements of the institute. A total revenue of Rs 171594 has been generated from the center during the period. This includes proceeds from planting material, publications, bio inputs and diagnostic services.

A total of 1463 visitors were benefited through advisory and diagnostic services. One video film on the services and achievements of the institute shot by the ASIANET was telecast through cable network. The leading farm journal of Malayala Manorama, "Karshakashree" covered a feature article about the research and services of the institute. The centre participated in four exhibitions; two within state and two outside. The centre also organized three farmers' seminars. The extension activities were regularly recorded and monitored over time to assess the impact of institute services.

From the secondary data recorded on the visit of farmers to the institute the pattern of advisory services delivered by the institute was detailed using frequency scores.

Pattern of advisory services

Purpose of visit	Frequency score
Planting material	81
Scientific information	108
Bio inputs	46
Diagnostic services	15
Publications	15

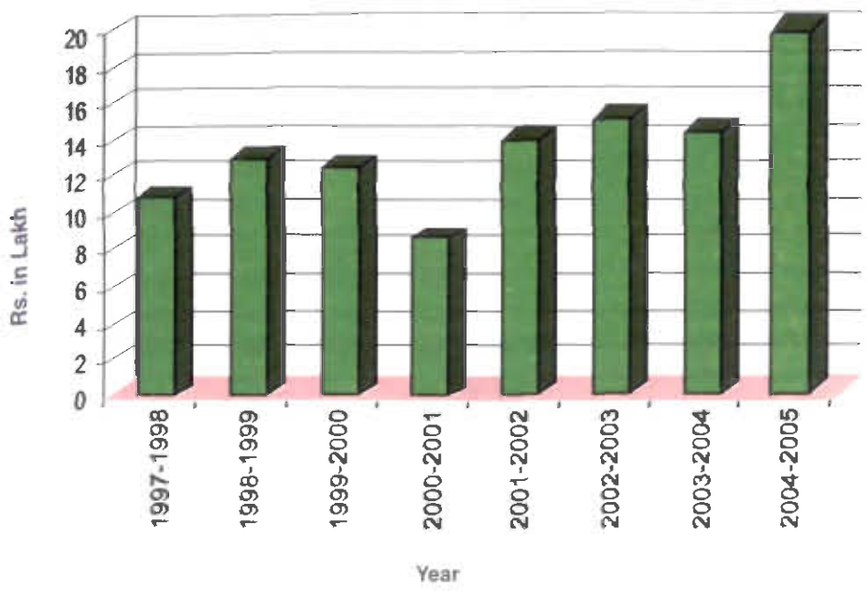
There has been a steady increase in the number of visitors to the ATIC, since inception. The data from IISR farm Peruvannamuzhi and KVK shows similar trend.

The recorded data showed thar there has been a steady increase in income generated through sales from ATIC, IISR farm and KVK as compared to previous 5 year plan period.

Training of research and extension personnel

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 line 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 and statistical applications in research and development. The details of training programme organized during the year 2004-05 are furnished below.

ATIC



Income generated at IISR during last eight years

TRAINING COURSES

Sl. No.	Title of the Course	Period	No. of Participants	Category
1.	Spices Production Technology	2 - 4 March 2004	20	Progressive farmers of Darjeeling, West Bengal
2.	Good Agricultural Practices for rural youth	24 - 27 April 2004	21	All Kerala.
3.	Vanilla Production Management	24 - 25 June 2004	29	Extension Officers of Coffee Board-Wyanad, Idukki and Palakkad.
4.	Pepper Production Management	15 - 17 July 2004	4	ATMA, NATP, Palampur.
5	Good Agricultural Practices	26 - 28 October 2004	21	Rural youth from Kerala, Tamil Nadu.
6	Spices Production Technology	2 - 4 December 2004	10	North Eastern States.
7	Ginger and Turmeric Production	3 -5 January 2005	6	Progressive farmers from Satara.

All the training programmes organized at the institute was evaluated to assess the effectiveness of the training using the following evaluation schedule

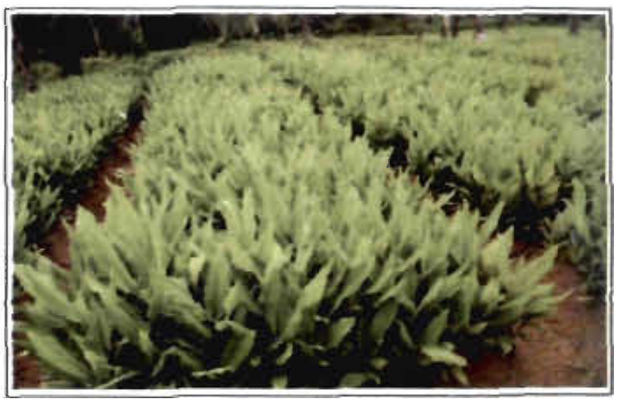
- Pre-training knowledge test
- Post-training knowledge test
- Gain in knowledge due to training- Paired t- test
- Training effectiveness index- 4 point continuum scale - Organizational effectiveness of training.
- Feed back by trainees

Central sector scheme - Technology Mission on Integrated Development of Horticulture in North Eastern States

A three day training programme on Production Management in Ginger, Turmeric and Tree Spices was organized at ICAR Research Complex for North East Hill Region, Barapani, Shillong during 15-17th March 2005 in which officers from Department of Horticulture representing four states participated. A team of six scientists from Divisions of Crop Production and Post Harvest Technology, Crop Improvement, Crop Protection and Social Sciences at IISR and scientists from ICAR station, Barapani acted as resource persons.

Integrated Programme for the Development of Spices (IPDS)

Non-availability of quality planting materials of elite lines in black pepper, ginger, turmeric, nutmeg etc are constraints in increasing the productivity. Efforts are made by IISR to supply nucleus-planting materials of released varieties to state departments for further multiplication and supply. Black pepper rooted laterals (20000), turmeric seed rhizomes (11 tonnes), ginger seed rhizomes (four tonnes), cardamom seedlings (5000 nos), cardamom suckers (1000 nos), cardamom capsules (20 kg) and nutmeg grafts (6500) were produced and distributed to farmers and other agencies in different states of Kerala.



Turmeric crops raised under IPDS for planting material

All India Coordinated Research Project on Spices (AICRPS)

The AICRPS is the largest network in the country in the spices research. At present 19 centres spread over in 15 states based at 15 Agricultural Universities are functioning under AICRPS. In addition, eight co-operating/voluntary centres including ICAR Research Complex, Gangtok for large cardamom are collaborating with this project. The budget of the project for the year 2003-2004 was Rs. 163.66 lakhs with Rs.123.00 lakhs as ICAR share.

The mandate of the project is to increase area, production and productivity of spices in the country through:

i) Evolving high yielding varieties with quality attributes, tolerant/resistant to pests and diseases for various agro-ecological situations

ii) Standardizing agro-techniques for spice crops under different agro-climatic conditions

iii) Evolving cost effective and efficient pest and disease management practices

iv) Working as interface between SAUs, IISR and ICAR.

About 120 research projects covering 12 spice crops are being operated at various centres under AICRPS. The project made several achievements during the year under report.

Genetic Resources

The AICRPS strengthened the genetic resources of spice crops and the germplasm was subjected to evaluation of various parameters. At present, the germplasm holdings of AICRPS centers consist of black pepper-550, cardamom-386, ginger-568, turmeric-1252, tree spices-170 and seed spices-3841. The promising lines/entries in each crop were identified for yield and quality parameters under CVT/IETs at various centers.

