वार्षिक रिपोर्ट
Annual Report
2008-09

भारतीय मसाला फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद्)

कालिकट - ६७३०१२, केरल, भारत

Indian Institute of Spices Research

(Indian Council of Agricultural Research)

Calicut - 673012, Kerala, India.

आई आई एस आर वार्षिक रिपोर्ट
2008 - 09

IISR Annual Report
2008 - 09

भारतीय मसाला फसल
अनुंसधान संस्थान
कालिकट

Indian Institute of
Spices Research
Calicut

भारतीय कृषि
अनुसंधान परिषद
नई दिल्ली

Indian Council of
Agricultural Research
New Delhi

Correct citation
Indian Institute of Spices Research, Annual Report 2008-09, Calicut

Publisher
Director
Indian Institute of Spices Research
Calicut - 673 012, Kerala, India
Phone: 0495-2731410, Fax: 0495-2731187
Website: www.spices.res.in, E-mail: mail@spices.res.in

Editorial board
V. Srinivasan
A.I. Bhat
K.N. Shiva
Utpala Parthasarathy
R. Dinesh

Hindi translation
Rashid Pervez and N. Prasanna Kumari

Type setting
Ms. Shyna K.S.

Cover design
A. Sudhakaran

ISBN : 13 - 978 - 81 - 86872 - 31 - 4

September 2009

Printed at
Modern Graphics
Malu's Complex
Kaloor
Cochin-682 017, Phone: 0484-2347266

Contents

प्रस्तावना

मुझें भारतीय मसाला फसल अनुसंधान संस्थान की वार्षिक रिपोर्ट 2008-09 थो प्रस्तुत करने कर प्रसन्नता हो रही है। मुझे गर्व है कि रिपोर्टाधीन काल में म्लानी रोग बाधित फसलों पर फाइटोफ्थोरा, फ्यूसेरियम तथा रालेस्टोनिया पर अनुसंधान कार्य के लिए आई आई एस आर को प्रधान केन्द्र तथा 20 अन्य केन्द्रों के साथ एक आउट रीच कार्यकम अनुमोदित हुआ, इसकी कुल लागत 19.65 करोड रूपये है। संस्थान ने सभी अधिदेश फसलों के जननद्रव्य को बढाया तथा दो अक्सेशनों को एन बी पी जी आर में पंजीकृत किया। पी पी वी एवं एफ आर प्राधिकरी ने डी यू एस मार्ग निर्देशों को अन्तिम रूप प्रदान किया तथा एक राजपत्रित अधिसूचना के लिये प्रकिया चल रही है। सर्वेक्षणों के परिणामानुसार यह ज्ञात हुआ कि काली मिर्च बेलों के लिये सहायक वृक्ष के रूप में एरिथ्रीना स्पीसीसों का उपयोग करने वाले सभी क्षेत्रों में एरिथ्रीना गाल वास्प का संकमण होता है। कुरकुमा स्पीसीसों के चरित्रांकन के लिये माइकोसेटेलाइट मारकेर्स को विकसित किया गया। सामर्थ्य अन्त: पादप जीवाणु की फाइटोफ्थोरा तथा पाइथीयम के प्रति जीवनाशी सकियता देखी गई। ग्रीष्म काल में दो सप्ताह के अन्तराल में सिंचाई करके तथा मृदा परीक्षण के आधार पर पोषक तत्व डालने के फलस्वरूप काली मिर्च के उत्पादन में वृधि हुई। अदरक को मय छीलके या बिना छीलके के सुखाने पर तेल एवं ओलिओरसिन की मात्राओं में कोई अन्तर नहीं था। कीट रहित हल्दी के नमूनों को नियन्त्रित वातावरण में भण्डारण करने पर ओलिओरसिन एवं कुरकुमिन की मात्राओं में कोई अन्तर नहीं था।

अनुसंधान सम्बन्धी उपलब्धियों को शोध पत्र के रूप में प्रकाशित किया गया तथा सूचना तकनीकियों का उपयोग करके अपनी अनुसंधान क्षमताओं को नवीनतम बनाया। संस्थान द्वारा काली मिर्च की विकसित प्रजातियों एवं तकनीकियों का अग्र पंक्ति प्रदर्शन किया जा रहा है। संस्थान द्वारा विकसित विभिन्न तकनीकियों के प्रभाव का भी अध्ययन हो रहा है। इसके अतिरिक्त कृषि विज्ञान केन्द्र ने किसानों की आवश्यकता अनुसार प्रशिक्षण कार्यकम आयोजित किये।

यह मेरा परम कर्तव्य है कि मैं, डॉ. मंगला राय, महानिदेशक, भारतीय कृषि अनुसंधान परिषद को उनके प्रोत्साहन एवं सहायता के लिये उनका धन्यवाद दूँ। मैं डॉ. एच. पी. सिंह, उप महानिदेशक (बागवानी) द्वारा दी गयी सभी सहायताओं एवं मार्ग दर्शन के लिये उनको आभार व्यक्त करता हूँ। उनके बिना यह कार्य असम्भव था। वह सदैव हमारी प्रेरणा के स्रोत रहे हैं। मैं डॉ. उमेश श्रीवास्तव, सहायक महानिदेशक (बागवानी II) का उनके द्वारा दी गयी सहायताओं के लिये आभारी हूँ। मैं संस्थान के शोध सलाहकार समिति के अध्यक्ष एवं सदस्यों द्वारा दिये गये शोध कार्यों के प्रति उत्कृष्ट सुझावों के लिए उनको धन्यवाद देता हूँ। मैं संस्थान के सभी कर्मचारियों को किसानों की भलाई के लिये संस्थान द्वारा संचालित कार्यक्रमों में किये गये सामूहिक प्रयासों एवं सहायता के लिये उनकी सराहना करता हूँ। मैं इस वार्षिक रिपोर्ट का संकलन करके प्रस्तुत करने पर सम्पादकों की प्रशंसा करता हूँ।

(वी. ए. पार्थसारथी)
निदेशक

कालिकट
दिनांक:01 सितम्बर 2009

PREFACE

I am happy to present the Annual Report of Indian Institute of Spices Research for the year 2008-09. I am proud to place on record the launch of outreach programme on wilt diseases affecting crops with an outlay of Rs 19.65 crores with IISR as the lead centre with 20 centres spread all over the country for research on *Phytophthora*, *Fusarium* and *Ralstonia*. The institute enriched its germplasm on all the mandate crops with two more accessions having been registered with NBPGR. The PPV & FR Authority has finalized the DUS guidelines and is in the process of getting it cleared through a gazette notification. Surveys conducted revealed the incidence of *Erythrina* gall wasp in all the areas where *Erythrina* spp is being used as standard for trailing black pepper vines. Microsatellite markers were developed for the characterization of *Curcuma* species. Biosurfactants from potential endophytic bacteria showed biocidal activity against *Phytophthora* and *Pythium* spp. Irrigation during summer months at fortnight intervals and targeted application of nutrients based on soil test results increased the yield in black pepper. Ginger when dried with and without peeling has shown no variation in oil and oleoresin contents. Turmeric samples stored under controlled atmosphere showed no variation in oleoresin and curcumin contents besides being free from insect attack.

The achievements made were published as research papers and use of information technology has helped in updating our research capabilities. Front line demonstrations on black pepper have been laid out with the varieties and technologies developed by the institute. The impact of various technologies developed by the institute is also being studied. Besides, KVK conducts training programmes based on the farmers' needs.

I consider it as my privilege to place on record the encouragement and support given by Dr. Mangala Rai, Director General, ICAR. But for the strong encouragement and guidance we received from Dr. H.P. Singh, Deputy Director General (Horticulture) we would not have made such achievements. He was a source of strength for us. We are also grateful to Dr. Umesh Srivastava, ADG (Hort. II) for all the support he gave to us. I am equally thankful to the Chairman and members of Research Advisory Committee for their suggestions and fine tuning our research programmes. I appreciate the efforts taken by all the staff of this institute for their united support in running our programmes for the welfare of farmers. I appreciate the editors for having compiled and brought out this Annual Report.

Calicut
Date: 01 September 2009

V.A. Parthasarathy
Director

सारांश

काली मिर्च

अनुवांशिक संसाधन

काली मिर्च जननद्रव्य संरक्षणशाला में दो हज़ार पांच सौ पचहत्तर अक्सेशनों (1266 वन्य अक्सेशन, 1300 स्थानीय कल्टिवर्स और नौ विदेशी अक्सेशन) का अनुरक्षण किया गया है। इलायची अनुसंधान केन्द्र, अप्पंगला में *वन्य पाइपर अक्सेशनों* के लिये वैकल्पिक जननद्रव्य संरक्षणशाला की स्थापना की गई जहाँ 238 वन्य पाइपर अक्सेशनों को खेत जीन परिक्षेत्र में स्थापित किया गया। चरमादि, मुडिगिरी, खालसा और कुदरेमुख वनों का सर्वेक्षण करके वहाँ से 32 वन्य पाइपर अक्सेशनों को एकत्रित करके जननद्रव्य संरक्षणशाला में अनुरक्षण किया। प्रमुख स्थानीय कल्टिवर्स और वन्य सम्बन्धित बुश पेप्पर विकसित करके आई. आई. एस. आर. कालिकट में रोपण किया। काली मिर्च अक्सेशनों के पादप नमूनों को तैयार करके पाईपर के लिये विकसित की गयी फिनोमिक सुविधा में संरक्षित रखा।

जननद्रव्य अक्सेशनों का पंजीकरण

दो निम्नलिखित अक्सेशनों को उनके विशिष्ठ लक्षणों के लिये एन बी पी जी आर में पंजीकृत किया।

1. आई एन जी आर 8099–*पाइपर थोमसोनी* (आई. सी. 398863)- उसके लिंग परिवर्तन के विशिष्ठ स्वभाव के लिए (नर से द्विलिंगी)।
2. आई एन जी आर 8100 – *पाइपर नाईग्रम* (आई. सी. 563950) प्रचुर मात्रा में उत्पन्न होने वाला अनोखा स्पाइक।

जल का उपयोग

करनाटक के जिला मेडिकेरी मे एक किसान के खेत में आयोजित परीक्षण के फलस्वरूप यह निष्कर्ष निकला कि मार्च से मई तक के महीनों में काली मिर्च की बेलों में एक बार 50 लिटर/प्रति बेल की दर से सिंचाई करने पर काली मिर्च के उत्पादन में वृद्धि होती हैं। सिंचाई आधारित फसल की शुष्क औसत उपज 6.8 कि. ग्राम प्रति बेल एवं वर्षा आधारित फसल की उपज 3.25 कि. ग्राम प्रति बेल प्राप्त हुई।

अन्त:फसल

तीन वर्षों तक विभिन्न फसलों पर परीक्षण करने के उपरान्त यह निष्कर्ष निकला कि जो काली मिर्च के बाग 15 वर्ष से अधिक पुराने है उनके साथ अन्त: फसल के रूप में अदरक (वरदा), टेपियोका (श्रीजया), कोलियस (निधि), अमोरफोफालस (गजेन्द्रन) और संकर नैपियर (सी ओ 3) उपयुक्त थी।

लक्षित उपज के लिये आवश्यक पोषण

काली मिर्च की शुष्क उपज 5, 7.5 और 10 कि. ग्राम प्रति बेल का लक्ष्य निर्धारित किया गया तथा मृदा की उर्वरता के आधार पर आवश्यक उर्वरकों की मात्रा अंकित की गई और उन्हें मेडिकेरी के मृग राजेन्द्रा एस्टेट और माडापुर में विभाजित करके डाला गया। निर्धारित उपज लक्ष्य को लगभग कुछ कमी के साथ प्राप्त कर लिया। प्राप्त उपज 5.5, 7.3 और 8.2 कि. ग्राम/बेल का लक्षित उपज 5, 7.5 और 10 कि. ग्राम/बेल में क्रमश: +11% , - 2.2% - 18.0% का विचलन था। नियन्त्रण की तुलना में उपज में 39-104 % वृद्धि हुई।

भूमि संरक्षित फसलों द्वारा मृदा उर्वरकता का प्रबन्धन

काली मिर्च बागों में भूमि संरक्षण फसलों, जैसे लोबिया और कुलथी को तीन ऋतुओं में अर्थात् सितम्बर से मई तक पोषक तत्वों का आकलन किया। मात्र लोबिया की फसल क्रम में नाइट्रोजन, फोस्फोरस, पोटैशियम, कैल्शियम और मैग्नीशियम क्रमश: 95.04, 5.81, 27. 46, 24.29, 3.96 कि.ग्राम प्रति हेक्टर, जबकि मात्र कुलथी के फसल क्रम में नाइट्रोजन, फोस्फोरस, पोटैशियम, कैल्शियम और मैग्नीशियम क्रमश: 26.08, 2.36, 15.90, 7.58, 2.48 कि. ग्राम/प्रति हेक्टर का योगदान है। लोबिया के बाद कुलथी या उसके समकक्ष का योगदान मात्र लोबिया लगाने की अपेक्षाकृत कुछ कम होता है।

कल्टिवर्स के सुगन्धित तेल के संघटकों पर क्षेत्रों का प्रभाव

आई. आई. एस. आर. फार्म, पेरूवन्नामुषि, कालिकट और काली मिर्च अनुसंधान क्षेत्र, पन्नियूर से काली मिर्च के पर्ण तेल के प्रमुख संघटक जरमाकीन-डी और एलिमोंल के रूप में मिले। दोनों क्षेत्रों के फलों में α -

कैरियोफिलिन अधिक था तथा फलों एवं पर्ण नमूने में अत्यधिक असमानता थी। पर्ण तेल में α-कैरियोफिलिन की मात्रा 2.03 से 8.47% तथा जरमाकीन- डी की मात्रा 4.08 से 44.2% मिली। जरमाकीन डी की अधिकतम मात्रा पन्नियूर-3 में तत्पश्चात् पन्नियूर-2, पन्नियूर-6 और पन्नियूर-7 में मिली थी। कई कल्टिवर्सों के पर्ण तेलों का अन्य प्रमुख संघटक एलिमोल की मात्रा 2.37 से 55.2% थी। एलिमोल की अधिकतम मात्रा वटमुण्डा तत्पश्चात् नीलमुण्डी तथा अंगमाली में होती है।

नियन्त्रित परिस्थिति में भण्डारण एवं गुणवत्ता

काली मिर्च के नमूनों को 480 दिनों तक 10% आर्द्रता वाले नियन्त्रित वातावरण (90% नाइटोजन+ 10% ओक्सीजन) में भण्डारण करने पर नियन्त्रण की अपेक्षा सुगन्धित तेल, ओलिओरसिन और पाइपरिन की मात्राओं में सार्थक भिन्नता नहीं दिखाई दी।

फाइटोफथोरा प्रतिरोधकता

आई. आई. एस. आर. शक्ति (04-पी 24-1) की खुले परागित संतति ने *पी. कैप्सीसी* द्वारा जडों के संक्रमण के विरूद्ध लगातार प्रतिरोधकता दिखाई। 155 संकर, 68 कल्टिवर्स और 13000 बीज संततियों का विवक्ति करण किया, जिनमें तीन खुले संततियों जैसे एच. पी 1533 (2), एच. पी 1533 (3) और 04- पी 24-1; चार संकर, एच. पी 449, एच पी 490, एच पी 521, एच पी 1375 और एक कल्टिवर सी.1530 की *पी. कैप्सीसी* के विरूद्ध मध्यम प्रतिरोधकता मिली। *पी. कैप्सीसी* के प्रति मध्यम प्रतिरोधकता वाली आशाजनक प्रकारो का खेतों में परीक्षण हो रहा है। आठ वन्य अक्सेशनों का विवक्ति करण किया, जिनमें 3362 (*पी. ओरनाटम*) ने *पी. कैप्सीसी, रैडोफोलस सिमिलस* तथा *मेलोडोगाइन इनकोग्निटा* के विरूद्ध प्रतिरोधकता दिखाई।

फाइटोफ्थोरा प्रबन्धन

जैविक नियन्त्रण: अन्त: पादपी एवं परिवेषी जैव नियन्त्रण कारक जैसे बी पी 35, बी पी 25, बी पी 17, टी सी 10, आई आई एस आर 853 और आई आई एस आर 6 को खेत में एकीकृत प्रबन्ध परीक्षण में *पी. कैप्सीसी, आर. सिमिलिस* और *एम. इनकोग्निटा* के प्रति परीक्षण किया। निरीक्षण के अनुसार छ: महीने के पौधों पर टी सी 10+ मेटालेक्सिल - एम ज़ेड तथा आई आई एस आर 853 + मेटालेक्सिल - एम ज़ेड का उपचार बहुत उत्साहजनक रहा है।