BLACK PEPPER

In biofertilizer trials of black pepper, application of 100% inorganic fertilizers alongwith *Azospirillum* 50 g/ P-solubilizers 50g has recorded highest yield (7.13 kg fresh vine^{-1} and 6.91 kg fresh vine $^{-1}$, respectively). In an organic farming trial, FYM 10 kg + burnt/smoked earth 10 kg gave the highest yield of 6.24 kg fresh vine $^{-1}$ at Sirsi Centre. At Panniyur, maximum spike yield was obtained with inorganic N 100% + *Azospirillum* 50 g/P-solubilizers 50 g + 10 kg FYM. However, in organic farming trial, recommended POP registered maximum spike yield (6.067 kg vine^{-1}). Spraying and drenching with Metalaxyl MZ 72 WP (1.25 g/l) @ 5 liters/vine alone and in combination with *T. harzianum* (50g) along with one kg neem cake per vine during the first week of June and September was found effective against *Phytophthora* disease in black pepper at Mudigere centre.

GINGER

In ginger, highest rhizome yield was obtained with recommended dosage of fertilizers (18.27 t ha^{-1}), followed by inorganic N (100%) + *Azospirillum* (50 g) + 5 kg FYM (12.70 t ha^{-1}) at Pottangi Centre. However, highest yield was obtained with inorganic N (100%) + *Azospirillum* (50 g) + 5 FYM (20.05 t ha^{-1}) at Raigarh and Pundibari centres. Application of FYM (10kg) + Pongamia oil cake (250 g) + Neem oil cake (250g) + sterameal (250 g) + Rock phosphate (250 g) + Wood ash (250g) per 3 m^2 bed gave maximum fresh yield (12.72 t ha^{-1}) at Dholi. Also soil application of zinc @ 10 kg ha^{-1} produced maximum yield (18.75 t ha^{-1}) at Dholi conditions.

TURMERIC

In turmeric, highest fresh rhizome yield was recorded with 100% N + 5g *Azospirillum* + 5 kg FYM, followed by recommended dose of fertilizers at Panniyur and Kumarganj centers. In turmeric, treatment of seed rhizomes with Mancozeb and carbendazim and 2-3 foliar sprays (0.2%) was found effective against leaf blotch and leaf spot diseases at Kumaraganj and Pundibari centers. In turmeric, application of NPK 125:60:90 kg ha^{-1} + FYM 10 t ha^{-1} + *T. viride* + *Pseudomonas fluorescens* @ 4g kg ha^{-1} as seed treatment + *T. viride* + *P. fluorescens* applied to soil (12.5 kg & 25.0 kg ha^{-1} as basal and top dressing, respectively) resulted in lowest rhizome rot incidence (11.70%) with higher yield (28.60 t ha^{-1}) at Jagtial Centre.

SEED SPICES

Nutritional Requirement for high yield in corriander

Application of 100% inorganic N (60 kg/ha) + *Azospirillum* (5 kg/ha as seed treatment) + FYM (5t/ha) gave maximum seed yield in seed spices at various centers. Application of $CuSO_4$ in soil (12.5 kg ha^{-1}) and foliar spray (0.25%) resulted in highest seed yield (1.94 t ha^{-1}) in coriander at Kumarganj centre.

Spraying of Neem seed kernel extract (NSKE) (5%) thrice, first spray immediately after the appearance of disease and second and third sprays at 15 days interval, thereafter was effective in checking the powdery mildew incidence in coriander at Coimbatore. Seed treatment with *P. fluorescens* @ 10 g kg^{-1} + soil application of *P. fluorescens* @ 5 kg ha^{-1} was found effective biocontrol agents against coriander wilt at Coimbatore Centre. In coriander, minimum wilt incidence (8.39%) with maximum seed yield (819 kg/ha^{-1}) was recorded with the application of *T. harzianum* through seed treatment and soil application at Jobner center. In a screening test against root rot, downy mildew and powdery mildew diseases in fenugreek, the entries, *UM-351* and *UM-3852* were recorded minimum incidences with maximum seed yield of 1944 and 1797 kg ha^{-1}, respectively. Soil application of *T. viride* (5 kg ha^{-1}) and neem cake @ 150 kg ha^{-1} was found effective in reducing root rot incidence in fenugreek at Coimbatore. Besides, the sources of resistance/tolerance against pest and diseases were identified.

Apart from this, 20 technologies developed under AICRPS were conducted at farmer's field as front-line demonstration trials by the 14 coordinating centers. Six ICAR ad-hoc schemes were also operated at SAUs/other organizations under AICRPS.

In the concluded Workshop of AICRPS, six entries/varieties namely *DH-246* in coriander, *RZ-223* in cumin, *HF-33* (Hisar), *GF-11* (Jagudan) and *RF-143* (Jobner) in fennel and *Rmt-305* (Jobner) in fenugreek of AICRPS centers; six varieties namely, *IISR-Thevam*, *IISR-Malabar Excell*, *IISR-Girimunda* and *IISR Shakti* in black pepper and *IISR-Kedaram* and *IISR-Alleppey Supreme* in turmeric of IISR, Calicut; five entries namely, *AN-01-1* in Nigella, *AD-01-43* and *AD-01-6* in dill, and *AA-01-61* and *AA-01-19* in ajowan of NRC Seed Spices, Ajmer were identified and recommended for state release.

Education and Training

The main functions of the HRD Cell include recommendation and deputation of staff for symposia/ training/summer institutes within India/abroad and study leave for Ph.D. Besides, Cell caters to the needs of research scholars working in schemes to do their Ph.D. IISR has been recognized as centre for Ph.D studies by Mangalore University, University of Calicut in all subjects and, by the Bharathiyar and Nagarjuna Universities in Botany and Biotechnology respectively. The cell also assists M.Sc and M Phil students to carry out their project work at the institute.

Postgraduate studies

Ph.D

Saju, K.A. Factors affecting the biological control of *Phytophthora capsici* infections in black pepper (*Piper nigrum* L.), University of Calicut, Calicut

Diby Paul. Physiological, biochemical and molecular studies on the root rot (caused by *Phytophthora capsici*) suppression in black pepper (*Piper nigrum* L.) by rhizosphere bacteria. University of Calicut, Calicut.

Minoo Divakaran. Seedling and somaclonal variation and their characterization in vanilla, University of Calicut, Calicut

Utpala Parthasarathy. A comparative study of coconut cultivation in coastal and inland river plain ecosystem of Kasaragod district of Kerala and Kamrup district of Assam, Gauhati University, Gauhati.

M.Sc

Twenty five students from various universities undertook their M.Sc project work in Biotechnology, Biochemistry, Microbiology and Plant Pathology under the guidance of the scientists of the institute.

Post M.Sc training

Four post M.Sc candidates under went hands on training in various techniques of Microbiology and Biotechnology.