फाइटोफथोरा के प्रति नये रसायनों का मूल्यांकन : नये रसायनों जैसे बेनज़ोयिक एसिड, सैलिसाईक्लिक एसिड (*कोमालिना ओडोराटा* से), पोटैशियम बाईकारबोनेट, कैप्टन हेक्साकोनाज़ोल और कारबैनडाज़िम- मैनकोज़ेब को *पी. कैप्सीसी* के प्रति प्रयोगशाला में परीक्षण किया। कैप्टन हेक्साकोनाज़ोल (50 पीपीएम), बेनज़ोयिक एसिड और सैलिसाईक्लिक एसिड कमश: 100 और 200 पीपीएम पूर्णत: निरोधी थे। पोटैशियम बाईकारबोनेट और कारबैनडाज़िम - मैनकोज़ेब की मात्रा कमश: 1000 पीपीएम और 500 पीपीएम न्यूनतम निरोधक थे।

एन्थ्राकनोज़ रोग का प्रबन्धन

काफी + काली मिर्च की मिश्रित फसल के अन्तर्गत रोगों का प्रबन्धन के लिये कवगनाशी (1% बोर्डियो मिश्रण, हैक्साकोनाज़ोल, कारबैनडाज़िम, पोटैशियम फोस्फोनेट, मैनकोज़ेब) तथा जैव नियन्त्रण कारक (*ट्राईकोडरमा हरज़ियानम* और *स्यूडोमोनोस फ्लूरीसेन्स*) के संयोजन से परीक्षण आयोजित किया, जिनमें *टी. हरज़ियानम* को पौधे के निचले भाग तथा 1% बोर्डियो मिश्रण को उपरी भाग में छिडकाव करना प्रभावशाली था। इन उपचारों के बाद खुर गलन रोग नहीं हुआ जबकि अनुपचारित नियन्त्रण में 22% खुर गलन का संकमण था। यह उपचार खुर गलन आपतन को प्रभावी ढंग से कम करते हैं। खेत में रोग बाधित मलबा (debris) में एन्थ्रक्नोज़ का रोगजनक आठ महीनों से अधिक समय तक जीवित रहते हैं।

काली मिर्च पौधशाला में रोग प्रबन्धन

सौरीकृत पोटिंग मिश्रण के साथ 12 विभिन्न उपचारों, जैसे, सीओसी (0.2%) + फोरैट, कारबैन्डाज़िम (0.2%) + फोरैट, मेटालैक्सिल एम ज़ैड (0.125%) + फोरैट, पोटैशियम फोस्फोनेट (0.3%) + फोरैट, कारबैन्डाज़िम एम ज़ैड (0.25%) + फोरैट, मैनकोज़ेब (0.25%) + फोरैट, *टी. हरज़ियानम* + फोरैट, आई आई एस आर 853, *पैसिलोमाइसिस लिलासिनस, पोकोनिया क्लामाईडोस्पोरिया*, आई आई एस आर 6 और नियन्त्रण (केवल साधारण पोटिंग मिश्रण) को नर्सरी रोग नियन्त्रण करने के लिए परीक्षण आयोजित किये। परीक्षण किये गये उपचारों में या नियन्त्रण में जहाँ पाली बैग की मृदा में आर्द्रता 10% से कम थी, फाइटोफथोरा का संकमण नहीं दिखाई दिया। नियन्त्रण में कोई भी रोग नहीं था।

विभिन्न कालों में विषाणुओं का वितरण

विषाणु बाधित काली मिर्च की पॉच प्रजातियों में, DAS-ELISA द्वारा पाइपर येल्लो मोटिल वाइरस (PYMov) तथा CMV की विविधता प्रत्येक माह के

अन्तराल पर जानने के लिये परीक्षण किया। परीक्षण के परिणाम से यह ज्ञात हुआ कि वर्ष के अलग अलग महीनों में दोनों विषाणुओं की मात्रा का अनुपात भिन्न होता है।

पाइपर येल्लो मोटिल वाइरस (पी. वाई. एम. ओ. वी.) वियुक्तियों में विभिन्नता

विभिन्न भौगोलिक क्षेत्रों (केरल के जिले कालिकट, इदुक्की, और वयनाडु तथा करनाटक के जिला कोडागु) की चार वियुक्तियों से ओ आर एफ I तथा ओ आर एफ III के एक भाग का क्लोन एवं अनुकम किया। ओ आर एफ I के अनुकम में अधिक विविधता थी जबकि + 0 III के अनुकम अन्य वियुक्तियों की अपेक्षा अधिक संरक्षित थे।

पाइपर लोंगम और *पी. बीटल* में बैडना विषाणु की पहचान

बैडना विषाणु बाधित *पाइपर लोंगम* तथा *पी. बीटल* के ओ आर एफ I तथा ओ आर एफ III का एक भाग प्रवर्धन, क्लोन एवं अनुकम किया गया। काली मिर्च के पी वाई एम ओ वी की वियुक्तियों में न्यूक्लियोटाइड स्तर पर *पी. बीटल* के साथ 94- 97% और *पी. लोंगम* के साथ 88- 89% पहचान की। अन्य बैडना विषाणु की तुलना में 60 प्रतिशत से कम अभिलक्षण थे। अत: अनुकम पहचान के आधार पर यह निष्कर्ष निकला कि भारत में बैडना विषाणु का *पी. बीटल* और *पी. लोंगम* में संकमण होता है तथा पाइपर येल्लो मोटिल वाइरस के विभेद है।

पोल्लु बीटल (*लोंगिटारसस निग्रिपेन्निस*) प्रतिरोधकता के लिए खेत में विविक्तकरण

काली मिर्च जननद्रव्य अक्सेशनों (113 कल्टिवर्स और 72 संकर) को पोल्लु बीटल प्रतिरोधकता के लिए परीक्षण किया गया। कल्टिवर्सों में अक्सेशन नम्बर 35 की बेरी को अधिकतम हानि (36.5%) तत्पश्चात् अक्सेशन नम्बर 88 (34.5%) में दर्ज की गई। बेरी की न्यूनतम हानि अक्सेशन नम्बर 1636(1.75%) तथा अक्सेशन नम्बर 1423(2.74%) में दर्ज की गई। संकरों में सबसे अधिक हानि अक्सेशन नम्बर 861 (44.4%)तत्पश्चात् अक्सेशन नम्बर 1471 (41.5%) में हुई। सबसे कम हानि अक्सेशन नम्बर 1388 (4. 49%) तत्पश्चात अक्सेशन नम्बर 1726(5.74%) में दर्ज की गई।

एरिथ्रीना गाल वास्प (*क्वाड्रास्टिकस एरिथ्रीनी*) का आपतन

केरल के 4 जिलों (इदुक्की, कोषिक्कोड, कन्नूर और वयनाडु) के 13 तालूकों तथा करनाटक के जिला कोडागु के 3 तालूकों के 276 काली मिर्च (*पाइपर नाइग्रम*) के बागों में अप्रैल से जुलाई 2008 तक एरिथ्रीना स्पीसीस, जिनको काली मिर्च बेलों के सहायक वृक्ष के रूप में उपयोग किया जाता है, पर एरिथ्रीना गाल वास्प (*क्वाड्रास्टिकस एरिथ्रीनी*) के आपतन का अध्ययन करने के लिए सर्वेक्षण किया! सर्वेक्षण किये सभी बागों में एरिथ्रीना के पेडों में एरिथ्रीना गाल वास्प का आपतन दर्ज किया गया तथा कीट बाधित पेडों का प्रतिशत वयनाडु जिले में सबसे अधिक (59.6%), तत्पश्चात् इदुक्की (53.4%), कोडागु (51.8%) और कन्नूर (39.1%) में दर्ज किया गया। कीट बाधित टहनियों का प्रतिशत भी वयनाडु जिले में सबसे अधिक (39.7%) तत्पश्चात् इदुक्की (35.5%), कोडागु (33.4%) और कोषिक्कोड (31.6%) जिले में था। एरिथ्रीना के विभिन्न स्पीसीसों/प्रकारों पर आपतन में विविधता होती है और *ई. वैरिगेटा* (सफेद कांटे जैसा) में सबसे अधिक औसतन 91.8% पेड़ और 66.8% टहनियॉ कीट बाधित थी। सर्वेक्षण से यह निष्कर्ष निकला कि गत वर्षों में गाल वास्प *एरिथ्रीना* स्पीसीस को बाधा पहुँचाती है जिससे केरल और करनाटक में काली मिर्च के उत्पादन में यह एक प्रमुख समस्या है।

सूत्रकृमि प्रतिरोधकता में फिनाइल प्रोपेनोयिड्स

फिनाइलेलेनिन अमोनिया लाएस (पीएएल) एवं केफिक एसिड–ओ –मीथाइलटान्सफेरेज़ (सीओएमटी) की सक्रियता को काली मिर्च की सुग्राही प्रजाति आई आई एस आर श्रीकरा की पत्तियों तथा जडों पर बढाने से *रेडोफोलस सिमिलिस* की संकमिकता पर पडता है। अत: *काली मिर्च में सूत्रकृमि और पादप की पारस्परिक* कियाओं में फिनाइल प्रोपनोयिड्स की भूमिका है।

अनुकम समानता

काली मिर्च के सूत्रकृमि प्रतिरोधक अक्सेशन एच पी 39 से क्लोन किये बहुरूपी 650 बी पी खण्ड की अनुकमण को एसिटाइल - सीओए कारबोज़ाइलेस से अधिकतम समानता है तथा सूत्रकर्षमि प्रतिरोधकता के लिए कोई विशेष जीन गुण नहीं है।

इलायची

अनुवांशिक संसाधन

गत वर्ष पचास अक्सेशनों को अभिलक्षिकरण किया, अब तक कुल अभिलक्षित अक्सेशनों की संख्या 350 हो गई है। इलायची अनुसंधान केन्द्र, अप्पंगला के एक्स सिटु जीन बैंक में कुल 442 अक्सेशनों (मलबार 278, मैसूर 73, वाषुका 63 और अन्य 28) का अनुरक्षण किया।

संकरों का मूल्यांकन

वर्ष 2008 - 09 में पीईटी I तथा पीईटी II के अन्तर्गत संकरों (सीसीएस -1 x आर आर -1, आर आर -1 x सीसीएस -1, एम बी- 5 x जी जी, एएसएच, एन के ई -19 x जी जी, जी जी x एन के ई -19) की पहचान के लिये मूल्यांकन किया गया। एम एल टी परीक्षणों में एस ए एम, सी पी- 4 और एन एच वाई- 10 अन्य की अपेक्षा उत्तम हैं।

जलाभाव सहिष्णुता

खेत में सूखा सहिष्णुता के लिए इलायची (संकर एवं स्वयं नवोदभिद) के चार संयुक्त कॉसों के मूल्यांकन से ज्ञात हुआ कि ग्रीन गोल्ड और उसके संयुक्त कॉस, अन्य कॉसों की तुलना में प्रतिबल के अन्तर्गत उत्तम वृद्धि और उपज क्षमता है। 893 x आर आर-1, जी जी x आर आर-1, सीसीएस-1 x जी जी, जी जी x 893 और सीसीएस-1 x जी जी अन्य कॉसों की अपेक्षा खुले प्रकाश में पत्तों को मुडने के लिए अधिक समय लेते है।

गुणवत्ता मूल्यांकन

इलायची के 5 संकरों सहित बासठ अक्सेशनों का बीजों, सुगन्धित तेल की मात्रा और सुगन्धित तेल के संघटकों के लिए विश्लेषण किया गया। इलायची कैप्स्यूल में 55 - 82% बीज तथा 4.0- 6.5% सुगन्धित तेल होता हैं। अक्सेशन संख्या वी ए - 1, एम ए -18, आई सी 391657, आई सी 547147, आई सी 547144, आई सी 349652, आई सी 349633, आई सी 547153 और आई सी 547220 में 66.74 % बीज एवं 6.5% सुगन्धित तेल की मात्रा अंकित की गई। तेल का प्रमुख संघटक 1, 8- सिनियोल 22 से 40% तथा α - टरपेनियल एसिटेट 32 से 47% होता है। अक्सेशन संख्याएं जी जी x एन के ई-12, एन के ई-19, ओ पी- 27, एम ए- 29, आई सी 547147, आई सी 547154 और आई सी 547144 को 1, 8 -सिनियोल की अत्यधिकता (> 35%) वाले चिनहित किये गये तथा पी सी, सी पी- 4, एन के ई-12 x जी जी, एन के ई-19 x जी जी, जी जी x एन के ई-19 और जी जी सकर्स में α - टरपनियल एसिटेट अधिक (> 45%) होता हैं।

मृदा गुणवत्ता

विभिन्न इलायची आधारित फसल चक जैसे., इलायची + जायफल, इलायची + आलस्पाइस, इलायची + दालचीनी, मात्र इलायची, इलायची + काफी एवं इलायची +सुपारी के खेतों की मृदा गुणवत्ता का अनुपात जानने के लिए मृदा नमूने का विश्लेषण किया गया। परिणाम से यह ज्ञात होता है कि सम्बन्धित फसल को विभिन्न भौतिक रसायनिक और जैव रसायनिक अनुपात पर थोडा प्रभाव होता है। मृदा का पी एच 4.8-5.2 और ओरगानिक कारबन 1.9 -2.7% के मध्य होता है। नाइट्रोजन की मात्रा 121 -148 मि. ग्राम/कि.ग्राम, रेंक फोस्फोरस 21- 41 मि. ग्राम/कि. ग्राम और पोटैशियम 212- 338 मि. ग्राम/कि. ग्राम के मध्य है। सूक्ष्म पोषण में, डीटीपीए ज़िक (0.72- 1.04 मि. ग्राम/कि.ग्राम) की मात्रा सभी मृदा नमूनों में कम थी।

कैट्टे विषाणु का शोधन एवं उनकी पहचान

करनाटक और केरल राज्यों से अठारह कैट्टे वियुक्तियों को संचित करके कीट रहित ग्लास हाउस में स्थापित किया। इलायची के कैट्टे/मोसाइक रोग के रोग कारक वाइरसों (मैक्लुरा वाइरस)के शुधीकरण के लिए प्रोटोकोल मानकीकृत किया। कैट्टे रोग बाधित इलायची के पौधों के पत्तों से मैक्लुरा वाइरस का पता लगाने के लिए आर एन ए वियुक्ति (आर टी - पी सी आर) के लिए प्रोटोकोल मानकीकृत किया गया। विषाणु की पहचान 7 टेम्प्लेट (जो नमूनों से निकला गया है) पर कर सकते है।

रोग प्रतिरोधकता के लिए विवक्तीकरण

इलायची में पर्णब्लाइट, प्रकन्द गलन और पर्ण दाग की प्रतिरोधकता ज्ञात करने के लिये अठावन अक्सेशनों का विवक्तीकरण किया गया। पर्णब्लाइट और प्रकन्द गलन रोग की प्रतिकिया के आधार पर अक्सेशनों को दो लगातार वर्षो 2007 और 2008 के परिणाम के आधार पर विभिन्न समूहों में बांटा गया। इनमें से कोई भी पर्णब्लाइट रोग के लिए अत्यधिक प्रतिरोधक नहीं था। आई सी 349646 में औसतन 20% पर्णब्लाइट रोग के लिये प्रतिरोधकता अंकित की गई। तेईस अक्सेशन प्रकन्द गलन रोग के लिए अधिक प्रतिरोधक थे।

हल्दी

अनुवांशिक संसाधन

वर्ष 2008 - 09 में चौंतीस हल्दी अक्सेशनों को एकत्रित करने के बाद जननद्रव्य संग्रहालय में जमा किया इनकी कुल संख्या 1026 हो गई।