Training/Meetings Organized by the Institute

- Computer training programme for Principal Scientists of the institute
- Basic computer training programme for technical and administrative staff of the institute
- Summer training programme on Techniques in Biochemistry and Biotechnology for M.Sc students
- Bioinformatics and Biotechnology – Applications in Agricultural Research.
- Workshop on 'Agri-Informatics 2004'
- Symposium on Spices and Aromatic Crops. (SYMSAC I)
- Training programme on adobe photoshop for research fellows working in the institute.
- Training programme on Instrumentation techniques for research fellows working in the institute.
- Good agricultural practices for rural youth.
- Vanilla production and management
- Pepper production and management
- Spices production technology
- Ginger and turmeric production

Workshop / Training Programmes Attended by Staff

Name	Training program/workshop	Institute	Duration
Dr M.Anandaraj	IPR in Biotechnology	National Law school of University, Bangalore	12-17 July, 2004
Dr S.Devasahayam	Mass production of entomopathogenic nematodes	PDBC, Bangalore	20-29 July, 2004
Dr S.J.Eapen	Biodiversity informatics and microbial culture collections	University of Pune	23-27 August, 2004
Mr. P.S.Manoj	Methodology of collection, documenration and validation of indigenous technical knowledge	JNKVV, Jabalpur	19 July-08 August, 2004
Dr T.E. Sheeja	Biotechnology and Bioinformatics-Application in agricultural research	IISR, Calicut	26 September-16 October, 2004
Dr S. Hamza	Heavy metals in food	CFTRI, Mysore	01-03 September, 2004
Mr K.M.Prakash	Rice-Fish integration through organic farming for sustainability and food security	KAU Regional Station Pattambi	28 September to October 07, 2004
Mr N.A.Madhavan	Agromet observers course	Pune	22 November to 10 December 2004
Mr T.R. Sadasivan	Agricultural machineries use and maintenance	Southern Regional Farm Machinery Training and Testing Institute, Garidin, A.P.	01-31 December, 2004
Mr K.Jayarajan	Effective technical assistance in management of agricultural research	NAARM, Hyderabad	03-09 February, 2005
Dr C.K.Thankamani	Microirrigation and fertilization	CWRDM, Calicut	03-10 March, 2005
Dr. T.E Sheeja Dr. A.I.Bhat Dr. A.Kumar Dr. V.Srinivasan Dr. K.N.Shiva	Capacity building program for Indian agricultural research, extension, development organization in globalized economy	NAARM, Hyderabad	29-30 March, 2005

Bioinformatics Centre

The Bioinformatics Centre was established in the year 2000 with the financial support of Department of Biotechnology, New Delhi. The Centre aims at providing basic infrastructure, training and computational support to the researchers in accessing, analyzing, storing and disseminating various biological data.

A database 'Piperbase' that contains all the information such as taxonomy, distribution, literature and patents on various *Piper* species reported from India was developed. It also includes a programme for identification of different *Piper* species.

The infrastructure was further strengthened by adding a new server (HP/Compaq ML 350), a workstation (HP xw 6000) and a multimedia projector (Sharp PGA 10x). Bioinformatics software packages viz. 'DS Gene' and 'DS Accord for Excel' were procured.

Library Activities

The library of the institute was set up to provide support to research activities of the institute and to function as a national information storage, retrieval and dissemination system for spices and related areas.

At present, the library has a collection of 3971 books, 2621 bound volumes, 2276 reprints, 825 technical reports and 114 theses. The library is subscribing to 34 foreign journals and 64 Indian journals in addition to CAB CDs. The new additions added to the library during the year include 77 books, 6 reprints, 27 technical reports,four theses and 32 project reports.

The library provides bibliographic services (published in the Journal of Spices and Aromatic Crops) and database services and publishes "Agri-science Tit Bits" at quarterly intervals. Sharing of resources between the libraries of Central Plantation Crops Research Institute, Kasargod, National Research Centre for Cashew, Puttur and IISR, Calicut, was continued ro avoid duplicate subscription of costly journals and CAB CDs. Access to online journals and content page service were provided using Institute website and research articles from journals were sent as *.pdf* files through e-mail to users of the concerned institutes. Urilizing the NATP allocation, three online journals were subscribed with 'Science Direct'.

Internet facility is provided in the Library for all the scientific and technical staff for literature search, searching web sites of other organizations, checking E-mails etc. Reference Manager software was procured for the library for management of references.

Agricultural Research Information System (ARIS)

As per the mandate, ARIS cell, undertakes a routine maintenance of Local Area Network with linkage of about 50 computers. Besides, ARIS has developed softwares especially of ad-hoc nature to provide specific utility services to Research Project Management and Administration. They can be broadly classified as (i) Data bases, (ii) Management information tools, (iii) software for diagnostic services. It also provides presentation facility to scientists for SRCs, RAC, seminars etc by developing slides and documenting.

ARIS maintains and updates on a regular basis information on all the staffs of the Institute by accessing and editing PERMIS net. It serves as a service centre for various purposes like Internet browsing, Statistical analysis of data, documenting and multimedia programs developed on various activites of the Institute

RESEARCH PUBLICATIONS

1. Bhat, A.I., Hareesh, P.S. and Madhubala, R. 2005. Sequencing of coat protein gene of an isolate of *Cucumber mosaic virus* infecting black pepper (*Piper nigrum* L.) in India. *J.Plant Biochem. & Biotech.* **14**: 37-40.

2. Bhat, A.I., Faisal, T.H., Madhubala, R., Hareesh, P.S. and Pant, R.P. 2004. Purification, production of antiserum and development of enzyme linked immunosorbent assay-based diagnosis for *Cucumber mosaic virus* infecting black pepper. *J. Spices and Aromatic Crops* **13**: 16-21.

3. Bhat, A.I., Sarma, Y.R., Sreenivasulu, P. and Pant, R.P. 2004. Occurrence and identification of a *Cucumber mosaic virus* isolate infecting Indian long pepper (*Piper longum*). *J. Medicinal & Aromatic Plant Sci.* **26**: 279-284.

4. Bhat, A.I., Venugopal, M.N., Pant, R.P. and Bhai, R.S. 2004. Occurrence and disrribution of viral diseases on vanilla (*Vanilla planifolia* Andrews) in India. *J. Spices and Aromatic Crops* **13**: 143-148.

5. Bimi, G. B., Anandaraj, M., Kumar, A., Heartwin Amaladhas and Sarma, Y.R. 2004. Changes in the microbial load of black pepper (*Piper nigrum* L.) during processing. *J. Food Sci. Technol.* **41**: 77-79.

6. Eapen, S.J., Beena, B. and Ramana, K.V. 2005. Tropical soil microflora of spice-based cropping systems as potential antagonists of root-knot nematodes. *J. Invertebrate Pathol.*(Elsevier) **88**: 218 – 225.

7. Hamza, S., Sadanandan, A.K. and Srinivasan, V. 2004. Influence of soil physico-chemical properties on black pepper yield. *J. Spices and Aromatic Crops* **13**: 6-9.

8. Hareesh, P.S., Sabija, S. and Sasikumar, B. 2004 Ampicillin promotes growth and differentiation of ginger callus. *Phytomorphology* **54**: 35-38.

9. Johnson George, K., Ganga, G., Sandeep Varma, R., Sasikumar, B. and Saji, K. V. 2005. Identification of hybrids in black pepper (*Piper nigrum* L.) using male parent specific RAPD markers. *Curr. Sci.* **88**: 216-218.

10. Kumar, A. and Sarma, Y.R. 2004 Characterization of *Ralstonia solanacearum* causing bacterial wilt of ginger in India. *Indian Phytopathol.* **57**: 12-17.

11. Kumar, A, Sarma, Y.R. and Anandaraj, M. 2004. Evaluation genetic diversity of *Ralstonia solanacearum* causing bacterial wilt of ginger using Rep-PCR and RFLP-PCR. *Curr. Sci.* **87**: 1555-1561.

12. Mathew, P.A, Rema, J. and Krisbnamoorthy, B. 2004. A note on interspecific grafting in *Garcinias*. *Indian J. Arecanut, Spices and Medicinal Pl.* **8**: 55-58.

13. Maya, K. M., John Zachariah, T. and Krishnamoorthy, B. 2004. Chemical composition of essential oil of nutmeg (*Myristica fragrans* Houtt) accessions. *J. Spices and Aromatic Crops* **13**: 135-139.