माइक्रोसैटेलाईट मार्कर्स का विकास और *कुरकुमा* स्पीसीस का चरित्रांकन

हल्दी (*कुरकुमा लोंगा* एल.) के कुल 140 माइक्रोसैटेलाईट के जीनोमिक डी एन ए के खण्ड को पृष्थकीकरण के साथ द्वि तथा त्रि - न्यूक्लियोटाइड बायोटिनिलेटेड को सपरीक्षित संकरण विधि द्वारा किया। एन सी बी आई डेटा बेस में जमा हल्दी के अभिव्यक्त अनुकम टेग का आकार एवं आवृत्ति के क्लास1 (हाइपरवेरियबिल) साधारण अनुकम दोहराने के लिये निरीक्षण किया। ई एस टी युक्त एस एस आर के प्रवर्धन के लिये आठ बहुरूपी प्राइमर की पहचान की गई। यह प्राइमर *कुरकुमा* की 13 विभिन्न प्रजातियों में भी अन्तरणीय है। तेरह *कुरकुमा* प्रजातियों के प्रकन्द की जल धुलन प्रोटीन के ए ई एच पी एल सी क्षालन परिच्छेदिका पर यु पी जी एम ए छः प्रमुख क्लस्टर्स बनाता है जो *कुरकुमा मलबारिका* तथा *कुरकुमा* ज़ेडोरिया में अधिकतम समानता प्रकट करता है। कुरकुमा की 13 प्रजातियों में *कुरकुमा सिलवाटिका* के अन्दर जैविक रूप से सकिय पेप्टाइड टरमरिन (320 मि. ग्राम/100 ग्राम) की मात्रा अंकित की गई।

घटना विज्ञान एवं शुष्क पदार्थों का वितरण

हल्दी की प्रजातियों जैसे, प्रतिभा, आलप्पी, सुप्रीम, सुगुणा, प्रभा और केदारम जिनको कमशः 30 अप्रैल, 15 मई, 30 मई और 15 जून को रोपण किया गया औसतन 23.5, 18.5, 16.5 और 12.3 दिनों बाद पौध ो का निर्गमन तथा पहली तलशाखा का निर्गमन 98. 4, 59.9, 56.7 और 48.5 दिनों बाद हुआ। जड, प्रकन्द, आभासी तना और पत्तों में शुष्क पदार्थों का वितरण जानने के लिये रोपण के पॉच महीने बाद विनाशात्मक नमूना लिये। उपरोक्त हल्दी प्रजातियों में औसत जड़, प्रकन्द, आभासी तना तथा पत्तों से कमशः 8.10%, 60.7%, 8.90% और 22.29% शुष्क पदार्थ की मात्रा अंकित की गयी।

नियन्त्रित वातावरण में भण्डारण एवं गुणवत्ता

हल्दी के 10% नमीयुक्त नमूने नियन्त्रित वातावरण (90% नाइट्रोजन + 10% ओक्सीजन) में 480 दिनों तक रखे गये। नियन्त्रण की तुलना में उसके सुगन्धित तेल में न्यूनतम विविधता तथा ओलिओरसिन और कुरकुमिन की मात्रा में कोई विविधता नहीं थी। नियन्त्रित वातावरण में भण्डारण किये नमूने पूरी तरह कीट बाधा से मुक्त थे।

शुष्क करने की विधियों का गुणवत्ता पर प्रभाव

हल्दी की प्रजातियॉ, प्रतिभा तथा आलप्पी को उबालकर या बिना उबाले संसाधित किया गया। इसके उपरान्त इन नमूनों को गरम वायु ऑवन, उल्टा प्रवाह तथा सूर्य प्रकाश में सूखा कर उसके तेल, ओलिओरसिन एवं कुरकुमिन की मात्रा के लिए मूल्यांकन किया गया। उबालकर या बिना उबाले संसाधित करने तथा विभिन्न सुखाने की विधियों से तेल, ओलिओरसिन और कुरकुमिन की मात्रा में कोई अन्तर नहीं था।

प्रकन्द गलन

ट्राइकोडरमा द्वारा प्रबन्धनः *ट्राइकोडरमा* स्पीसीस की बाईस वियुक्तियों को हल्दी के राइसोस्फियर से पृथकीकरण करके उनकी *पी. अफेनीडरमेटम* (हल्दी के प्रकन्द गलन रोग का कारक) के विरूद्ध प्रतिरोधकता का मूल्यांकन किया। इन विटो अध्ययन से बाईस वियुक्तियों में से कुल छः वियुक्तियों में ही 70% से अधिक की माइसीलियल निरोधकता थी। बाष्पशील उपापचय द्वारा अधिकतम निरोधकता सीएलटी 118 (84.82%) और सीएलटी 121 (82.22%) में अंकित की गई। बाष्पशील रहित उपापचय द्वारा उत्पादित सीएलटी 102 (37.78%), सीएलटी 107 (38.52%), सीएलटी 110 (46.30%) और सीएलटी 114 (42.22%) रोग कारक के प्रति अपेक्षाकृत प्रभावी थे। सीएलटी 114 को बिदार (करनाटक) तथा सीएलटी 102 को वयनाडु, (केरल) के रोग जनक की कोशिका द्रव्यीय स्कन्दन को द्वैती संवर्धन में प्रेरित किया।

रसायनिकों द्वारा प्रबन्धनः तमिलनाडु के कोयम्बटोर जिले के अन्नूर के निकटवर्ती सेट्टिपुतूर ग्राम में हल्दी के खेत में वर्ष 2007–09 में विभिन्न रसायनिकों का उपयोग करके रोग प्रबन्धन पर परीक्षण किया। हल्दी के पैदावार क्षेत्रों में किसानों के लिए यह रोग एक प्रमुख समस्या है। कुल दस उपचारों में, मेटेलेक्सिल-मैनकोज़ेब (44.5%)तत्पश्चात् कोप्पर ओक्सीक्लोराइड (36.5%) द्वारा नियन्त्रण की तुलना में रोग में कमी दर्ज की गई।

हल्दी के प्रकन्द गलन से पाईथियम वियुक्ति का आणविक अभिलक्षणीकरण

सार्वत्रिक प्राइमर्स आई टी एस I और आई टी एस 4 का संयोजन रोगजनक पाईथियम वियुक्ति (केरल के दक्षिण क्षेत्रों में हल्दी उगाने वाले क्षेत्रों से संचित) के अभिलक्षणीकरण के लिए उपयोग किया जिनसे पी सी आर में एक 900 बीपी खण्ड उत्पादित हुए। प्रवर्धित उत्पादन को सीमित एनज़ाइमों से (एमएसपी 1, टी ए क्यु1 और ए एल यु 1) के साथ पी सी आर - आर एफ एल पी का विश्लेषण किया। आर एफ एल पी फिंगर प्रिन्ट डाटा के आधार पर वियुक्तियों को 10% समानता के साथ दो वर्गों में बॉटा गया।

तना बेधक (*कोनोगीथस पंक्टिफैरालिस*) के लिये जननद्रव्य का विविक्तीकरण

हल्दी के अक्सेशनों (नम्बर 915) को तना बेधक के प्रति खेत में विविक्तीकरण किया। अधिकतम तने की हानि (80%) अक्सेशन संख्या 345, 525 और 882 में अंकित की गई। बारह अक्सेशनों में (अक्सेशन संख्या 405 444, 455, 692, 718, 880, 888, 897 917, 979 और 995) 75% तने की हानि अंकित की गई। चवालीस अक्सेशन तना बेधक के आकमण से मुक्त रहे।

प्राकृतिक शत्रु

हल्दी को हानि पहुँचाने वाला तना बेधक(*कोनोगीथस पंक्टिफैरालिस*) की प्राकृतिक शत्रुओं का प्रलेख किया गया। फसल काल में *अपान्टीलस टारागमे,* पहचान रहित हाईमेनोप्टेरस पैरासिटोयिड्स और कर्णकीट को प्राकृतिक शत्रुओं के रूप में प्रलेखित किया गया।

प्रबन्धन

चार कीटनाशी(मैलाथियोन 0.1%, कारबोसल्फान 0.075%, इमिडेक्लोप्रिड 0.0125%, और लामदा सिहालोतिहरिन 0.0125%), जो ग्रीन हाउस में प्रभावकारी थे। तना बेधक के प्रबन्धन में उनकी प्रभावशीलता के लिए पेरूवन्नामुषि फार्म के खेत में परीक्षण किया गया। कीटनाशियों को जुलाई से नवम्बर में 21 दिनों के अन्तराल में छिडकाव किया गया तथा दिसम्बर में कीट बाधित तने का फसल परिपक्वता पर आकलन किया। परिणाम से यह ज्ञात हुआ कि इमिडेक्लोप्रिड (0.0125%) के अतिरिक्त अन्य सभी कीटनाशी तना बेधक के प्रभाव के प्रतिशत को कम करते हैं!

अदरक

अनुवांशिक संसाधन

अदरक के छरू सौ अस्सी अक्सेशनों का खेत जननद्रव्य संग्रहालय में अनुरक्षण किया। वर्ष 2008-09 में बीस अक्सेशनों को जननद्रव्य संरक्षणशाला में शामिल किया गया।

जननद्रव्य का मूल्यांकन

बारह चयनित विदेशी (नेपाल) अक्सेशनों को परिक्षार्थ आई आई एस आर वरदा के साथ उपज एवं आकृति लक्षणों के लिए मूल्यांकन किया। इन अक्सेशनों की शाखाओं/सपुंजन गुच्छन तथा प्रकन्द उपज में महत्वपूर्ण सार्थक अन्तर थे। अक्सेशन 578 में सबसे अधिक (9.82 कि. ग्राम/3 मीटर) सपुंजन गुच्छन की उपज अंकित की गई जो परिक्षार्थ (9.63 कि. ग्राम/3 मीटर) के लगभग बराबर है। अधिक तेलयुक्त 13 अदरक अक्सेशनों की आकृति एवं उपज का मूल्यांकन करने पर, अक्सेशन 162 में अधिक उपजता तत्पश्चात् अक्सेशन 217 और 209 से उपज प्राप्त हुई। इन अक्सेशनों में उपज का अन्तर 5.26 से 8.74 कि. ग्राम/3मीटर^2 बेड था।

अधिक पराग उर्वरकता वाले अक्सेशन

अभिरंजकता तथा इन विट्रो अंकुरण द्वारा अदरक के जननद्रव्य में अधिक पराग उर्वरकता की पहचान विविक्तीकरण द्वारा की गई। अदरक अक्सेशन संख्या 195 में ग्लिसिरो कारमिन अभिरंजन द्वारा औसत पराग उर्वरकता 67.73% और इन विट्रो अंकुरण द्वारा 60. 3% अंकित की। पराग अंकुरण को वार्तिकाग्री के सतह पर तथा स्व परागण भी देखा गया। प्रेरणिक बीज समुच्चय पर भविष्य में अध्ययन करने पर जीन प्रारूप उत्तम है।

घटना विज्ञान तथा शुष्क पदार्थों का वितरण

अदरक की प्रजातियॉ जैसे, रजता, महिमा, हिमाचल, वरदा और मारन जिनको कमशः 30 अप्रैल, 15 मई, 30 मई और 15 जून में रोपण करने पर औसतन 30. 9, 25.3, 25.7 और 23.9 दिनों बाद पौधे का निर्गमन तथा 74.8, 46.8, 46.4 और 42.6 दिनों बाद पहली तलशाखा का निर्गमन हुआ। शुष्क पदार्थों का वितरण (रोपण के पॉच महीने बाद विनाशात्मक नमूना द्वारा आकलन) के आकलन से यह ज्ञात हुआ कि कमशः जड, प्रकन्द, आभासी तना और पत्तों में औसतन 12.35%, 65.34%, 7.69% और 14.61% शुष्क पदार्थ होते हैं।

स्वच्छ और शुष्क अदरक प्रकन्द के सुगन्धित तेल का संयोजन

स्वच्छ तथा शुष्क अदरक के प्रकन्द में सुगन्धित तेलों के संघटकों का तुलनात्मक अध्ययन करने से यह ज्ञात हुआ कि स्वच्छ प्रकन्द में मोनोटरपेन्स ज़ेड - सिट्रल तथा ई - सिट्रल अधिक मात्रा में वही शुष्क प्रकन्द में सीसक्योटरपेन हाइड्रोकार्बन, ज़िंजिबिरेन, फरनेसेन्स तथा सीसक्युफीलान्ड्रीन अधिक प्रभावशाली होते हैं।

शुष्क करने की विधि एवं गुणवत्ता

अदरक की वरदा प्रजाति की छाल निकालकर या बिना निकाल कर गरम वायु के ओवन, उल्टा प्रवाह तथा सूर्य प्रकाश में सुखा कर उसके तेल, ओलिओरसिन और ज़िंजरोल मात्रा के लिए मूल्यांकन किया। छाल निकाले या बिना निकाले अदरक में तेल और ओलिओरसिन की मात्रा में कोई अन्तर नहीं देखा गया। लेकिन बिना छाल निकाले प्रकन्द, सूखने में अधिक समय लेते है।

तना बेधक (*कोनोगीथस पंक्टीफैरालिस*) के लिए जननद्रव्य का विविक्तिकरण

खेत में तना बेधक (*कोनोगीथस पंक्टीफैरालिस*) के प्रति चार सौ बानबे अदरक (*ज़िंजिबर ओफीसीनेले*) अक्सेशनों को विविक्तिकरण किया गया। इन अक्सेशनों को उनकी प्रतिरोधकता/सुग्राह्यता के लिए अंकित किया गया। अक्सेशन 49, 251, 130 और 62 को इस कीट के लिए कमशः प्रतिरोधक, मध्यम प्रतिरोधक, सुग्राह्य और अधिक सुग्राह्य के रूप में अंकित किया गया।

जीवन चक्र का अध्ययन

तना बेधक के जीवन चक्र का अध्ययन 5 प्रतिरोधक अक्सेशनों (अक्सेशन संख्या 31, 247, 409, 430 और 631), 6 अधिक सुग्राह्य अक्सेशनों (17, 43, 70, 190, 191 और 514) तथा एक सुग्राह्य कल्टिवर (वरदा) में किया गया। प्रतिरोधक, अधिक सुग्राह्यक और सुग्राह्यक अक्सेशनों में, कोशित अवधि में क्रमष 6–21, 7–11 और 8–9 दिनों का अन्तर था। इसके वयस्क की आयुकाल प्रतिरोधक, अधिक सुग्राह्यक और सुग्राह्यक अक्सेशनों पर क्रमश 2–3, 2–4, और 3 दिन की थी।

पैप्रिका

अनुवांशिक संसाधनें

जननद्रव्य संग्रहालय में 5 संग्रहों (वाईएसपीयुएचएफ, सोलन, हिमाचल प्रदेश से दो, केरल से दो और तमिलनाडु से एक) को शामिल किया गया। चउन जननद्रव्य अक्सेशनों जिनमें 21 बिदगी संग्रह और छः विदेशी संग्रहों को बहुगुणित करके बढाया। एकल पौधा चयन और सेल्फिंग द्वारा सत्ताईस नये जननद्रव्य अक्सेशनों का शोधीकरण किया गया।

जननद्रव्य का अभिलक्षीकरण

जननद्रव्य अक्सेशनों की आकृति एवम गुणवत्ता के चरित्रांकन से प्रकट होता है कि फलों के वजन में अधिकतम विविधता (31.26: सी वी) तत्पश्चात् प्रति पौधे की उपज (30.88 सी वी) तथा सबसे कम विविधता (33.34: सी वी) फलभित्ती की मोटाई में अंकित की गई।

रंग

देशी जननद्रव्य अक्सेशनों में आई सी बी डी–11, आई सी बी डी–23, और आई सी बी डी–10 को 300 से अधिक एएसटीए यूनिटों के साथ अधिकतम रंग मान पंजीकृत किया। विदेशी लाइन में ईसी–71, ईसी–6, ईसी–490 और ईसी–18 में अधिक रंग मान अंकित किया गया। जननद्रव्य अक्सेशनों में कैप्साइसिन की मात्रा में 0.0081 से 0.513 प्रतिशत का अन्तर था। कुल मिलाकर, आई सी बी डी–10, के टी पी एल–19 और ई सी–18 में अधिक रंग मान तथा कम तीखापन था।

वैनिला

वैनिला तहिटेनसिस में पुष्पण

वैनिला तहिटेनसिस, वी. प्लानिफोलिया के बाद वैनिला की दूसरी सबसे महत्वपूर्ण मसाला फसल है। चार साल बाद, पहली बार आई आई एस आर प्रायोगिक क्षेत्र, पेरुवन्नामुषि में पुष्पित हुए। उसी खेत में रोपण किये *वी. प्लानिफोलिया* में पुष्पण दो प्रावस्थाओं में प्राप्त हुए। पहली प्रावस्था में सितम्बर से अक्तूबर तक तथा दूसरी प्रावस्था में फरवरी माह में प्रारम्भ होकर प्रगति हो रही है।

वैनिला का बीन कोमन मोसाइक वाइरस (बीसीएमवी)

वैनिला पर नेक्रोसिस और मोसाइक के साथ संयोजक एक वाइरस को प्राटीन आवष्त जीन अनुक्रम की तुलनात्मक तथा जाति वृत्तीय अध्ययन के आधार पर बीन कोमन मोसाइक वाइरस (बी सी एम वी) के प्रभेद के रूप में पहचान की गई।

वृक्ष मसाले

जायफल

संततियों का मूल्यांकन

जायफल के श्रेष्ठ प्रकारों के संतति परीक्षण मूल्यांकन में, अक्सेशन ए 9/185 में औसत अधिकतम उंचाई (592 से. मीटर), चौडाई (582 से.मीटर), मुख्य शाखाओं की संख्या (63. 2) और व्यास 30 से. मीटर तथा भू स्तर से ऊपर की उंचाई (50.3 से. मीटर), जबकि अधिकतम फलों की संख्या (28) प्रति पौधा श्रेष्ठ प्रकार ए9/150 में अंकित की गई।

कैसिया (*सिन्नमोमम कैसिया*)

जननद्रव्य का पंजीकरण

कैसिया के श्रेश्ठ प्रकार ए1 (आई सी संख्या. 370400) को छाल तेल (81.5:) तथा पर्ण तेल (80.5:) में अधिक सिनामलडिहाइड की मात्रा के लिए एन बी पी जी आर, नई दिल्ली में पंजीकृत किया गया (पंजीकरण संख्या– आई एन जी आर 08045)।

आकृति एवम गुणवत्ता का मूल्यांकन

कैसिया के चार श्रेष्ठ प्रकारों में पौधों की उंचाई, चौडाई और मुख्य शाखाओं की संख्या में सार्थक अन्तर अंकित किया। श्रेष्ठ प्रकार डी 1 में पौधों की उंचाई (296.9 से. मीटर), चौड़ाई (234.8 से. मीटर) और मुख्य शाखाएँ/पौधा (14.6) अंकित किया। अप्पंगला में उगाये 15 अक्सेशनों में जैव रसायनिक लक्षणों जैसे छाल तेल, ओलिओरसिन एवम सिनामलडिहाइड की मात्रा को अंकित किया। छाल तेल में 1.2 (डी1) से 3.71 (बी 2), ओलिआरसिन में 7. 52 (बी 8) से 14.14 (बी 2) तथा सिनामलडिहाइड की मात्रा में 65.07 (बी 8) से 89.63 (डी1) का अन्तर है। आर ए पी डी प्रोफाइलों का विकास किया गया और दालचीनी के सात स्पीसीसों में जाति के अन्तः सम्बन्ध ा का अध्ययन किया।

सिनामोमम स्पीसीस में सुगन्धित तेल के संघटक

सिनामोमम सलफुरेटम, सी. ल्यूसिसेन्स, सी. ग्लान्डुलिफीरम, सी. मैक्रोकारपम और *सी. पेरोटीटी* के पत्तों में सुगन्धित तेल के रसायनिक घटकों का जी सी–एम एस विश्लेशण करने पर ज्ञात हुआ कि " फिल्लानड्रीन, ह्य –फिल्लानड्रीन, कैम्फर, टी–कैरियोफाइलिन और जरमाक्रीन–डी इन तेलों के प्रमुख रसायनिक संघटक है।

सी. तमला के पत्तों के सुगन्धित तेल में यूजिनोल, जबकि पेटियोल, नरम तना और तने के तेल में ह्य. फिल्लानड्रीन और पी.सिमने प्रमुख संघटक है। उसी प्रकार, ज. केरियोफिलिन, *सी. मलाबाट्रम* के पर्ण तेल का प्रमुख संघटक है तथा पेटियोल, नरम तना और तना के तेल में लिनालूल की मात्रा अधिक होती है। *सी. सलफुराटम* के पेटियोल एवम नरम तने से प्राप्त तेल में लिनालूल, जबकि पत्तों के तेल में ".फिल्लानड्रीन मुख्य संघटक है। *सी. वीरम* और *सी. मलाबाट्रम* के फूलों के तेल में ज.कैरियोफिलिन अधिक था।

मसाले

विषाणुओं की पहचान के लिये किट

काली मिर्च और वैनिला को हानि पहुँचाने वाले विषाणुओं को ईलाइसा और पीसीआर के आधार पर उन की पहचान के लिये किट विकसित किया गया।

मसालों से *एस्परजीलस* की वियुक्तियों का अभिलक्षीकरण

काली मिर्च, अदरक, हल्दी और जायफल से *एस्परजीलस* की 15 वियुक्तियों का छः विभिन्न कवग मीडिया का उपयोग करके आकृति चरित्रांकन किया। इन पन्द्रह वियुक्तियों में 6 आविषाजन तथा नौ आविषाजन रहित थी।

काली मिर्च एवम अदरक से अन्तः पादपी जीवाणु

आर पी – एच पी एल सी अध्ययन द्वारा अन्तः पादपी जीवाणु से विभिन्न बायोसरफेक्टेन्ट्स को निकाला तथा मासेटोलिडे – ए यौगिक की पहचान की। आठ जीवाणुओं का विविक्तिकरण करने पर, *पी. एरूगिनोसा* आई आई एस आर जी बी 9 तत्पश्चात् आई आई एस आर बी पी 35 में बायोसरफेक्टेन्ट्स का अधिकतम उत्पादन हुआ। इन विट्रो और इन विवो अध्ययन में चाक्रिक लिपोपेप्टाइड का उपयोग करने पर *फाइटोफ्थोरा कैप्सीसी* और *पाइथियम माइरिओटाइलम* के प्रति जीवनाशकता प्रकट हुई। *पी. एरूगिनोसा* आई आई एस आर 853 से आर पी–एच पी एल सी द्वारा प्रोटीएस एनजाइम को निकालकर शुधीकरण किया, इनकी *आर. सिमिलिस* के प्रति नीमेटीसाइडल सक्रियता अधिक है।

काली मिर्च एवम अदरक से राइजोबैक्टीरिया का पृथकीकरण अथवा अभिलक्षीकरण

केरल और करनाटक से वर्षा 2008–09 में एकत्रित किये गये मृदा नमूनों में से पचपन राइजोबैक्टीरियल वियुक्तियों (24 काली मिर्च तथा 31 अदरक) का

पृथकीकरण किया जिनको मिलाकर कुल एक सौ चौहत्तर वियुक्तियाँ (74 काली मिर्च और 100 अदरक) हो गई है। काली मिर्च की चार और अदरक की छः वियुक्तियों को फाईटोफ्थोरा, पाईथियम और फ्यूसेरियम के प्रति इन विट्रो विरोधी क्षमता के आधार पर उन्हें लघु सूचिबध किया। इन आठ वियुक्तियों को 16 S + I अनुक्रम विश्लेशण द्वारा इनकी पहचान की पुष्टि की गयी। तीन *प्स्यूडोमोनास एरूगिनोसा*, दो *सेराटिया मारसीसेन्स* तथा एक प्रत्येक *क्लेबसियल्ला, बैसिलस अमिलोलेक्विफेसिन्स* और *बुखोल्डोरिया पाइरोसिनिया* से सम्बन्धित है। इन वियुक्तियों का अनुक्रम राष्ट्रीय जैव प्रौद्योगिकी सूचना डेटाबेसस केन्द्र (एन सी बी आई) में जमा किया गया।

कीटनाशी सूत्रकृमि

चार कीटनाशी सूत्रकृमियों को अदरक एवम हल्दी के राइज़ोस्फियर से संचित 71 मृदा नमूना से पृथकीकरण किया गया। इनमे से, एक हेटरोरहेबडाइटिस स्पीसीस और दूसरी स्टेयिनरनिमा स्पीसीस है।

मसाला सार की प्रति आक्सीकारक क्षमता

काली मिर्च (थेवम), अदरक (रजता), हल्दी (आलप्पी सुप्रीम), और दालचीनी (नित्यश्री) के सार तत्वों की प्रति आक्सीकारक गुणों की विभिन्न समय एवम मात्रा की तुलना प्रयोगशाला विधि द्वारा की गयी। फोस्फोमोलिबडिनम विधि द्वारा कुल प्रति आक्सीकारक क्षमता, डीपीपीएच रेडिकल अपमार्जन क्षमता और एफई (III) से एफई (II) की सक्रियता कम की गई। डीपीपीएच रेडिकल अपमार्जन की सक्रियता जल सार में कम थी जबकि कुल प्रति आक्सीकारक क्षमता और एफई (III) से एफई (II) की सक्रियता को कम करना अन्य की तुलना में पानी के सार में अधिक थी।

प्रसार

प्रशिक्षण कार्यक्रम

वर्ष 2008–09 में निम्नलिखित प्रशिक्षण कार्यक्रम आयोजित किये गये।

- मसालों का उत्पादन और संसाधन तकनीक, बागवानी और खाद्य संसाधन विभाग, उत्तराखण्ड के लिए 1– 6 मई, 2008
- मसालों में अनुसंधान और विकास पर ओरियन्टेशन प्रशिक्षण कार्यक्रम, स्पाईसेस बोर्ड के कृषि अधिकारियों के लिए 21–24 मई, 2008
- अदरक एवम हल्दी के उत्पादन और संसाधन तकनीक पर कृषि सहायकों, कृषि विभाग, केरल, पालघाट जिले के लिये 17–20 अगस्त, 2008
- उत्तर पूर्व राज्य–एम एम–1 में बागवानी के एकीकृत विकास के लिए टेकनोलोजी मिशन के अन्तर्गत प्रशिक्षण कार्यशाला, हॉर्टीकल्चर रिसर्च काम्प्लेक्स, नागेचेरा, अगरतला, 3–5 फरवरी, 2009.

तकनीकी प्रसारण

अग्र पंक्ति प्रदर्शन: आई आई एस आर द्वारा विकसित काली मिर्च की उन्नत प्रजातियों की योगिकता का अग्र पंक्ति प्रदर्शन कार्यक्रम कालिकट जिले के तीन ग्रामों में 18 चयनित कृषक खेतों में किया गया। संस्थान के विभिन्न विभागों के वैज्ञानिकों का दल इन खेतों का निरीक्षण करके कृषकों को सलाह और अन्य सेवाएँ प्रदान करते हैं। रिपोर्टाधीन वर्ष में कुल 14 बार इन कृषक खेतों का निरीक्षण किया गया।

वीडियो सम्मेलन: राष्ट्रीय सम विकास योजना/वीसाट कार्यक्रम के अन्तर्गत आई एस आर ओ तथा केरल राज्य योजना बोर्ड के तत्वाधान से केरल के वयनाडु जिले के 5 ग्रामीण संसाधन केन्द्रों में 10 वीडियो सम्मेलन पाठ प्रसारित किये गये। जिनमें तीन सौ उन्नीस किसानों ने भाग लिया!

आई आई एस आर द्वारा विकसित तकनीकियों का प्रभाव

किसानों के खेतों में आई आई एस आर प्रजातियों की योगिकता का अध्ययन करने पर यह ज्ञात हुआ कि अधिक उपज वाली प्रजातियों में वैज्ञानिकों की सलाह का अनुसरण करने पर औसतन 1160 कि. ग्राम/हेक्टर उपज प्राप्त हुई जबकि परम्परागत विधि द्वारा खेती करने पर 620 कि. ग्राम/हेक्टर उपज प्राप्त हुई। इसका आकलित लाभकारी मूल्य अनुपात 2.48 था। संस्तुत तकनीकियों के अनुसरण का अध्ययन करने पर यह ज्ञात हुआ कि बोर्डियो मिश्रण का पौधों के ऊपर छिडकाव करने पर 57.14% और जैव नियन्त्रण एजेन्टों द्वारा उपचार करने पर 64.2% कवग रोगों को नियन्त्रण कर सकते हैं। मृदा में संस्तुत स्तर पर कवगनाशी, उर्वरक एवं कीटनाशी का अनुप्रयोग क्रमशः 21.14% 7.7% और 7.6% बहुत कम था।

जैव सूचनाएँ

नये डेटाबेसस

रिपोर्टाधीन वर्ष में जैव सूचना केन्द्र द्वारा निम्नलिखित डेटाबेसस विकसित किये गये।

* स्पाइसईएसटी: दो प्रमुख मसाले जैसे हल्दी और अदरक ईएसटीएस का एक डेटाबेस विकसित और परिपोति किया (www.spices-res-in/spicest)! स्पाइसईएसटी में इन पौधों के सभी ईएसटी, उनकी व्याख्या और एस एस आर और एस एन पीयों पर सूचना शामिल है।

* स्पाइस जीन्स: काली मिर्च जननद्रव्य डेटाबेस को कई अतिरिक्त विशेषताओं के साथ नवीन बनाया गया। इलायची जननद्रव्य पर डेटाबेस पहली बार विकसित किया गया।

* रेडोबेस: बरोयिंग सूत्रकृमि पर उत्पत्ति विभिन्न *रेडोफ़ोलस* स्पीसीस और उनके अनुक्रम की सूचनाओं पर एक नया डेटाबेस विकसित किया। इन सिलिको टूल्स का प्रयोग कर के *आर. सिमिलिस* में लगभग 70 एमआई आरएनए की पहचान की गयी।

मसालों में माइक्रो आरएनए

एक पूर्वानुमान में हल्दी में 47, अदरक में 82 और पैपरिका में 98 माइक्रो आरएनए का उपयोग इन सिलिको उपगमन ईएसटी संसाधनों में किया जाता है। परिणामों को स्पाइसईएसटी डेटाबेस में समेकित किया। एक माइक्रो आरएनए ब्लास्ट टूल को एन सी बी आई। ब्लास्ट स्टेंड वर्जन 2.2.19 के उपयोग द्वारा विकसित किया।

मानव संसाधन विकास

पाइपैरेसिया पर राष्ट्रीय संगोष्ठी

डॉ. डी. पी. राय, उप कुलपति उडीसा कृषि एवं टेकनोलोजी विश्वविद्यालय, भुवनेष्वर ने आई आई एस आर, कालिकट में 21 – 22 नवम्बर 2008 को सम्पन्न हुए पाइपैरेसिया पर राष्ट्रीय संगोष्ठी का उद्घाटन किया। यह संगोष्ठी मुख्यतः काली मिर्च और पान के उत्पादन में किसानों को होने वाली समस्याओं का निवारण करने तथा उत्पादन बढाने के लिए उपलब्ध नवीनतम तकनीकियों की जानकारी किसानों को प्रदान करने के लिए आयोजित की गई। विभिन्न उत्तर और दक्षिण राज्यों से 250 प्रतिनिधियों एवम कृषकों ने इस संगोष्ठी में भाग लिया।

भारतीय कृषि अनुसंधान परिषद द्वारा प्रायोजित प्रशिक्षण कार्यक्रम

वर्ष 2008–09 में आई आई एस आर में भारतीय कृषि अनुसंधान परिषद द्वारा प्रायोजित दो प्रशिक्षण कार्यक्रम आयोजित किये गये।

बागवानी फसलों में सुगंध, न्यूट्रास्यूटिकल्स और खाद्य रंगों पर विन्टर स्कूल: यह कार्यक्रम 7 से 28 जनवरी 2009 को आयोजित किया गया। इस प्रशिक्षण की कोर्स निदेशक डॉ. बी. चेम्पकम, विभागाध्यक्षा, फसल उत्पादन और फसलोत्तर प्रौद्योगिकी विभाग थी। डॉ. ए. षमीना और डॉ. के. एन. शिवा सह–समन्वयक थे। विन्टर स्कूल का उद्घाटन डॉ. जी. आर. सी. रेड्डी, निदेशक, एन. आई. टी., कालिकट ने किया और इसकी अध्यक्षता डॉ. वी. ए. पार्थसारथी, निदेशक, आई. आई. एस. आर. कालिकट ने की। उद्घाटन सत्र में डॉ. पार्थसारथी ने "स्पाइसिंग दि फ्लेवर्स" पर एक विषेश लेक्चर दिया। इसमें 16 प्रशिक्षार्थियों ने भाग लिया। इसमें बागवानी फसलों में सुगंध, रंग तत्वों एवं न्यूट्रास्यूटिकल्स पर लेक्चर (अतिथि स्पीकर सहित) एवम प्रायोगिक अभ्यास होते थे।

पादप जैव विविधिता और बागवानी में जी आई एस का अनुप्रयोग

यह प्रशिक्षण 25 फरवरी से 6 मार्च 2009 को आयोजित किया गया। डॉ एम. तमिल सेल्वन, निदेशक, सुपारी और मसाला विकास निदेशलय, कालिकट ने प्रशिक्षण कार्यक्रम का उद्घाटन किया। प्रशिक्षण में 15 प्रशिक्षार्थियों ने भाग लिया जिसमें 5 भारतीय कृषि अनुसंधान परिषद, 6 विश्वविद्यालयों, 2 कालेजों और 2 शोध छात्र थे। डॉ. टी. जॉन जकरिया और डॉ. उत्पला पार्थसारथी प्रशिक्षण कार्यक्रम के समन्वयक थे। प्रशिक्षण का सबसे आकर्षक भाग विभिन्न क्षेत्रों में जी आई एस की उपयोगिता पर सत्र एवम लेक्चर थे।

जैव सूचना प्रशिक्षण

वैज्ञानिकों/शोध छात्रों के लिए जैव सूचनाओं के दो प्रशिक्षण कार्यक्रम जैसे., एग्रि बायोइनफोरमेटिक्स टूल्स एण्ड एप्लिकेशन्स, 20-24 अक्तूबर, 2008 और ईएसटी का इन सिलिको विशलेषण और व्याख्या 17-19 दिसम्बर, 2008 को आयोजित किये गये।

EXECUTIVE SUMMARY

Black pepper

Genetic resources

Two thousand five hundred and seventy five accessions (1266 wild accessions, 1300 local cultivars and nine exotic accessions) are maintained in the black pepper germplasm conservatory. An alternate germplasm conservatory for wild *Piper* accessions has been established at CRC, Appangala with 238 accessions in the field gene bank. Survey was conducted for collecting germplasm from Charmadi, Mudigere, Khalsa and Kudremukh forests and collected 32 *Piper* accessions. Bush peppers of important local cultivars and wild relatives were developed and planted at IISR, Calicut. Herbarium specimens of black pepper accessions were prepared and preserved in the phenomics facility developed for *Piper*.