14. Remya, R., Syamkumar, S. and Sasikumar, B. 2004. Isolation and amplification of DNA from turmeric powder. *British Food J.* **106**: 673-678.

15. Sasikumar, B. and Jayarajan, K. 2004. Phenotypic stability for fresh rhizome yields in turmeric. *J. Medicinal & Aromatic Plant Sci.* **26**: 277-278.

16. Sasikumar, B., Haridas, P., Johnson George, K., Saji, K.V. and Parthasarathy, V.A. 2004. Phenotypic stability for berry yield in black pepper (*Piper nigrum* L.). *Indian J. Agric. Sci.* 74: 279-280.

17. Sasikumar, B., Haridas, P., Johnson K. George, Saji, K.V., John Zachariah, T., Ravindran, P.N., Nirmal Babu, K., Krishnamoorthy, B., Mathew, P.A. and Parthasarathy, V.A. 2004. '*IISR Thevam*', '*IISR Malabar Excel*' and '*IISR Girimunda*'- three new black pepper (*Piper nigrum L.*) clones. *J. Spices and Aromatic Crops* 13: 1-5.

18. Sasikumar, B., Syamkumar, S., Remya, R. and John Zachariah, T. 2004. PCR based detection of adulteration in market samples of turmeric powder. *Food Biotech.* 18: 299-306.

19. Shanmugam, V., Kumar, A. and Sarma, Y.R. 2004 Survival of *Ralstonia solanacearum* in ginger seed rhizomes stored at different temperature. *Pl. Disease Res.* 19: 40-43.

20. Srinivasan, V., Hamza, S., *Krishnamurthy, K.S* and Thankamani, C.K. 2004. Threshold level of soil zinc for optimum production of ginger (*Zingiber officinale* Rosc.). *J. Spices and Aromatic crops* 13: 55-57.

21. Thankamani, C.K and Asokan, P.K. 2004. Screening of black pepper (*Piper nigrum* L.) cultivars for water stress. *Agril. Sci. Digest* 24: 162-165.

22. Utpala Parthasarathy, Sandeep Varma, R., Ganga, G., Johnson George, K., Mathew, P.A. and Parthasarathy, V.A. 2004. Micropropagation of Rambutan (*Nephelium lappaceum* L.) *J. Appl. Hort.* 6: 106-108.

23. Utpala Parthasarathy, Kumaran, P.M. and Das, M. M. 2004 Application of satellite imagery to identify vegetation types. *J. Plantation Crops* 32 (Suppl.): 229-231.

List of Projects

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

1. Gen. I (813): Collection, conservation, cataloguing and evaluation of black pepper germplasm [1972-2008] [K. V. Saji, Johnson K. George and R. Ramakrishnan Nair]

2. Gen.IX (813): Collection, conservation, cataloguing and evaluation of cardamom germplasm [1976-2007] [D.Prasath and M.N.Venugopal]

3. Gen. II (813): Collection, conservation, cataloguing and evaluation of germplasm of ginger and turmeric [1976-2007] [B. Sasikumar, Johnson K. George, K. V. Saji and R. Ramakrishnan Nair]

4. Gen. XIV (813): Characterization of turmeric germplasm for curcuminoids [2004-2007][B. Chempakam and N. K. Leela]

5. Gen. VI (813): Collection, conservation, cataloguing and evaluation of germplasm of tree spices [1976-2007] [B. Krishnamoorthy, J. Rema, P. A. Mathew, D. Prasath and T. John Zachariah].

6. Gen. XIII (813): Collection, conservation and improvement of vanilla [1995-2005] [R. Ramakrishnan Nair and K. V. Saji].

7. Hort. III (813): Collection, characterization, evaluation and maintenance of paprika and paprika alike chillies [2004-2009] [KN Shiva, T.J. Zachariah and V.A. Parthasarathy].

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

1. Gen. VII.1 (813): Breeding black pepper for high yield, quality, drought and resistance to pests [1977-2007] [B. Sasikumar, Johnson K. George, K. V. Saji, T. John Zachariah, K. S. Krishnamurthy and Santhosh J. Eapen].

2. Gen. X (813) : Breeding cardamom for high yield and resistance to 'katte' disease [1976-2007] [M. N. Venugopal and D. Prasath].

3. Gen. XV (813): Investigations on the reasons and solutions for the absence of seed set in ginger [*Zingiber officinale* Rosc.] [2005-2008] [R Ramakrishnan Nair].

4. Biotech. IV (813): Biotechnological approaches for crop improvement in black pepper [1995-2005] [K. Nirmal Babu and M. Anandaraj].

5. Biotech. VII (813): ISSR markers for black pepper improvement [2004-2007] [Johnson K. George and B. Sasikumar].

6 Biotech. VIII (813): Molecular characterization and *in vitro* propagation in *Myristica* sp.[2004-2007] [Sheeja T.E and B. Krishnamoorthy.].

7. Hort. IV (813): Rootstock-scion interactions in tree spices [1998-2008] [J. Rema, P. A. Mathew and K. S. Krishnamurthy.]

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

1. SSC IV (813): Nutrient Budgeting For Improved Varieties of Spices [2005-2010] [V.Srinivasan, R. Dinesh, C.K.Thankamani, K. Kandiannan, S.J. Anke Gowda and S.Hamza].

2. Agr. XXI (813):Efficacy of biofertilizer on nutritional management of black pepper [2000-2007][C. K. Thankamani, K. S. Krishnamurthy, V. Srinivasan and K. Kandiannan].

3. Agr. XXII (813): Biometeorological investigations and modeling in black pepper [2003-2013] [K. Kandiannan, C. K. Thankamani, K. S. Krishnamurthy, V. Srinivasan and Utpala Parthasarathy]

4. SSC. III (813): Assessment of quality of soils under spices based cropping systems [2005-2008] [R.Dinesh, V. Srinivasan, T.E. Sheeja, B. Chempakam, S. Hamza].

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

1. Biochem. II (813) Characterization of turmeric germplasm for Curcuminoids [2004-2007] [B.Chempakam and NK Leela]

2. Phy. VII (813): Physiological and biochemical basis for productivity in black pepper [2003-2008][K. S. Krishnamurthy and B. Chempakam]

3. Phy. VIII (813): Mechanism of drought tolerance in cardamom and black pepper [2005-2007] [S.J. Anke Gowda and K.S. Krishnamurthy]

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

1. PHT. III (813):Studies on drying and storage parameters in black pepper, ginger, turmeric and nutmeg [2004-2007] [E. Jayashree and T. John Zachariah]

2. PHT. IV. Evaluation for physical and biochemical quality of spices . [2005-2009] [T. John Zachariah, N.K. Leela, K.N. Shiva]

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

1. Agr. XX (813): Production of nucleus planting materials of improved varieties of spice crops [1972-2007] [C. K. Thankamani, P. A. Mathew, K. Kandiannan and S. J. Ankegowda]

2. Agr. XXIII (813): Development and evaluation of nursery mixtures for spice crops [2004-2009] [C.K.Thankamani, A.Kumar, Santosh J.Eapen, A. Ishwara Bhat, R.Dinesh, K.S.Krishnamurthy].