Registration of germplasm accessions

Two accessions were registered with NBPGR for their unique characters. They are:

1. INGR 8099- *Piper thomsonii* (IC- 398863) - for its unique character for sex change (from male to bisexual plant).
2. INGR 8100- *Piper nigrum* (IC- 563950) – A novel spike variant with proliferating spikes.

Water use

An experiment conducted in a planter's field at Madikeri revealed that irrigating pepper vines once in a fortnight from March to May months @ 50 litres/ vine can enhance pepper yields substantially. The mean dry yield obtained was 6.8 kg/vine in irrigation treatment against 3.25 kg/vine under rainfed condition.

Intercropping

Among various crops tried for a period of three years crops such as ginger (Varada), tapioca (Sreejaya), coleus (Nidhi), amorphophallus (Gajendran) and hybrid napier (Co-3) were found suitable for intercropping in black pepper gardens of more than 15 years old.

Nutrient requirement for targeted yield

In black pepper 5, 7.5 and 10 kg dry yield/ vine was targeted and fertilizer doses for the same based on soil fertility was calculated and imposed in two splits in Mrigarajendra estate, Madapur, Madikeri. The yield targets could be achieved with minimum deviation from the targets. The recorded yield levels were 5.5, 7.3 and 8.2 kg/vine in the targets of 5, 7.5 and 10 kg/vine, with a deviation of +11%, -2.2% and -18.0% respectively. The yield increase as compared to the control was 39-104%.

Soil fertility management by cover crops

Nutrient addition by cover crops *viz.*, cowpea and horse gram for three seasons from September to May was estimated in the black pepper plantation. The crop sequence with cowpea alone could add 95.04, 5.81, 27.46, 24.29, 3.96 kg N, P, K, Ca, Mg, per ha, respectively, whereas, a sequence with horse gram alone could contribute 26.08, 2.36, 15.90, 7.58, 2.48 kg of N, P, K, Ca, Mg, per ha, respectively. A sequence with cowpea followed by horse gram or vice-versa could contribute less than the sequence with cowpea alone.

Locational effect on constituents of essential oil of cultivars

Germacrene D and elemol were found to be the major constituents of leaf oil of black pepper cultivars from IISR Experimental Farm, Peruvannamuzhi, Calicut and from Pepper Research Station (PRS), Panniyur. β-caryophyllene was high in berries at both locations and it showed more variability in berries compared to leaf samples. The concentration of β-caryophyllene in leaf oil varied from 2.03 to 8.47% and that of germacrene D from 4.08 to 44.2%. Highest germacrene D content was found in Panniyur-3 followed by Panniyur-2, Panniyur-6 and Panniyur-7. Another major constituent in the leaf oil of many cultivars was elemol and its concentration varied from 2.37 to 55.2%. Highest concentration of elemol was found in Vatamunda followed by Neelamundi and Angamali.

Controlled atmospheric storage and quality

Black pepper samples stored with a moisture content of 10% under controlled atmosphere (90% nitrogen + 10% oxygen) for 480 days did not show significant variation in essential oil, oleoresin and piperine contents compared to control.

Phytophthora resistance

Open pollinated progeny of IISR Shakthi (04- P24 -1) continued to show resistance to root infection by *P. capsici* with repeated inoculations. Out of 155 hybrids, 68 cultivars and 13000 seedling progenies screened, three op progenies *viz.*, HP 1533(2), HP 1533(3) and

04-P24-1; four hybrids, HP 449, HP 490, HP 521, HP 1375 and one cultivar C 1530 were found moderately resistant. The promising lines showing moderately resistant reaction towards *P. capsici* are under field evaluation. Among the eight wild accessions screened against *P. capsici, R. similis* and *M. incognita*, accession 3362 (*P. ornatum*) showed resistance towards *Phytophthora* and also towards both the nematodes.

Phytophthora management

Biological control: Endophytic and rhizospheric biocontrol agents *viz.,* Bp 35, Bp 25, Bp 17, TC 10, IISR 853 and IISR 6 are being evaluated in an integrated management trial under field conditions against *P. capsici, R. similis* and *M. incognita*. The observations on six month old plants indicated that the treatments TC 10 + metalaxyl-mz and IISR 853 + metalaxyl-mz are promising.

Evaluation of new chemicals against *Phytophthora:* New chemicals such as benzoic acid, salicylic acid (a.i. from *Chromalaena odorata*), potassium bicarbonate, captanhexaconazole and carbendazim mancozeb were tested *in vitro* against *P. capsici*. Captanhexaconazole was found to be completely inhibitory at 50 ppm. Benzoic acid and salicylic acid were inhibitory at 100 and 200 ppm respectively. Minimum inbibitory concentration for potassium bicarbonate and carbendazim mancozeb were 1000 ppm and 500 ppm, respectively.

Management of anthracnose disease

In the disease management trial with combination of fungicides (1% Bordeaux mixture, hexaconazole, carbendazim, potassium phosphonate, mancozeb) and biocontrol agents (*Trichoderma harzianum* and *Pseudomonas fluorescens*) conducted in hot spots of anthracnose and spike shedding under coffee + black pepper cropping system, the treatment with basal application of *T. harzianum* and aerial spray with 1% Bordeaux mixture was superior. No foot rot incidence was noticed in this treatment compared to 22.6 % mortality in untreated control. This treatment effectively reduced foot rot incidence also. Under field conditions, the anthracnose pathogen survived beyond 8 months in the infected debris.

Management of diseases in black pepper nursery

An experiment was conducted with solarized potting mixture, having 12 different treatments including control *viz.*, COC 0.2% + phorate, carbendazim 0.2% + phorate, metalaxyl-mz 0.125% + phorate, potassium phosphonate 0.3% + phorate, carbendazim-mz 0.25% + phorate, mancozeb 0.25% + phorate, *T. harzianum* + phorate, IISR 853, *Paecilomyces lilacinus*, *Pochonia chlamydosporia*, IISR 6 and control (potting mixture alone) to study their efficacy in controlling nursery diseases. No *Phytophthora* infection could be noticed in any of the treatments or control where the moisture content of soil in the poly bag was less than 10%.

Establishment of virus-free mother vines of black pepper

PCR technique was used to identify virus-free nucleus materials of all released varieties of black pepper. They are being maintained under insect proof conditions and used for further multiplication in nurseries.

Transformation of black pepper with viral constructs

PYMoV ORF III construct containing 409 bp region in sense and antisense orientation and CMV coat protein gene construct in sense orientation were used for *Agrobacterium* mediated transformation of different explants like leaf, internode and petiole. Callus formed readily from leaf, internode and petiole within 30 days when they were cultured both on SH and MS media supplemented with BAP, NAA and TDZ. Types of callus observed in different phytohormone combinations were friable creamish, white powdery and hard callus (both green and creamy).

Seed transmission of *Piper yellow mottle virus* (PYMoV) in black pepper

Symptomatology and PCR tests of seedlings showed the existence of seed transmission of PYMoV in black pepper.

Screening of Piper germplasm against *Piper yellow mottle virus* (PYMoV)

All the 481 accessions of *Piper* screened against PYMoV showed susceptible reaction.

Field screening for pollu beetle (*Longitarsus nigripennis*) resistance

Black pepper germplasm accessions (113 cultivars and 72 hybrids) were screened for resistance to pollu beetle. Among the cultivars, Acc. No. 35 recorded the highest berry damage (36.5%), followed by Acc. No. 88 (34.5%). The lowest damage was on Acc. No. 1636 (1.75%), followed by Acc. No. 1423 (2.74%). Among the hybrids the damage was highest on Acc. No. 861 (44.4%), followed by Acc. No. 1471 (41.5%). The lowest damage was recorded on Acc. No. 1388 (4.49%), followed by Acc. No. 1726 (5.74%).

Incidence of *Erythrina* gall wasp (*Quadrastichus erythrinae*)

Surveys conducted in 276 black pepper (*Piper nigrum*) gardens in 13 taluks in 4 districts (Idukki, Kozhikode, Kannur and Wayanad) in Kerala and 3 taluks in 1 district (Kodagu) in Karnataka, during April to July 2008, on the incidence of *Erythrina* gall wasp (*Quadrastichus erythrinae*), on *Erythrina* spp., used as standards for trailing black pepper vines indicated that gall wasp incidence was observed in all the locations surveyed and the percentage of trees infested by the pest was significantly higher in Wayanad District (59.6%) that was on par with Idukki (53.4%), Kodagu (51.8%) and Kannur (39.1%) districts. The percentage of twigs infested by the pest was also significantly higher in Wayanad District (39.7%) that was on par with Idukki (35.5%), Kodagu (33.4%) and Kozhikode (31.6%) districts. The severity of incidence varied on various species / types of *Erythrina* and was significantly higher in *E. variegata* (white-thorn type) wherein a mean of 91.8% trees and 66.8% twigs were infested by the pest. The surveys indicated that infestation of *Erythrina* spp. by the gall wasp has become one of the major constraints in black pepper production in Kerala and Karnataka, in recent years.

Phenyl propanoids in nematode resistance

Activities of phenylalanine ammonia lyase (PAL) and caffeic acid-O-methyltransferase (COMT) increased in roots and leaves of susceptible black pepper variety (IISR Sreekara) on infection with *Radopholus similis* indicating the role of phenyl propanoids in black pepper – nematode interactions.

Sequence similarity

Sequencing of the polymorphic 650 bp fragment cloned from nematode tolerant accession HP 39 of black pepper showed maximum similarity to acetyl-CoA carboxylase and not to any genes attributed for nematode resistance.

Cardamom

Genetic resources

Fifty accessions were characterized during the year thus making total number characterized so far to 350. A total of 442 accessions have been maintained in the *ex situ* gene bank at Cardamom Research Centre, Appangala (Malabar 278, Mysore 73, Vazhukka 63 and others 28).

Evaluation of hybrids

Evaluation of hybrids under PET 1 and PET 2 during 2008-09, led to the identification of the following hybrids *viz.*, CCS-1 x RR-1, RR-1 x CCS-1, MB-5 x GG, ASH, NKE 19 x GG, GG x NKE 19. In MLT trials, SAM, CP-4 and NHY- 10 performed better compared to others.

Drought tolerance

Evaluation of four cross combinations of cardamom (hybrids and selfed seedlings) for drought tolerance in field revealed that Green Gold and its cross combinations were better in terms of growth and yield characters under stress compared to other crosses. 893 x RR1, GG x RR1, CCS1 x GG, GG x 893 and CCS1 x GG took more time to fold leaves (leaf rolling) under open light than other crosses.

Quality evaluation

Sixty two accessions of cardamom, including 5 hybrids were analyzed for seed content, essential oil yield and essential oil composition. The cardamom capsules contained 55- 82% seeds and 4.0-6.5% essential oil. The accession nos. VA-1, MA-18, IC 391657, IC 547147, IC 547144, IC 349652, IC 349633, IC 547153 and IC 547220 recorded 66-74% seed content and 6.5% essential oil yield. The major constituents of the oil, *viz.*, 1, 8-cineole varied from 22 to 40% and α-terpenyl acetate from 32 to 47%. The accession numbers, GG x NKE 12, NKE 19, OP27, MA 29, IC 547147, IC 547154 and IC 547144 were identified as 1, 8-cineole rich accessions (>35%) and PC, CP-4, NKE 12 x GG, NKE 19 x GG, GG x NKE 19 and GG suckers were rich in α-terpenyl acetate (>45%).

Soil quality

Soil samples collected from various cardamom based cropping systems *viz.*, cardamom + nutmeg, cardamom + allspice, cardamom + cinnamon, cardamom alone, cardamom + coffee and cardamom + arecanut were analyzed for various soil quality parameters. The results revealed that the component crops had little influence on the various physico-chemical and biochemical parameters studied. Soil pH varied between 4.8-5.2 and organic C between 1.9- 2.7%. Available N levels ranged between 121- 148 mg/kg, Bray P between 21-41 mg/kg, and available K between 212-338 mg/kg. Among the micronutrients, DTPA Zn was low at all the sites (0.72-1.04 mg/kg).

Katte virus purification and detection

Eighteen *Katte* isolates were collected from Karnataka and Kerala states and established under insect proof glass house conditions. Protocol for purifying the causal virus (*Macluravirus*) of *Katte*/mosaic disease of cardamom has been standardized. Protocols for RNA isolation for detecting *Macluravirus* by RT-PCR from

the leaves obtained from *Katte* affected cardamom plants has been standardized.

Screening for resistance to diseases

Fifty eight cardamom accessions were screened for leaf blight, rhizome rot and leaf blotch resistance under natural field conditions. Based on their reaction towards leaf blight and rhizome rot diseases, the accessions were categorized into different groups by combining the information obtained from two consecutive years *i.e.*, 2007 and 2008. None of the accessions were found highly resistant to leaf blight disease. However, IC- 349646 was found to be resistant to this disease with an average leaf blight incidence of 20%. Twenty three accessions exhibited highly resistant reaction to rhizome rot disease.

Turmeric

Genetic resources

Thirty four turmeric accessions were added to the germplasm repository during 2008-09, thus raising the total germplasm collections to 1026.

Development of microsatellite markers and characterization of *Curcuma* species

A total of 140 microsatellites containing genomic DNA fragments were isolated from turmeric (*Curcuma longa* L.) adopting the selective hybridization method with di and trinucleotide biotinylated probes. Expressed sequence tags (EST's) of turmeric hosted in the NCBI database were screened for type and frequency of class I (hypervariable) simple sequence repeats (SSR's). Eight polymorphic primers were identified for amplifying SSR containing ESTs. These primers were also transferable to 13 different species of *Curcuma*. The AE HPLC elution profiles of water soluble rhizome proteins of thirteen *Curcuma* species on UPGMA formed six major clusters with *C. malabarica* and *C. zedoaria* showing maximum similarity. The biologically active peptide turmerin isolated from all the 13 species of *Curcuma* showed highest concentration in *Curcuma sylvatica* (320 mg/100 gm).

Phenology and dry matter distribution

Turmeric varieties *viz.*, Prathibha, Alleppey Supreme, Suguna, Prabha and Kedaram on an average took 23.5, 18.5, 16.5, and 12.3 days for emergence and 98.4, 59.9, 56.7, and 48.5 days for producing first tiller under 30 April, 15 May, 30 May and 15 June planted crops, respectively. The dry matter distribution among root, rhizome, pseudo-stem and leaf was estimated by destructive sampling at fifth month after planting. On an average turmeric varieties recorded 8.10%, 60.7%, 8.90% and 22.29% dry matter in root, rhizome, pseudo-stem and leaf, respectively.