List of Projects

Identification, characterization and development of diagnostics against pests, pathogens nematodes of spice crops [Project Leader: M. N. Venugopal]

1. Path. XV (813): Investigations on diseases of vanilla [2003-2008] [A. Ishwara Bhar, R. Suseela Bhai and M. N. Venugopal]
2. Nema. III (813): Investigations on nematodes associated with spices [1992-2005] [Santhosh J. Eapen]

Conventional and molecular approaches for developing pest, pathogen and nematode resistance in spice crops [Project Leader: M. Anandaraj]

1. Crop Prot. I.1 (813): Screening germplasm of spice crops for reaction to diseases [1978-2006] [R. Suseela Bhai, M. Anandaraj, M. N. Venugopal and K. V. Saji]
2. Crop Prot. 1.3 (813): Screening germplasm of spice crops for reaction to nematodes [1978-2006] [Santhosh J. Eapen and K. V. Saji]
3. Crop Prot. 1.2 (813): Screening germplasm of spice crops for reaction to insect pests [1978-2006] [K. M. Abdullah Koya, S. Devasahayam, T. K. Jacob, K. V. Saji and B. Sasikumar]

Developing integrated pest and disease management strategies in spice crops [Project Leader: S. Devasahayam]

1. Path. II.3 (813): Disease management in *Phytophthora* foot rot affected black pepper plantations [1988-2006] [M. Anandaraj, V. Srinivasan and C. K. Thankamani]
2. Hort. II (813) : Utilization of *Piper colubrinum* Link and *P. arboreum* as rootstocks in the management of foot rot disease of black pepper [1996-2006] [P. A. Mathew]
3. Path XVI (813):Etiology and management of rhizome rot complex in ginger and turmeric [2004-2009] [A.Kumar, R.Suseela Bhai, S.J.Eapen, K.N.Shiva]
4. Org. Chem. II (813): Characterization of bioactive compounds with pesticide properties [2002-2005] [N. K. Leela and M. Anandaraj]
5. Biocontrol II. (813) : Development of consortium of bioinoculants for management of pests, diseases and nematodes in spices [2004-2008] [M. Anandaraj, M. N. Venugopal, S. Devasahayam, R. Suseela Bhai, K. M. Abdulla Koya, Santhosh J. Eapen and A. Kumar]
6. Ent. XII (813) : Bioecology and integrated management of shoot borer, *Conogethes punctiferalis* Guen. infesting turmeric [2005-2009] [S. Devasahayam, T. K. Jacob and K. M. Abdulla Koya]

Economics, statistics and modeling [Project Leader: M. S. Madan]

1. Econ. III (813) : Remote sensing and GIS in evaluating the impact on socio-ecological changes on spices production in Western Ghats region [2003-2008] [M. S. Madan, K. Kandiannan, V. Srinivasan and Utpala Parthasarathy]

Extension and training [Project Leader: P. Rajeev]

1. Ext. IV (813): Training of research and extension workers [1971-2007][P. Rajeev and T. K. Jacob]
2. Ext. VI (813): Agricultural Technology Information Centre .[2004-2007] [P. Rajeev]

Developing customized software and expert systems on spices [Project Leader: K. N.Kurup]

1. Stat. I (813) Development of data bases and software [K.N. Kurup, Santhosh J. Eapen, P. Rajeev and K. Jayaraj 2004-2007]

External funded Projects.

DBT

1. On farm evaluation of tissue culture derived black pepper plants [2002-2006] [K. Nirmal Babu, M. Anandaraj, V. Srinivasan and R. Ramakrishnan Nair]

2 Determination of purity of powdered market samples of major spices using PCR techniques, protein profiling and /or HPLC techniques [2004-2007] [B.Sasikumar and B.Chempakam]

3. Molecular characterization of viruses causing stunted disease in black pepper and development of PCR based methodology for their detection [2003-2006] [A. Ishwara Bhat and R. Suseela Bhai]

4. Endophytic bacteria for biological system management of *Radopholus similis*, the key nematode pest of black pepper [*Piper nigrum* L] [2003-2006] [K. V. Ramana, Santhosh J. Eapen, R. Ramakrishnan Nair and A. Kumar]

5. Distributed Information Sub-Centre [Bioinformatics Centre] [2000-2007] [S.J.Eapen]

6. Improvement of selected spices through Biotechnology tools [2001-2005] [K. Nirmal Babu, Johnson K. George, M. Anandaraj, M.N. Venugopal, R. Ramakrishnan Nair]

ICAR

1. Network Project on Organic Farming [2004-2007] [V. Srinivasan, C. K. Thankamani, A. Kumar and T. John Zachariah]

2. Prevention and management of Mycotoxin contamination in commercially important Agricultural commodities [2005-2008] [B.Chempakam, M. Anandaraj, T. John Zachariah, N.K. Leela and E. Jayashree]

3. Impact, adaptation and mitigation of climate change effects on growth and productivity of plantation crops with special reference to coconut and black pepper. [2004-2007] [K.S. Krishnamurthy, K. Kandiannan and B.Chempakam]

4. Cloning of *Phytophthora* resistance and defense genes from *Piper colubrium* [2004-2007] [Johnson K. George and M. Anandaraj]

5. Chemical characterization of *Cinnamomum* germplasm [2005-2008] [N K Leela and J. Rema]

6. Development of chilli [*Capsicum annuum* L.] hybrids for paprika [oleoresin] production [2004-2007] [T. John Zachariah and K. N. Shiva]

7. Strengthening the cause of Geographical Indication of major spices using molecular, morphological and quality profiling techniques. [2004-2007] [(B.Sasikumar and T.John Zachariah]

8. Identification and development of diagnostics for the viruses causing stunted disease in black pepper [2003-2006] [A. Ishwara Bhat and R. Suseela Bhai]

9. Molecular characterization and maintenance of national repository of *Phytophthora* [2004-2007] [M. Anandaraj, R. Suseela Bhai and A.I.Bhat]

10. Bioecology and integrated management of root mealybug [*Planococcus* sp.] infesting black pepper [2003-2006] [S. Devasahayam, K. M. Abdulla Koya and M. Anandaraj]

OTHERS

1. IPL: Evaluarion of sulphate of potash (SOP) as potassium source on growth, yield and auality of black pepper [2004-2007] [K. Kandiannan and V. Srinivasan]

2. Kerala State Council for Science, Technology and Environment project: Production of white pepper through fermentation technology [2005-2008] [T. John Zachariah, A. Kumar and E.Jayashree]

3. BRNS: Migration of pesticides in soil, water and plant environment – A study using ^{32}P labeled potassium phosphonate [2002-2005] [K. Vasu and R. Suseela Bhai] [Collaborative project with CRWDM]

Institute Management Committee

1. Dr. V.A. Parthasarathy, Director, IISR, Calicut.
2. Dr. S. Devasahayam, Principal Scientist, IISR, Calicut.
3. Sri. P.A. Mathew, Principal Scientist & Scientist in-Charge, IISR Farm, Peruvannamuzhi
4. Dr. George V. Thomas, Head (Crop Production), CPCRI, Kasaragod.
5. Dr. K.V. Nagaraja, Principal Scientist, NRC for Cashew, Karnataka.
6. Dr. K.V. Ramana, ADG (Plantation Crops), ICAR, New Delhi.
7. Shri. K. Mukundan, Vaduvanchal, Wyanad – 673 581.
8. Shri. Dhirendra Bahadur Singh, Lucknow.
9. Additional Director of Agriculture (CP), Government of Kerala, Thiruvananthapuram.
10. Commissioner of Horticulture and Plantation Crops, Govt. of Tamil Nadu, Chennai.
11. Finance and Accounts Officer, CRRI, Cuttack.

MEMBER SECRETARY

13. Sri. A. P. Sankaran, AAO, IISR, Calicut.

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MEMBER SECRETARY:

1. Dr. M. Anandaraj, Pr. Scientist & Head (Crop Protection), IISR, Calicut

Research Advisory Committee 2004
Recommendations and Action Taken Report

Sl. No.	Recommendations	Action taken
	Division of Crop Production and Post Harvest Technology	
1.	While fixing the targeted yields, care should be taken that NPK levels do not exceed the optimum dose for the crop.	The levels may exceed the optimum dose recommended, if the soils are deficient in the nutrient of interest.
2.	Conditions prevailing during spike initiation to initial fruit set should be considered for correlating yield with biometeorological factors.	This aspect has been included in the ongoing project 'Biometeorological Investigations and Modeling in black pepper'.
3.	Physiological/biochemical traits for higher productivity may be identified which can be utilized in screening the germplasm.	The objective of the project is to identify traits associated with highet productivity.
4.	The possibility of using the information generated on biosynthetic pathway of curcumin may be explored.	This will be taken care of while formulating future programmes.
5.	The conditions under which the crop was grown and stage of maturity at harvest are to be considered while evaluating produce quality.	The suggestion has been implemented in the routine analysis for quality parameters.
6.	An ad-hoc scheme on 'Impact of planting materials supplied by IISR' may be submitted.	Scientist (Extension) has initiated a project on Impact of Integrated Disease Management.
7.	Production of allspice planting materials may be reduced in view of the problems in marketing.	During 2004, all spice planting materials were produced to the minimum.
8.	The quantity of planting materials produced in each crop/variety should be specified in the technical programme/	Variety/ crop wise specification of the planting material produced has been implemented.
9.	For production of quality planting materials IISR may identify a few farmers.	In the case of ginger and turmeric, planting materials have been disttibuted to selected farmers.
	Section of Social Sciences	
1.	Economics and statistics should be better integrated with relevant programmes.	The data generated from pepper technology mission project have been analyzed. Soil and water conservation technologies developed were economically evaluated.
2.	Directors of Agriculture/ Horticulture may be contacted to nominate the officials for institute's diverse training programmes.	Communication on training is regularly sent to all directors on a regular basis.

3.	Success stories from the farmers may be popularized among other farmers through mass media and it should make available in the Institute's website.	Success stories are regularly consolidated and efforts are regularly made to popularize among the farmers through mass media and the Institute's website.
4.	There is scope and need for testing various technologies developed by the institute in farmers' field.	The new technologies developed are regularly tested in farmers' field before release.
5.	Cost of production of crops has to be updated.	This is being regularly updated.
6.	Full details of the technologies developed should not be put in the website and internet	This recommendation is taken note of.

Division of Crop Protection

1.	For the management of viral diseases of vanilla, an ad-hoc recommendation should be formulated.	In order to create awareness popular articles on viral diseases of vanilla has been written in Spice India and Journal of Arecanut & Spices
2.	Developmental agencies may be apprised/ sensitized on the viral diseases of vanilla	Spices Board has been appraised about virus infection in vanilla.
3.	Technical expertise may be extended to developmental agencies in indexing the vanilla planting materials for viral diseases.	Training is also imparted to organizations like Parry Agro Ltd and Wynad farmers through Rashtriya Sam Vikas Yojana on identification and management of viral diseases.
4.	Scoring methodology for soft rot disease of ginger germplasm has to be refined.	Screening methods for soft rot of ginger is being standardized.
5.	An integrated package for the management of pests and diseases in spice crops has to be developed.	Integrated pest and disease management strategies have been developed and recommended.
6.	Bioactive principles from more number of plant species have to be screened against pests, pathogens and nematodes	A large number of plants species have been screened initially for the bioactive compounds and the promising ones are being characterized.
7.	Biocontrol agents/bioactive compounds, particularly novel ones must be registered and protected by patenting.	A strain of *Pseudomonas fluorescens*-IISR-6 and a strain of *Trichoderma harzianum* have been recommended for commercial exploitation.

Division of Crop Improvement and Biotechnology

1.	Instead of using the term *Piper* zero which is not authentic, Piper sp. should be used.	*'Piper zero'* is used only as a vernacular term.
2.	A group meeting for research in vanilla with Spices Board has to be organized.	A letter will be sent to Chairman, Spices Board in this regard.
3.	Vanilla germplasm, particularly *Vanilla andamanica* should not go to the farmers.	Germplasm material are not distributed to farmers

4.	Studies on disease resistance in vanilla have to be given priority.	Priority is given to develop disease resistance in vanilla
5.	Registration of germplasm has to be hastened.	2 accessions were registered, 1 ginger, 2 bl. pepper and 1 clove sent for registration.
6.	Bydagi chilli cannot be mixed with real paprikas.	Three lines are maintained separately
7.	The technical programme of paprika project has to be modified as Paprika Network Project.	Institute project closed and network project initiated.
8.	Following modifications are suggested in the parameters for the evaluation of spices germplasm.a. Black pepper: Oleoresin > 12%, Piperine >3.5%, Essential oil > 4.0%b. Ginger: Yield -20 t/ha, Driage-20%, Oleoresin-4%; Disease reaction- Resistant (1 to 2% infection)c. Turmeric: Yield-25 t/ha, Driage- >20%, Curcumin (powder)> 3%, Oleoresin-4%, Disease reaction- Resistant (1 to 2% infection)d. Cardamom: Yield > 500 kg/ha, In place of capsule size, number of capsules per 100 g has to be considered, Oil - 5% and above.e. Nutmeg: Age of the tree-10 years, Yield-1000 nuts/ tree/yr, Nut wt > 9 g, Mace wt-1.5 g.f. Cinnamon: Age of the tree-6 yrs, Yield- Fix after examining the data, Bark oil- 2.5%.	Suggestions accepted with modifications
9.	Data on *HP-728* need further verification.	Evaluation is being continued on *HP- 728*
10.	Molecular characterization should be further deliberated.	Suggestions accepted. It will be exhaustively deliberated.
11.	All evaluations should be based on the parameters fixed.	Being done
12.	A group meeting on recombinant breeding was also held. The recommendations were:A project has to be prepated on recombinant breeding and black pepper is the crop selected.Mr. B. Krishnamoorthy and Dr. B. Sasikumar will lead the project. Recombinants with multiple characters should be selected instead of single character of interest. Mr. B. Krishnamoorthy will finalize the project.	A project on Gene pyramiding in black pepper was prepared and sent to ICAR on a network project along with other crops. The ongoing black pepper breeding programme at the Institute is aimed at conveying favourable genes through recombination breeding. Crosses involving known sources of resistance, viz. *Coll.1041, P-24* for *Phytophthora Acc. 2070,* (*P. nigrum* wild) for pollu and drought such as Op Karimunda.