Controlled atmosphere storage and quality

Turmeric samples stored with a moisture content of 10% under controlled atmosphere (90% nitrogen + 10% oxygen) for 480 days showed minimal variation in essential oil and no variation in oleoresin and curcumin contents compared to control. Samples stored under controlled atmosphere were totally free from insect attack.

Influence of drying methods on quality

Turmeric varieties Prathibha and Alleppey were processed with and without boiling. Later, these samples were dried in hot air oven, reverse flow drier and sun dried and evaluated for oil, oleoresin and curcumin. Processing with or without boiling or different drying methods did not lead to variation in oil, oleoresin and curcumin contents.

Rhizome rot

Management using *Trichoderma*: Twenty two isolates of *Trichoderma* spp. isolated from the turmeric rhizosphere were evaluated for their antagonistic potential against *P. aphanidermatum* causing rhizome rot of turmeric. Out of twenty two isolates, six isolates showed mycelial inhibition of above 70% *in vitro*. The highest inhibition by volatile metabolites was shown by CLT 118 (84.82%) and CLT 121(82.22%). The non volatile metabolites produced by CLT 102 (37.78%), CLT 107 (38.52%), CLT 110 (46.30%) and CLT 114 (42.22%) were comparatively effective against the pathogen. CLT 114 from Bidar (Karnataka) and CLT 102 from Wayanad (Kerala) induced cytoplasmic coagulation of the pathogen in dual culture.

Management using chemicals: Field trial conducted during 2007-09 in turmeric fields at Settiputhur, near Annur in Coimbatore District, Tamil Nadu, using various chemicals to manage the disease indicated that the disease is a serious threat to turmeric farmers in the region. Out of ten treatments, maximum disease reduction was observed with metalaxyl-mancozeb (44.5%) followed by copper oxychloride (36.5 %) when compared to control.

Molecular characterization of *Pythium* isolates

The combination of universal primers ITS1 and ITS4 were used to characterize pathogenic *Pythium* isolates (collected from turmeric growing tracts of southern districts of Kerala) which generated a 900 bp fragment in PCR. The amplified products were digested with restriction enzymes *Msp* I, *Taq* I and *Alu* I for PCR-

RFLP analysis. RFLP finger print data grouped the isolates into two main groups with 10% similarity.

Shoot borer (*Conogethes punctiferalis*)

Germplasm screening: Turmeric accessions (915 Nos.) were field screened against the shoot borer. The maximum shoot damage (80%) was observed on accessions 345, 525 and 882. Twelve accessions (Accs. 126, 405, 444, 455, 692, 718, 880, 888, 897, 917, 981 and 995) recorded 75% shoot damage on them. Forty four accessions remained free from the shoot borer attack.

Natural enemies: The natural enemies of shoot borer (*Conogethes punctiferalis*) infesting turmeric were documented. The natural enemies documented during the crop season included *Apanteles taragamme* (?), an un-identified hymenopterous parasitoid and earwigs.

Management: Four insecticides (malathion 0.1%, carbosulfan 0.075%, imidacloprid 0.0125%, and lamda cyhalothrin 0.0125%) that were promising in the greenhouse were evaluated in the field at Peruvannamuzhi for their efficacy in the management of the shoot borer. The insecticides were sprayed at 21-day intervals during July to November and the incidence of infested shoots was recorded at crop maturity during December. The trials indicated that all the insecticides except imidacloprid (0.0125%) were promising in reducing the percentage of shoots infested by the shoot borer.

Ginger

Genetic resources

Six hundred and eighty accessions of ginger are being maintained in field germplasm conservatory. Twenty accessions were added to the germplasm repository during 2008-09.

Germplasm evaluation

Twelve selected exotic (Nepal) accessions along with check IISR Varada were evaluated for morphological and yield characters. Tillers/clump and rhizome yield varied significantly among the accessions. Maximum yield per clump was recorded in Acc. 578 with 9.82 kg/3m^2 which was on par with check (9.63 kg/3m^2). Evaluation of 13 high oil ginger accessions for morphological and yield characters revealed highest yield in Acc. 162 followed by Acc. 217 and Acc. 209. Yield varied from 5.26 to 8.74 kg/3m^2 bed in these accessions.

Accession with high pollen fertility

A collection with high pollen fertility was identified from the germplasm of ginger by pollen fertility screening through stainability as well as *in vitro* germination. Ginger Acc. No. 195 showed mean pollen fertility of 67.73% by glycero-carmine staining and 60.31% by *in vitro* germination. Pollen germination was observed on stigmatic surface also on self pollination. The genotype is suitable for future studies on induction of seed set in ginger.

Phenology and dry matter distribution

Ginger varieties *viz*., Rejatha, Mahima, Himachal, Varada and Maran took on an average 30.9, 25.3, 25.7 and 23.9 days for emergence and 74.8, 46.8, 46.4 and 42.6 days for producing first tiller under 30 April, 15 May, 30 May and 15 June planted crops, respectively. The dry matter distribution (estimated by destructive sampling at fifth month after planting) indicated on an average 12.35%, 65.34%, 7.69% and 14.61% dry matter in root, rhizome, pseudo-stem and leaf, respectively.

Essential oil composition of fresh and dry ginger rhizomes

Comparison of essential oil constituents of fresh and dry ginger rhizomes indicated that fresh rhizomes contained higher level of monoterpenes namely, *Z*-citral and *E*-citral whereas the dry rhizomes were predominated by the sesquiterpene hydrocarbons namely, zingiberene, farnesene and sesquiphellandrene.

Drying methods and quality

Ginger variety Varada, was dried with and without peeling in hot air oven, reverse flow drier and sun dried and evaluated for oil, oleoresin and gingerol contents. No variation was observed in oil and oleoresin contents between peeled and unpeeled samples but unpeeled samples took more time for drying.

Shoot borer (*Conogethes punctiferalis*)

Germplasm screening: Four hundred and ninety two accessions of ginger were screened in the field against the shoot borer (*Conogethes punctiferalis*). The accessions were rated for their resistance/susceptibility and 49, 251, 130 and 62 accessions were rated as resistant, moderately resistant, susceptible and highly susceptible, respectively to the pest.

Life cycle studies: The life cycle of the shoot borer was studied on 5 resistant accessions (Acc. Nos. 31, 247, 409, 430 and 631), 6 highly susceptible accessions (Acc. Nos. 17, 43, 70, 190, 191 and 514) and one susceptible cultivar (Varada). In the resistant, highly susceptible and susceptible accessions, the pupal period varied from 6-21, 7-11 and 8-9 days respectively.

The adult longevity was 2-3, 2-4 and 3 days on resistant, highly susceptible and susceptible accessions respectively.

Paprika

Genetic resources

Five collections (two from YSPUHF, Solan, Himachal Pradesh, two from Kerala and one from Tamil Nadu) were added to the germplasm. Fifty four germplasm accessions including 21 Bydagi collections and six exotic collections were raised and multiplied. Twenty seven new germplasm accessions were purified by single plant selection and by selfing.

Characterization of germplasm

Morphological and quality characterization of germplasm accessions revealed maximum variability in fruit weight (31.26% CV) followed by yield per plant (30.88% CV). Least variability (3.34% CV) was recorded for pericarp thickness.

Colour and pungency

Among the indigenous germplasm accessions, ICBD-11, ICBD-23 and ICBD-10 registered the highest colour value of above 300 ASTA units. In case of exotic lines, high colour value was recorded in EC-71, EC-6, EC-490 and EC-18. The capsaicin content among germplasm accessions varied from 0.0081 to 0.513 %. Overall, the lines ICBD-10, Kt-pl-19 and EC-18 were found promising with high colour value and low pungency.

Vanilla

Flowering in *Vanilla tahitensis*

Vanilla tahitensis, the second commercially important species of vanilla after *V. planifolia* flowered at IISR Farm, Peruvannamuzhi, for the first time, after 4 years of growth. The flowering occurred in two phases unlike in *V. planifolia*. The first phase started in the month of September and ended by October. Second phase started in the month of February and ended in March.

Detection of viruses

RT-PCR based method was developed for the detection of all the four viruses (*Bean common mosaic virus, Bean yellow mosaic virus, Cucumber mosaic virus* and *Cymbidium mosaic virus*) known to infect vanilla in India.

Tree Spices

Nutmeg

Evaluation of progenies

In the progeny evaluation trial of elite nutmeg lines, accession A9/185 recorded maximum mean height (592 cm), width (582 cm), number of main branches (63.2) and girth at 30 cm above ground level (50.3 cm), while elite line A9/150 recorded the maximum mean number of fruits per plant (28).

Cassia (*Cinnamomum cassia*)

Germplasm registration

The cassia elite line A1 (IC No. 370400) has been registered with NBPGR, New Delhi for high cinnamaldehyde content in bark oil (81.5%) and leaf oil (80.5%) (Reg. No. INGR 08045).

Morphological and quality evaluation

Significant differences were observed among the 4 elite cassia lines for plant height, width and number of main branches. Elite line D1 recorded the maximum plant height (296.9 cm), width (234.8 cm) and number of main branches/plant (14.6). Biochemical characters namely bark oil, oleoresin and cinnamaldehyde were recorded for 15 accessions grown at Appangala. Bark oil ranged from 1.2 (D1) to 3.71% (B2) and percentage of oleoresin varied from 7.52 (B8) to 14.14 (B2). Cinnamaldehyde content varied from 65.07 (B8) to 89.63 % (D1). RAPD profiles were developed and species inter relationships was studied in seven species of *Cinnamomum*.

Essential oil constituents of *Cinnamomum* species

GC-MS analysis of the chemical constituents of essential oils in leaves of *Cinnamomum sulphuratum, C. glaucescens, C. glanduliferum, C. macrocarpum* and *C. perrottetti* revealed that the major chemical constituents in these oils were β-phellandrene, α-phellandrene, camphor, t-caryophyllene and germacrene-D respectively.

Essential oil from leaves of *C. tamala* was dominated by eugenol whereas the oil from petiole, terminal shoots and shoots contained α-phellandrene and p-cymene as major components. Similarly, t-caryophyllene was the chief compound in the leaf oil of *C. malabatrum* and the essential oils from petiole, terminal shoots and shoot were rich in linalool. The essential oil from petiole and terminal shoots of *C. sulphuratum* contained linalool as chief constituent whereas that from leaves contained β-phellandrene. Essential oils from flowers of *C. verum* and *C. malabatrum* were dominated by t-caryophyllene.

Spices

Detection kits for viruses

ELISA and PCR based diagnostics for the sensitive detection of viruses infecting black pepper and vanilla were developed.

Characterization *of Aspergillus* isolates

Morphological characterization of 15 isolates of *Aspergillus* from pepper, ginger, turmeric and nutmeg has been done using six different mycological media. Among the fifteen isolates, 6 have been identified as toxigenic and nine as non- toxigenic isolates.

Endophytic bacteria from black pepper and ginger

Biosurfactants from different endophytic bacteria were extracted and the compounds were identified as massetolide A using RP-HPLC studies. Among the eight bacteria screened, the highest production of the biosurfactant was noticed in *P. aeruginosa* IISR GB 9 followed by IISR BP 35. *In vitro* and *in vivo* studies using this cyclic lipopeptide showed biocidal activity against *Phytophthora capsici* and *Pythium myriotylum*. Protease enzyme from *P. aeruginosa* IISR 853, extracted and purified by RP-HPLC, possessed high nematicidal activity against *R. similis*.

Rhizobacteria from black pepper and ginger

Fifty-five rhizobacterial strains, 24 from black pepper and 31 from ginger were isolated from soil samples collected from Kerala and Karnataka during 2008-09, making the total collection to one hundred and seventy four, 74 from black pepper and 100 from ginger. Four isolates from black pepper and six from ginger were short-listed as efficient based on their *in vitro* antagonistic activity against *Phytophthora, Pythium* and *Fusarium*. The identity of these eight isolates was confirmed through 16S rDNA sequence analysis. Three belonged to *Pseudomonas aeruginosa*, two were *Serratia marcescens*, one each belonged to *Klebsiella, Bacillus amylolequifaciens* and *Bukholderia pyrrocinia*. The sequences of these isolates were deposited with National Centre for Biotechnology Information databases (NCBI).

Entomopathogenic nematodes from ginger and turmeric

Four strains of entomopathogenic nematodes were isolated from 71 soil samples collected from rhizosphere of ginger and turmeric. Out of these, one strain each was tentatively identified as *Heterorhabditis* sp. and *Steinernema* sp.

Antioxidant potential of spice extracts

The antioxidant property of spice extracts of black pepper (Thevam), ginger (Rejatha), turmeric (Alleppey Supreme) and cinnamon (Nithyasree) were compared at different time periods and quantified using the *in vitro* methods: total antioxidant capacity by the phosphomolybdenum method, DPPH radical scavenging ability and Fe(III) to Fe(II) reducing activity. DPPH radical scavenging activity was less in water extract while total antioxidant capacity and Fe(III) to Fe(II) reducing activity were greater in water extract compared to the other extracts.

Extension

Training programmes

The training programmes conducted during the year were,

- Production and processing technology of spices for Department of Horticulture and Food Processing, Uttarakhand, 1-6 May 2008
- Orientation training programme on research and development in spices for field officers of Spices Board, 21-24 May 2008
- Production and processing technology of ginger and turmeric for agricultural assistants, Department of Agriculture, Kerala, Palakkad District, 17-20 August 2008
- Training workshop under the technology mission for integrated development of horticulture in NE states -MM-I at Horticulture Research Complex, Nagecherra, Agartala, 3-5 February 2009

Technology dissemination

Front line demonstration: Front line demonstration programme on performance of improved varieties of black pepper released from IISR was laid out in 18 selected farmer's plots in three villages in Calicut District. A multi disciplinary team of scientists visit these plots as per a schedule to follow up and provide advisory services. A total of 14 visits were carried out to these fields.

Video conferencing: Under the Rashtriya Sam Vikas Yojana/VSAT programme sponsored jointly by ISRO and Kerala State Planning Board, 10 video conferencing lessons were broadcasted to the 5 Village Resource Centers (VRCs) in Wayanad District of Kerala. Three hundred and nineteen farmers from 5 VRCs attended the sessions.

Impact of technologies developed by IISR

Studies on performance of IISR varieties of black pepper in farmers' fields indicated that the mean yield

for high yielding varieties was 1160 kg/ha with the adoption of scientific packages as compared to 620 kg/ha for traditional varieties. The estimated cost benefit ratio was 2.48. The level of adoption studies of recommended technologies indicated that the adoption level for foliar spraying of Bordeaux mixture for the control of fungal diseases was 57.14% and for application of bio control agents was 64.2%. The adoption levels for application of soil fungicides, fertilisers and pesticides were very low at 21.14%, 7.7% and 7.6 % respectively.

Bioinformatics

New databases

The Bioinformatics Centre has developed the following databases during the period under report:

- **SpicEST:** A database of ESTs of turmeric and ginger was developed and hosted (www.spices.res.in/spicest). SpicEST contains all ESTs of these plants, their annotation, and information on SSRs and SNPs.
- **Spice Genes:** The black pepper germplasm database was updated with several additional features. Another database on cardamom germplasm was developed for the first time.
- **Radobase:** A new database on burrowing nematode containing the information on various *Radopholus* species and their sequence information was developed. About 70 miRNAs were identified in *R. similis* using *in silico* tools.

miRNAs in spices

A total of 47 microRNAs were predicted in turmeric, 82 in ginger and 98 in paprika using *in silico* approaches on EST resources. The results were incorporated in SpicEST database. A microRNA blast tool was also developed using NCBI – BLAST stand alone version 2.2.19.

Human Resource Development

Seminars

- National Seminar on Piperaceae during 21-22 November 2008.

ICAR sponsored trainings

- Winter School on Flavours, Nutraceuticals and Food Colours from Horticultural Crops from 7th to 28th January 2009.
- Application of GIS in Plant Biodiversity and Horticulture from 25th February to 6th March 2009.

Bioinformatics training

- Agri-Bioinformatics: Tools and Applications, 20-24 October 2008.
- *In silico* analysis and annotation of ESTs, 17-19 December 2008.
- Summer training for MSc students on biochemistry, biotechnology and bioinformatics from 12th May to 11th June 2008.