Quinquennial Review Team (1997 -2001) Recommendations and Action Taken Report

Sl. No.	Recommendations	Action taken
	Division of Crop Production and Post Harvest Technology	
1.	Reduce and synchronize flowering and harvesting period in black pepper and cardamom.	Hormonal spray can reduce duration only by a fortnight. Will be highly uneconomical.
2.	Training private agencies for production of quality planting materials	IPDS Scheme in collaboration with KVK and Spices Board has imparted training programs.
3.	Effects of climatic changes on performance of black pepper, cardamom and ginger should be studied.	A Project on "*System Approach for Sustainable Production of Spices*" has been initiated to study these effects
4.	New standard trees for black pepper having ideal qualities need to be studied	Ideal trees have already been identified and planted in the field during 2004.
5.	Quality of spice produce should be emphasized by more standards	Quality parameters like weight per litre (bulk density), grade of the berries (in the case of black pepper) have also been included.
6.	The programme on biopesticides needs a clear perspective	Programmes in organic chemistry have been modified accordingly.
7.	Efforts should be strengthened on INM based on nutrient removal studies	INM studies in black pepper, ginger and turmeric have been intensified.
8.	The feasibility and effects of using *Azospirillum*, azolla, phosphobacteria and VAM in spice crops needs focus.	Effects of *Azospirillum*, phosphobacteria and VAM in spice crops are being presently studied.
9.	Monitor the effects of climatic change, actual light and moisture stress of understorey spice crops.	Network project to study the effect of climate change has been started. Data on photosynthetic rate, leaf water potential, membrane leakage, catalase, peroxidase and SOD activities of released varieties are already available.
10.	The IISR may take up work on organic farming in black pepper, cardamom, turmeric etc.	ICAR network project on organic cultivation of black pepper, ginger and turmeric is in progress.
	Section of Social Sciences	
1.	Undertake a major survey to study the impact of foot rot management in black pepper in the state.	A project to assess the impact of various technologies developed by the institute is underway.
2.	Effectively monitor the adoption and field testing of technologies developed.	Impact assessment and economic viability of important technologies were carried out during 2004.
3.	Periodical consolidation of data to assess the extent of spread of the released varieties and farmers' perceptions about them.	Suggestion will be carried out

1.	Research areas that need attention are	
	a) Standardization of methods for early detection of the pathogens.	Methods for detection of ***Ralstonia solanacearum***, and *Phytophthora* from soil and plant have been developed. Studies for detection of *Pythium* and *Fusarium* sp have been taken up.
	b) Variability in *P. capsici* should be further characterized and their distribution studied.	Molecular characterization of *Phytophthora capsici* will be done under a new ICAR ad-hoc project.
	c) Screening of the getmplasm using molecular marker for identifying resistant/tolerant lines.	Molecular markers are being developed for *Phytophthora* resistance.
	d) Accession *P-24*, tolerant to *P. capsici*, should be used in breeding programmes.	*P-24* is already being been used in the breeding program.
	e) Evaluate the performance of the identified resistant rootstocks in black pepper	Trials are underway in farmer's plots to evaluate the performance of *P. colubrinum*.
2.	The vector and alternate hosts of phyllody disease of black pepper may be identified and appropriate measures may be developed to check its spread.	Two species of plant hoppers, possibly vectors are being studied. Characterization of Phytoplasma has been completed.
3.	To combat the slow decline disease of black pepper	
	a) Methods should be developed to keep nurseries free of nematode infestation.	Priority will be given to produce and distribute quality planting materials free from pests, pathogens and nematodes.
	b) Biological control of nematodes needs to be intensified.	Adhoc & DBT Projects on biological control of nematodes of Spices are under progress.
4.	a) The identified sources of resistance for 'Pollu' beetle must be used to develop resistant varieties	The work is in progress
	b) Biology of virus vectors should be investigated.	Biology of aphids/ mealy bugs that are vectors of viruses of black pepper are being studied.
5.	For integrated pest and disease management in black pepper)	
	a) Develop biocontrol technology for pests and diseases and standardize procedures for mass rearing of biocontrol agents and their utilization.	Documentation has been done to identify potential bio-agents and standardized the mass multiplication methods for most of them.
	b) Identify pheromones for use in the management of major insect pests.	A project on 'Identification, characterization and evaluation of pheromones against pollu beetle of black pepper' has been submitted.
	c) Identify useful botanicals for their potential application in pest and disease management.	Extracts of various plants and plant products have been evaluated against pollu beetle.

	d) Identify agrochemicals effective against major pests and diseases and develop methods for detecting their residues to maintain a safe limit.	Evaluation of plant products against root mealy bug is being undertaken. Evaluarion of new agrochemicals is in progress.
	e) Post-harvest processing, packaging and storage for checking residues and maintaining minimum microbial load meeting WTO/SPS related requirements.	The studies on Post harvest technology are being srrengthened and the requirements of WTO/SPS would be taken into consideration.
6.	Systematic studies to understand the exact nature and mechanism of resistance to *Phytophthora* foot rot.	The host pathogen interactions in black pepper – *P. capsici* pathosystem have been studied.
7.	Viruses causing diseases in cardamom should be characterized and virus specific antisera be produced.	Characterization of 'Katte' virus has already been done. Production of virus specific antisera will be raken up in future.
8.	Techniques should be developed for simultaneous detection, Integrated management and Etiology and interaction of pests and pathogens associated with the rhizome rot and bacterial wilt diseases of ginger.	A new project on "Etiology and management of rhizome rot complex in ginger and turmeric" has been initiated during 2004 to study these aspects.
9.	Recommending the use of infected seeds after solarization treatment may be validated through the AICRPS.	All the technologies developed for the production of disease free planting material and other management strategies are tested through AICRPS centres.
10.	Constant vigil on several emerging diseases in various spice crops may be maintained.	Basic information on distribution, etiology, etc. of emerging diseases in various spice crops would be generated.

Division of Crop Improvement and Biotechnology

1.	Imparting earliness in ginger and turmeric:	Turmeric varieties available in the country are classified as short duration, medium duration and long duration. In case of ginger, IISR has released 3 varieties which take 200 days for maturity.
2.	Reducing harvesting period in black pepper and cardamom.	In black pepper there is only one picking. Hence reduction of picking in black pepper is not relevant. An early bearing black pepper line will be released in 2007.
3.	The IISR may develop a vanilla research programme jointly with SB.	A meeting with Spices Board will be held to have a mutual understanding regarding areas of vanilla research.
4.	The IISR and SB may arrange a consultation of all the interested agencies on garcinia and allspice.	About 65 acc. of Garcinia and 22 acc. of Kokum have been collected, planted and are being evaluated. There is no market for allspice in India.

5.	Field tolerance in varieties	IISR has recommended release of disease/ field tolerant varieties.
6.	Use of multi-lines	IISR always advocates growing more than one variety.
7.	New standards for black pepper	Would be completed during 2010.
8.	Quality control	Would be completed during 2008.
9.	Partnership arrangements	Already four net work projects exist
10.	Increasing the competence of scientists	Opportunities for deputation abroad are very limited as compared to other institutes.
11.	Developing specialization of horticultural scientists	The project or vegetative propagation in tree spices was complete and closed in 1997.
12.	The current reports do not indicate that evaluation. and cataloguing has gone on apace with the collection programme.	Characterizations of all the accessions of spices collected till 2002 were completed rest will complete by2007.
13.	No reports on adequate checks to ensure the genetic integrity of *in vitro* germplasm were made available.	Random checking of fidelity of *in vitro* maintained germplasm was being done.
14.	In case of the tree spices, it is difficult to envisage that India can develop international trade in these crops.	A final project report on "Vegetative propagation of Tree spices was submitted in 1997".
15.	The results presented in the reports do not indicate either new data or new approach.	Practical leads on these aspects may be obtained by 2007.
16.	The results presented are meandering and descriptive in nature; hardly any results are presented.	Practical leads in these aspects would be obtained by 2007.
17.	The spice germplasm collections have to be characterized by using PCR based techniques.	Tagging of important genes with molecular markers is in progtess.
18.	Emphasis to be given for identification and cloning of resistance genes and improving the efficiency of conventional and molecular breeding in black pepper.	An ICAR Adhoc project "Full length sequencing of cDNA corresponding to resistance and defense genes" was sanctioned
19.	Through review of the Biotechnology work may be done and fresh directions given by Institutional Biosafety Committee (IBSC).	The IBSC was reorganized and activated.
20.	Pepper tissue culture protocol should be put to use in evolving transgenic cardamom lines.	Work at Appangala would resume by 2005. Work on ginger somaclones would be completed by 2005.

Empowerment of Women

International Women's day was observed on 7 March 2005. Chief Guest Smt. B.M. Suhara, the renowned Malayalam Novelist, gave a lecture on latest trends in Malayalam novels highlighting the role of women. A cultural programme was organized on the occassion. Women's cell organized the Communal Harmony Day and presented a thematic programme based on commonness of religions, quoting Geeta, Bible and Quran. Onam celebrations were also organized which included various competitions like cooking with spices, flower carpet etc. Efforts have been made for peaceful settlement of cases by women employees of the Institute.

International Women's day celebrations

Official Language Implementation Activities

Hindi Implementation Committee meeting was held four times during the period 2004-05. Fifteen computers were made bilingual. The administrative staff was encouraged to work in bilingual. All the application forms and registers were made bilingual. Two administrative staff were nominated to attend the Hindi Workshop in NAARM, Hyderabad. Five Scientific and administrative staff have qualified in Prabodh and nine in Pragya. Director, Dr. V.A. Parthasarathy as well as Hindi Officer attended the discussion programme of the drafting and evidence, conducted by subcommittee of Parliament on official language. Hindi week was celebrated with many competitions among the office staff.

PERSONNEL

SCIENTIFIC, CALICUT

Sl. No.	Name	Designation
1.	Dr. V.A. Parthasarathy	Director
2.	Dr. K. Narayana Kurup	Principal Scientist (Agri. Statistics)
3.	Dr. M. Anandaraj	Principal Scientist (Plant Pathology)
4.	Dr. (Mrs.) B. Chempakam	Principal Scientist (Biochemistry)
5.	Dr. S. Devasahayam	Principal Scientist (Entomology)
6.	Mr. B. Krishnamoorthy	Principal Scientist (Plant Breeding)
7.	Dr. K. Nirmal Babu	Sr. Scientist (Plant Breeding)
8.	Dr. M.S. Madan	Sr. Scientist (Agril. Economics)
9.	Dr. T. John Zachariah	Sr. Scientist (Biochemistry)
10.	Dr. B. Sasikumar	Sr. Scientist (Plant Breeding)
11.	Dr. (Mrs.) J. Rema	Sr. Scientist (Horticulture)
12.	Dr. K. Johnson George	Sr. Scientist (Gen. & Cytogenetics)
13.	Dr. (Mrs.) C.K. Thankamani	Sr. Scientist (Agronomy)
14.	Dr. R. Dinesh	Sr. Scientist (Soil Science)
15.	Dr. R. Suseela Bhai	Sr. Scientist (Plant Pathology)
16.	Dr. A. Ishwara Bhat	Sr. Scientist (Plant Pathology)
17.	Dr. R. Ramakrishnan Nair	Sr. Scientist (Gen. & Cytogenetics)
18.	Dr. P. Rajeev	Sr. Scientist (Agril. Extension)
19.	Dr. K.S. Krishnamoorthy	Sr. Scientist (Plant Physiology)
20.	Dr. K. Kandiannan	Sr. Scientist (Agronomy)
21.	Dr. Santhosh J. Eapen	Sr. Scientist (Nematology)
22.	Dr. N.K. Leela	Sr. Scientist (Org. Chemistry)
23.	Mr. K.M. Abdulla Koya	Scientist (SG) (Entomology)
24.	Mr. K.V. Saji	Scientist (SG) (Economic Botany)
25.	Dr. A. Kumar	Scientist (Sr. Scale) (Plant Pathology)
26.	Dr. V. Srinivasan	Scientist (Sr. Scale) (Soil Science)
27.	Dr. K.N. Shiva	Scientist (Sr. Scale) (Horticulture)
28.	Dr. T.E. Sheeja	Scientist (Biotechnology)

TECHNICAL OFFICERS

1.	Dr. Johny A. Kallupurackal	Technical Officer (T9)
2.	Dr. Hamza Srambikkal	Tech. Officer (Lab) (T7-8)
3.	Mr. P. Azgar Sheriff	Tech. Officer (T7-8)
4.	Dr.(Mrs.) Utpala Parthasarathy	Tech. Officer (Lib.) (T6)
5.	Mr. M.M. Augusthy	Tech. Officer (T5)
6.	Mr. K. Jayarajan	Tech. Officer (Stati.) (T5)
7.	Mr. M. Vijayaraghavan	Technical Officer (T5) (Workshop)
8.	Mr. K.T. Muhammed	Technical Officer (T5) (Farm)
9.	Mr. V. Sivaraman	Technical Officer (T5) (Farm)
10.	Smr. C.K. Sushamadevi	Technical Officer (T5) (Lib.)

IISR EXPERIMENTAL FARM, PERUVANNAMUZHI

SCIENTIFIC

1.	Mr. P.A. Mathew	Principal Scientist (Horticulture)
2.	Ms. E. Jayashree	Scientist (Sr. Scale)(AS & PE)

TECHNICAL

1.	Mr. V.K. Abubacker Koya	Farm Supdt. (T7)
2.	Mr. N.A. Madhavan	Technical Officer (T5) (Farm)
3.	Mr. K. Kumaran	Technical Officer (T5) (Farm)

KVK

SCIENTIFIC

1.	Dr. T. K. Jacob	CTO in Charge & Sr. Scientist (Agril. Entomology)

TECHNICAL OFFICERS

1.	Mr. P. S. Manoj	(T7) (Hort.)
2.	Mr. S. Shanmugavel	T (7-8) (Veterinary Science)
3.	Mr. K.M. Prakash	T (7-8) (Agronomy)

IISR CARDAMOM RESEARCH CENTRE, APPANGALA

SCIENTIFIC

1.	Dr. M.N. Venugopal	Principal Scientist (Plant Pathology)
2.	Dr. S.J. Anke Gowda	Sr. Scientist (Physiology)
3.	Sri. D. Prasath	Scientist (Horticulture)

WEATHER

Monthly average weather data at IISR Farm, Peruvannamuzhi 2004

Month	Max. Temp °C	Min. Temp °C	Humidity (%)	Rainy Days	Rainfall (mm)
January	33.8	24.8	66.6	0	0
February	34.9	24.9	65.8	0	0
March	36.2	26.1	66.2	3	13
April	35.8	26.9	67.9	5	83
May	30.1	25.8	80.5	24	615
June	29.1	25.6	90.2	25	259
July	28.8	25.9	89.0	28	801
Augusr	29.1	25.5	87.9	23	834
September	31.4	26.7	82.5	14	302
October	31.2	25.1	82.3	14	349
November	31.9	22.3	77.4	12	290
December	33.5	18.3	68.0	0	0

Monthly average weather data at IISR Regional Research Station, Appangala

Month	Max. Temp °C	Min. Temp °C	Humidity (%)	Rainy Days	Rainfall (mm)
January	27.2	14.7	75.2	0	0
February	30.9	14.3	62.3	0	0
March	32.5	16.9	63.1	4	75
April	31.3	18.9	76.6	13	103
May	27.0	19.0	85.8	15	169
June	25.7	18.3	90.6	20	654
July	24.3	18.2	93.1	30	777
August	24.0	18.2	91.8	20	393
September	27.0	18.1	82.9	5	81
October	26.7	17.4	81.7	11	159
November	27.5	15.1	75.7	1	30
December	12.3	28.3	66.0	0	0

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