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, Madikeri, 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 snre 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

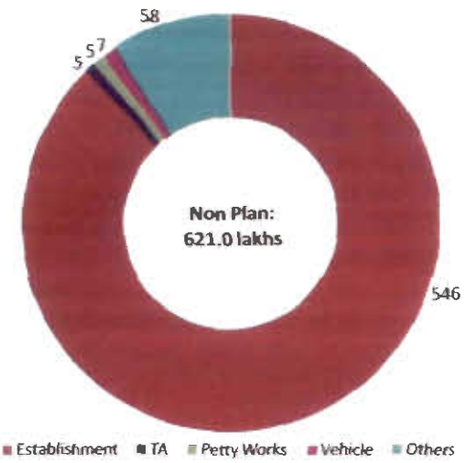
The Director is the administrative head of the institute. The Institute Management Committee, Research Advisory Committee and Institute Research Committee assist the Director in matters relating to management and research activities of the institute. Research on various aspects of the mandate crops is 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 for the All India Coordinated Research Project on Spices, and Indian Society for Spices. An outreach project on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops was also sanctioned in the XI plan (2007-12) with IISR, Calicut as the lead centre and 17 coordinating centres at different ICAR institutes/ SAUs across India. The institute has also linkages with several universities, research institutes, and developmental agencies for collaborative research and developmental activities in spices.

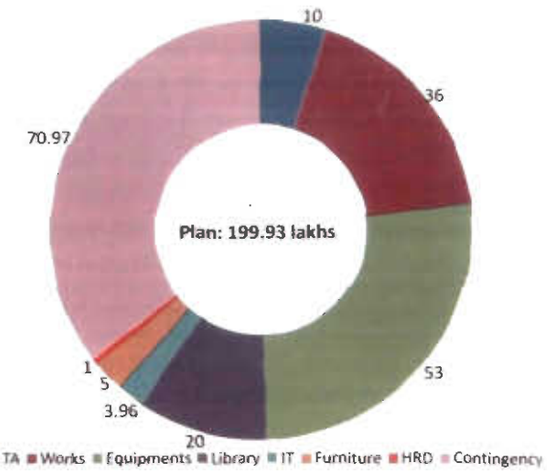
Budget

The total budget of the institute was Rs. 820.93 lakhs during the year, which included Rs. 199.93 lakhs under Plan and Rs. 621.0 lakhs under Non Plan.

Resource generation

Institute earned a total of Rs. 27.30 lakhs through sale of planting materials, biocontrol agents, training, publications and consultancy services.





Staff Position of the Institute

Category	Sanctioned	Position			Total	Vacant
		Calicut	Peruvannamuzhi	Appangala		
Scientist	43	27	5	5	37	6
Technical	36	16	13	3	32	4
Administration	19	12	-	1	13	6
Supporting	61	21	11	18	50	11
Total	159	76	29	27	132	27

Staff position of KVK

Category	Sanctioned	Position			Total	Vacant
		Calicut	Peruvannamuzhi	Appangala		
Technical	7	1	4	-	5	2
Administration	2	1	1	-	2	-
Supporting	2	-	2	-	2	-
Total	11	2	7	-	9	2

Staff: The institute has a sanctioned strength of 43 scientific, 19 administrative, 36 technical and 61 supporting staff, of which 37, 13, 32 and 50 of scientific, administrative, technical and supporting staff are in position, respectively. The KVK has a sanctioned strength of 2 administrative, 7 technical and 2 supporting staff.

Research

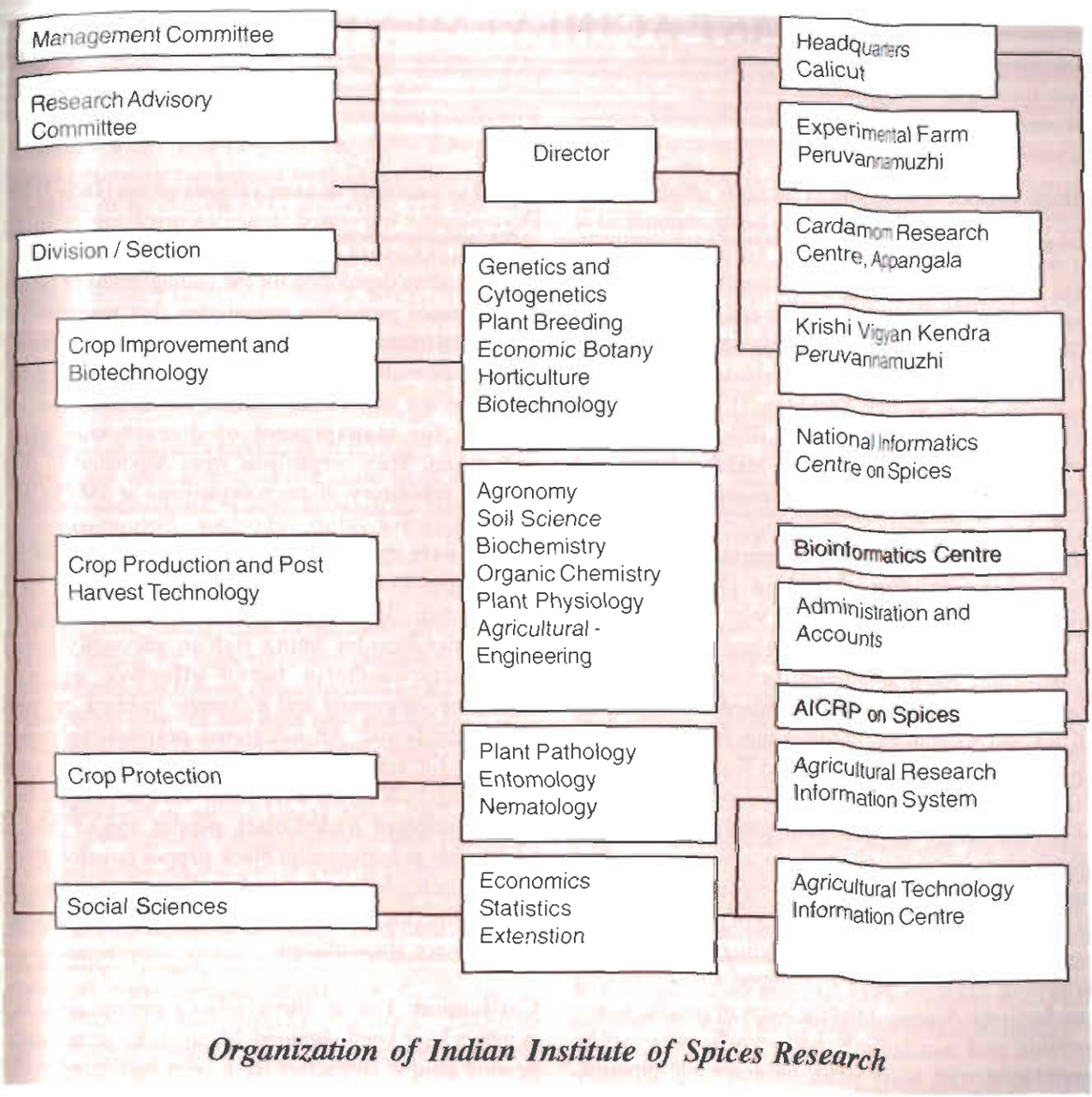
New facilities

BIOLOG for automated microbial identification

A new automated system to identify bacteria and fungi based on conventional phenotypic tests has been installed at IISR, Calicut. The Biolog System rapidly identifies over 1,900 species of aerobic bacteria, anaerobic bacteria, yeast and filamentous fungi. This easy to use system provides reference laboratory quality identification without the labour-intensive requirements of conventional microbiological assays.

Biometric facility in Library

IISR Library is equipped with biometric system for access management and control. All the staff members are enrolled in the system by registering their finger prints which are subsequently used for authentication. The biometric technology provides a single point of



Organization of Indian Institute of Spices Research

control for administrators to manage access to library resources such as computers, buildings, doors, the internet, and software applications. The database is useful in analyzing the library usage pattern and generating various reports. CCTV cameras are also installed in the library for real time surveillance.

Net house for virus free material multiplication

For the production of virus free nucleus planting materials of released black pepper varieties an insect proof net house was constructed at Chelavoor, to prevent the entry of aphids and mealybug which are the known vectors of viruses infecting black pepper.

Phenomics facility (Herbarium)

The facility to develop database on *Piper* has been started with imaging and herbarium facilities.

BIOLOG - automated microbial identification system

PAST ACHIEVEMENTS

Black pepper: Germplasm collections obtained over the years through explorations are being maintained at IISR as well as in other alternate sites *viz.*, Madikeri and Kidu of Karnataka state for developing improved varieties for yield, quality, abiotic and biotic stresses. GIS is being employed to identify species richness. The genetic stock has lead to release of improved varieties such as IISR-Sreekara, IISR-Subhakara, IISR-Panchami, IISR-Pournami, IISR-PLD-2, IISR-Thevam, IISR-Girimunda, IISR-Malabar Excel and IISR-Shakthi. Front-line demonstration programme was undertaken using the released varieties in the farmers' field. Some of the unique germplasm have been registered with NBPGR at New Delhi. Putative transgenic black pepper plants with osmotin gene conferring resistance to drought and *Phytophthora capsici* has been developed. *In vitro* and *in vivo* propagation methods were standardized. Plantlets developed through micropropagation were established in farmers' field in Kerala and Karnataka. Gene conferring resistance against *Phytophthora capsici* was isolated by targeted gene amplification using degenerate primers from *Piper colubrinum*. The spacing, nutrient and water requirements were standardized for different soil types of pepper growing regions. High production technologies and mixed cropping systems were developed for increasing productivity. Among different forms of potash, water-soluble and available K had significant positive correlation with berry yield, oleoresin and piperine. Organic production technology for black pepper has been standardized. Cost effective method for production of disease-free rooted cuttings was developed. Mathematical models for optimum climatic factors for high production of black pepper have been developed. Major pests, pathogens, viruses & their insect vectors and nematodes affecting pepper were characterized and documented. Morphological and molecular characterization of black pepper isolates of *Phytophthora* further revealed that isolates shared the characters of both *P. capsici* and *P. tropicalis*. A RNA virus, Cucumber mosaic virus (CMV) and a DNA virus, Piper yellow mottle virus (PYMoV) are found to be associated with stunted disease of black pepper. A method for simultaneous isolation of RNA and DNA from infected black pepper plants and multiplex PCR for simultaneous detection of CMV and Badna virus in a single reaction was standardized. Phytoplasma with phyllody symptoms was most closely related to members of aster yellows group (16Sr I) of Phytoplasma. 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. Large scale multiplication of biocontrol agents such as *Trichoderma* and *Pseudomonas* for distribution to farmers for management of disease was also undertaken. These organisms were deposited in the national repository of microorganisms at IMTECH, Chandigarh for future reference. Species-specific primers were developed for detection of *R. similis* in soil and plant samples. Black pepper accessions, HP-39 and Acc. 1090 were found to be resistant to nematodes besides being rich in caryophyllene. Endophytic bacteria found effective against *Phytophthora capsici* and *R. similis* in black pepper have been found. An integrated pest management schedule for management of root mealy bug has been developed. PCR based techniques were developed for identification of traded black pepper and to detect adulterants in commercial black pepper powder. Post harvest technologies for drying, processing, storage and production of value-added product like white pepper were standardized.

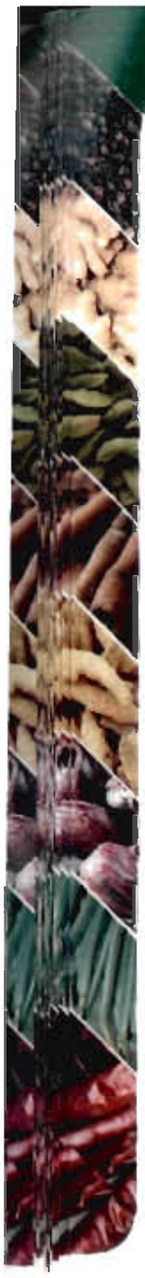
Cardamom: For all the available germplasm, IC numbers have been obtained. Meanwhile, germplasm bearing unique characters have been registered with NBPGR, New Delhi. GC-MS study confirmed superiority of Indian cardamom over Guatemalan and Sri Lankan cardamom. Molecular profiling of Indian cardamom revealed the existence of two genetically distinct clusters such as "Kerala cluster" and "Karnataka cluster' among the germplasm collections. The improved varieties such as IISR-Vijetha, IISR-Avinash and IISR-Suvasini have been developed. Two of them having mosaic or rhizome rot resistance have been popularized among the farming community. Coupled with production technologies, these varieties resulted in increasing productivity of cardamom. New high yielding varieties such as APG 293, 398, 416 and 250 are found to be promising. Characterization of export grade cardamoms from India, Sri Lanka and Guatemala based on physical, biochemical parameters and molecular techniques revealed the superiority of Indian produce for the physical parameters such as seed to husk ratio, weight of 100 capsules, number of

capsules in 100g, bulk density and moisture content. High production technology has been standardized. Drip irrigation and sprinkler irrigation once in 12 days recorded significantly for yield attributing characters. Soil and water conservation measures have been standardized in cardamom based cropping system. Cardamom accessions APG 257, APG 414 and APG 434 were found to be promising for drought tolerance. High quality (more than 40% α- terpinyl acetate) cardamom such as NHY-14, MB-3, NHY-18 and OP-28 have been identified. The screening programme against leaf spot and leaf blotch resulted in several moderately resistant types.

Ginger: Germplasm repository at IISR has the largest collections with several exotic collections and high quality accessions. These accessions have been regularly utilized in the genetic improvement programme. An *in vitro* gene bank was established for conservation of germplasm. Three ginger varieties namely, IISR Varada, IISR Rejatha and IISR Mahima were released for high yield and quality. Ginger oil components have been characterized by GC-MS. A relationship between leaf P/Zn ratio and soil P/Zn ratio to rhizome yield of ginger have been established. Post harvest technologies for processing and technologies for preparation of value added products such as salted ginger were standardized. Bacterial wilt pathogen, *Ralstonia solanacearum* in North Eastern states, Sikkim and Kerala were found similar in a molecular fingerprinting indicating strain migration from one place to another. Ginger strain of *R. solanacearum* was found to infect turmeric, cardamom, *C. aromatica*, *C. zedoaria*, *Kaempferia galanga*, *Zingiber zerumbet* and tomato. Indian Mango ginger, *Curcuma amada* was found to be free from bacterial wilt even under inoculated conditions. The species of *Pythium* causing rhizome rot of ginger in Kerala, Karnataka, Uttar Pradesh and Sikkim was identified as *P. myriotylum*. Technique for ginger seed rhizomes treatment (for elimination of bacterial wilt pathogen) and integrated disease management strategy for soft rot & bacterial wilt diseases and shoot borer was developed. 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 publications, training programmes and demonstrations. Large scale multiplication and distribution of elite planting material was also undertaken.

Turmeric: The germplasm collected over the years have been conserved in the field gene bank and they were characterized for yield, quality, and resistance to pests and diseases. Op seedling progenies generated over the years are being evaluated for their yield and quality characters. Molecular genetic fingerprints of sixteen *Curcuma* species using RAPD and Inter Simple Sequence Repeats (ISSR) technique revealed high degree of polymorphism among the accessions. Microsatellites have been isolated from *Curcuma longa*. Seven high curcumin and high yielding varieties, IISR-Suvarna, IISR-Sudarsana, IISR-Suguna, IISR-Prabha, IISR-Prathibha, IISR-Alleppey Supreme and IISR-Kedaram were released for commercial cultivation. Efficient protocol for plant regeneration through organogenesis and somatic embryogenesis was standardized. Variations in rhizome morphology were observed among calli-regenerated somaclones indicating somaclonal variation. Accessions with high curcumin and root knot nematode resistance were identified. Three different curcuminoids (curcumin, de methoxy curcumin and bis de methoxy curcumin) could be separated from oleoresin of turmeric rhizomes by employing chromatographic techniques. Turmeric oil components have been characterized by GC-MS. 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. Basic data on distribution, bioecology, population dynamics of shoot borer (*Conogethes punctiferalis*) and its natural enemies and crop loss due to shoot borer was generated. The improved varieties and technologies were disseminated to farmers and other agencies through publications and demonstrations.

Tree spices: The germplasm holdings of three important tree spices, nutmeg, clove, cinnamon including cassia, garcinia and allspice are being conserved. IC numbers for cinnamon, clove, nutmeg and allspice accessions were obtained from NBPGR, New Delhi. Cassia C1 (IC 370415) has been registered as INGR 05029 with NBPGR, New Delhi for its high oleoresin content (10.5%) besides a dwarf clove accession. Two high quality cinnamon varieties, IISR-Navashree and IISR-Nithyashree and a nutmeg variety, IISR-Viswashree were released. Nutmeg accession, A11/25 was found to be promising for high yield. Tissue culture protocols have been developed for nutmeg. Protocols for DNA isolation from nutmeg have been standardized. Performance of nutmeg on *M. malabarica* continued to be better than other rootstocks for productivity. GC-MS study revealed the presence of two chemotypes in *Cinnamomum verum*. Drying and processing methods for cinnamon, nutmeg and



mace have been developed. Antioxidant properties and food color value are being studied in tree spices. Vegetative propagation techniques were standardized for nutmeg, cassia and cinnamon. Major pests and diseases on tree spices were documented. The improved varieties and technologies developed on propagation and post harvest processing were disseminated to farming community.

Vanilla: Vanilla germplasm are being maintained in the repository, which includes a flower colour variant collected from Andaman and Nicobar islands. Comparative anatomical analysis of different vanilla species was carried out. Interspecific hybridization was made between *Vanilla planifolia* and *V. aphylla*. Over 1000 seed progenies of *V. planifolia* are being field tested for yield and disease resistance. Protocols for micro propagation through direct shoot multiplication as well as callus regeneration were standardized. Root rot and wilting were found to be the major problems in most of the plantations. Root rot incidence ranged from 5 to 100%. Mosaic and necrosis were also observed in all the plantations and the incidence ranged from 2 to 80%. Cucumber mosaic virus (CMV) of vanilla was characterized on the basis of biological and coat protein (CP) nucleotide sequence properties, which showed that CMV infecting vanilla belongs to subgroup IB. A virus causing mild chlorotic mottle and streaks on leaves of vanilla was identified as a strain of Cymbidium mosaic virus (CymMV) based on coat protein gene sequence comparison and phylogenetic studies. Similarly, a virus associated with necrosis and mosaic was identified as a strain of Bean common mosaic virus (BCMV) based on coat protein gene sequence studies.

Paprika: The germplasm collected from various places of cultivation have been characterized for various morphological, yield and quality characters such as oleoresin, pungency and colour value. Considerable variability was observed in capsaicin content (pungency) of selected paprika accessions. Accessions with high yield and colour values and low pungency were also identified. PCR based technique was developed to detect adulterants in commercial chilli powder.

BLACK PEPPER

Genetic resources

Conservation and characterization

Presently, 2575 accessions of black pepper germplasm (Wild pepper - 1266, Cultivars - 1300, Exotic species - 9) are conserved in the nursery and field genebank. In order to safeguard the germplasm accessions two alternate centers have been identified for conserving the germplasm. The alternate centers are CPCRI Kidu (for cultivated accessions) and CRC, Appangala (for wild accessions). Two hundred and thirty eight accessions were planted at CRC, Appangala during the year.

The wild accessions established in the field genebank and nursery premises were characterized for morphological characters using IPGRI descriptors.

A bush pepper germplasm block consisting of 42 local cultivars and 30 wild species was established at IISR, Calicut.

Phenomics facility (herbarium) was established at the head quarters. About 750 herbarium specimens of black pepper and related species are available at present in the facility.

Registration of germplasm: Two black pepper accessions having unique characters were identified and registered by the Plant Germplasm Registration Committee of NBPGR. They are:

1. Collection number 5529; INGR 08099, *Piper thomsonii*- a transexual species, male changed to bisexual. Bushy form
2. Collection number 5705; INGR08100, *Piper nigrum* having noval spike variant with 100% proliferating spikes

Breeding

Resistance to 'pollu' beetle

A total of 650 cross combinations were made by using 238 spikes of IISR-Subhakara with identified 'pollu' resistant lines. More than 640 hybrid seedlings were raised using "pollu" resistant lines (Acc. 1114, Acc. 841, Acc. 1084 and Acc. 816) as donor parents and the improved variety, IISR-Subhakara as female parent. The hybrid progenies were characterized morphologically and multiplied vegetatively for planting them in the field for further studies.

High yield and caryophyllene

Four hundred and fifty seedlings were raised from different cross combinations for planting them in the field for further evaluation.

β-caryophyllene is a sesquiterpene very specific to the flavouring properties of black pepper. It shows wide variation with respect to cultivars, altitude and location. Leaf and berry samples of major black pepper cultivars from IISR Experimental Farm Peruvannamuzhi, Calicut, and from Pepper Research Station (PRS), Panniyur, Kerala were collected and studied for its constituents.

Among the cultivars, IISR-Subhakara showed high oil content (6%) followed by Kottanadan and IISR-Sreekara. Among the hybrids, HP-1117 had high leaf oil followed HP- 785. Highest oleoresin in berries (13.9%) was found in IISR-Subhakara followed by IISR-Panchami, IISR-Sreekara and Kottanadan.

At PRS, Panniyur, Panniyur-4 recorded highest berry oil (5%) followed by Karimunda. Maximum oleoresin content (11%) was found in Panniyur-4 followed by Neelamundi and Panniyur-5. The leaf oil content at PRS, Panniyur was maximum for cultivar Angamali. Piperine content was maximum (4.2%) for IISR Sreekara at Calicut, followed by IISR Panchami while it was maximum (3.8%) for Panniyur-4 followed by Panniyur-5 and Karimunda at PRS, Panniyur.

All cultivars collected from PRS, Panniyur showed β-caryophyllene in the leaf oil. Germacrene D was a major constituent in the leaf oil. The concentration of β-caryophyllene in leaf oil varied between 2.03 to 8.47% and that of germacrene D varied between 4.08 to 44.2%. Highest germacrene D was found in

Panniyur-3, Panniyur-2, Panniyur-6 and Panniyur-7. Another major constituent in the leaf oil of many cultivars was elemol. Its concentration varied between 2.37 to 55.2%. Highest elemol was found in cultivars such as Vatamunda, Neelamundi and Angamali followed by Panniyur-4. Few cultivars had α-bisabolol, eudesmol, nerolidol and farnesol.

Major berry oil constituents were pinene, sabinene, myrcene, limonene, β-caryophyllene and germacrene D (Table 1.1). Pinene, sabinene, myrcene and limonene were absent in the leaf oil of most of the cultivars. Compared to the leaf oil more variability was observed in the β-caryophyllene of berry oil. Except Panniyur-4 and Angamali all the cultivars had relatively high β-caryophyllene with the highest concentration in Panniyur-1, Panniyur-2, Kottanadan, Panniyur-3 and Aimpiriyan. The concentration of germacrene-D in the berry oil was less than 20% of that of the leaf oil in many cultivars.

Like samples from PRS, Panniyur, in cultivars grown at IISR Farm, Calicut, β-caryophyllene and germacrene D were found in the leaf oil of all the cultivars evaluated (Table 1.2). Variability was more with germacrene D than β-caryophyllene in leaf oil. β-caryophyllene ranged from 1.2 to 10.2% with the highest in Panniyur-3. Germacrene D ranged from 4.56 to 56.71% in the leaf oil. Panniyur-2, Panniyur-3, IISR-Sreekara, Neelamundi and IISR-Malabar excel had higher concentration. The pattern followed the same trend as that of cultivars grown at PRS, Panniyur. Elemol levels in leaf oil varied from 1.64 to 51.6% with the highest being in cultivars such as IISR-Thevam, HP-1117, Kottanadan and Panniyur-4. Other constituents of leaf oil were nerolidol, eudesmol, α-bisabolol and farnesol.

In the berry oil, pinene, sabinene, myrcene, limonene, β-caryophyllene, germacrene D, nerolidol and elemol were the major constituents. High caryophyllene was found in HP-1117 and HP-785 (Table 1.1).

Path analysis

Path analysis was carried out to find out the direct and indirect effects of the leaf constituents on berry constituents. Leaf piperine has shown direct effect on berry piperine and the leaf constituents such as caryophyllene, germacrene D, nerolidol, elemol, essential oil, piperine, total phenol, total amino acids, total starch, total carbohydrate and protein had a residual effect of about 49% on berry piperine. Leaf piperine and leaf phenols showed strong positive correlation with berry piperine. This is strongly supported by direct effects of these two on berry piperine.

Resistance to *Radopholus similis*

Planting of hybrid progenies from the cross IISR-Subhakara x HP39 was undertaken in the Experimental Farm at Peruvannamuzhi. The three black pepper lines (IISR-Subhakara, HP 39, C-820) were analyzed using 36 RAPD primers out of which one primer (OPJ-09) produced an unique band of 650 bp in HP 39 (resistant) which was absent in other two lines, IISR-Subhakara (susceptible) & C-820 (tolerant). The particular band was excised from the agarose gel and successfully cloned. Sequencing of the polymorphic 650 bp fragment cloned from HP 39 was found to have maximum similarity to acetyl-CoA carboxylase. Selfed seeds collected from HP 39 were also germinated for screening for resistance to *Radopholus similis*.

Table 1.1. Major constituents in back pepper berry oil – IISR Experimental Farm (Peruvannamuzhi, Calicut)

Variety	Pinene (%)	Sabinene (%)	Myrcene (%)	Limonene (%)	Caryo-phyllene (%)	Germacrene D (%)	Nerolidol (%)	Elemol (%)
Kottanadan	12.07	27.47*	-	23.84	13.4	8.75	4.49	-
HP-785	4.88	12.77	21.04	16.68	23.97	8.19	0.49	-
HP-1117	4.83	18.2	16.83	19.58	29.24	-	-	-
HP-846	5.51	20.11	18.21	26.78	10.3	4.67	-	-
IISR-Sreekara	6.4	17.82	19.92	18.62	18.64	9.09	-	1.15
IISR-Subhakara	5.75	16.83	20.4	18.78	18.68	10.15	0.49	0.91
Karimunda	4.6	15.39	18.51	17.92	21.7	-	-	-
Panniyur 1	4.65	18.18*	-	17.99	22.62	12.77	4.25	-

*percentage composition of Sabinene+ Myrcene is given.

Table 1.2. Major constituents in black pepper leaf oil – IISR Experimental Farm (Peruvannamuzhi, Calicut)

Variety	β-caryo-phyllene (%)	Germacrene D (%)	Nerolidol (%)	Elemol (%)	Eudesmol (%)	α-bisa-bolol (%)	Farnesol (%)
Kottanadan	1.82	9.16	3.61	41.48	-	-	-
HP-785	6.15	29.29	-	35.58	-	-	-
HP-1117	5.12	9.41	0.91	42.07	-	-	-
HP-846	7.87	30	9.43	1.98	-	-	-
IISR-Sreekara	5.38	37.64	-	22.39	-	1.97	-
IISR-Subhakara	6.95	13.85	19.88	27.82	-	3.03	-
Karimunda	5.27	17.33	11.75	26.16	-	-	-
Panniyur 1	5.99	30	9.43	1.98	-	14.67	1.49
Panniyur 2	5.25	56.71	-	5.16	-	-	-
Panniyur 3	10.24	44.31	-	1.64	5.28	4.82	2.26
Panniyur 4	1.9	10.94	4.21	40.05	4.56	31.62	-
IISR-Panchami	1.21	6.19	3.05	33.97	-	32.97	1.54
IISR-Pournami	7.14	10.65	21.84	31.52	14.08	3.35	-
Neelamundi	3.56	29.83	2.11	3.48	-	-	-
IISR-Malabar excel	*7.12*	*28.95*	*10.81*	*3.48*	-	-	*1.61*
IISR-Thevam	4.44	4.56	2.56	51.66	-	-	-
IISR-Girimunda	6.45	9.2	22.24	29.7	-	3.46	-

Tolerance to drought

Bush pepper plants of IISR-Subhakara and drought tolerant lines *viz.*, Coll. 1495, Coll. 813 and Coll. 931 were raised. Intercultivar crossing was initiated using male and female parents. The total number of spikes pollinated were 74 in IISR-Subhakara x 813, 66 in IISR-Subhakara x Coll. 1495 and 70 in IISR-Subhakara x Coll. 931.

Seedlings generated were collected, germinated and transferred to plastic bags. The number of seedlings generated were 215 in IISR-Subhakara x 813, 124 in IISR-Subhakara x 1495 and 60 in IISR-Subhakara x Coll. 931.

Screening for drought was initiated with first batch of 50 seedling progenies by withdrawing watering for a period of 15 days and then the plants were revived. Observations were taken on relative water content and membrane stability.

Resistance to *Phytophthora*

Data on floral and other morphological characters which are segregating in Panniyur-1 x IISR-Subhakara mapping population were recorded. Spike characters like spike length, fruit set, fruit size, male-female flower ratio were seen segregating and most of the progenies were found to be inter mediate in forms. The mapping population was screened with 3 RAPD primers and 3 ISSR primers and molecular profiles were recorded. Twenty crosses were made between IISR-Subhakara x IISR-Shakthi for tagging *Phytophthora* resistance and about 100 seedlings were germinated and established from the crosses made last year. About 100 lines were collected and multiplied for screening against *Phytophthora* and to develop a population for association mapping. Fifty more lines from mapping population were field planted during the year.

Development of transgenics

For resistance to *Phytophthora* and drought

About 20 more transgenics were regenerated with osmotin. Ten putative transgenic plants were transferred for hardening. Another 30 more are ready for transfer. Five putative transgenics with osmotin were multiplied into 50 each for screening. The transgenics showed different expressions of resistance when tried with one isolate in leaf, stem and root inoculation methods. One TGP 3 has given initial tolerant reaction in root inoculation.

Development of core ESTs and cloning of genes from *Piper nigrum* and *P. colubrinum*

As an approach towards isolating genes of importance from *Piper* on the basis of homologous sequence comparisons, genes previously reported in other plants as responsive to stress factors, defense, primary and secondary metabolism were downloaded. All the conserved motifs will serve as candidates for degenerate primer synthesis and amplifications from RNA.

Rootstock intervention to manage root infection of *Phytophthora* and nematodes

Wild species *Piper ornatum* (Acc. 3362), *Piper galeatum* (Acc. 3030), *Piper attenuatum* (Acc. 664) and *Piper trichostachyon* (Acc. 611) were screened against *Phytophthora capsici* and the nematodes *Radopholus similis* and *Meloidogyne incognita* using rooted cuttings. Out of these only *Piper ornatum* was found resistant to all the pathogens.

Grafting IISR-Sreekara on HP-39, IISR-Shakthi and C-1090 was performed giving a success of 10%, 66.67% and 78%, respectively. HP-39 gave very poor success owing to its very poor growth habits. Screening of grafts of Sreekara with C-820, a nematode resistant line, as rootstock indicated that the graft combination was infested by the nematode-*Radopholus similis*. Hence C-820 cannot be used as a resistant rootstock. Grafts of Sreekara on IISR-Shakthi and C-1090 as rootstocks both being tolerant to *Phytophthora capsici*, were screened against the pathogen with nematode control using pborate. The results showed that C-1090 is highly tolerant to root rot. The survival of grafts was 91.67% with the lowest root rot incidence of 14% when nematodes were controlled. The combination IISR-Sreekara grafted on C-1090 is found very promising and needs field evaluation along with nematode control.

Enhancing the productivity

Intercropping

Tapioca, amorphophallus, coleus, ginger, turmeric, hybrid napier, Congo signal grass, and Guinea grass were raised in black pepper gardens of 15 years old at RARS, Ambalavayal to select profitable intercrops in black pepper garden (Fig 1.1). Maximum yield was recorded by the intercrop hybrid napier grass followed by amorphophallus. Maximum net return (Rs 82700/ ha) was obtained from the crop combination of black pepper with Amorphophallus followed by black pepper with ginger (Rs 75337/ha) (Table 1.3). Based on B:C ratio, profitable and suited intercrops are greater yam (B:C ratio 4.6), ginger (B:C ratio 4.5) and amorphophallus (B:C ratio 4.4). Maximum income was obtained from the crop combination of black pepper with amorphophallus (Rs.1,31,100/ha) followed by greater yam (Rs.1,26,400/ha) in juvenile garden.

Fig. 1.1. Black pepper intercropped with Guinea grass

Soil fertility management by cover crops

Nutrient addition by cover crops *viz.*, cowpea and horse gram for three seasons from September to May was estimated in the black pepper plantation. The crop sequence with cowpea alone could add 95.0, 5.8, 27.5, 24.3, 3.9 kg N, P, K, Ca and Mg per ha respectively, whereas, a sequence with horse gram alone could contribute 26.1, 2.4, 15.9, 7.6, 2.5 kg of N, P, K, Ca and Mg per ha, respectively. A sequence with cowpea followed by horse gram or vice-versa could contribute less than the sequence with cowpea alone.

Summer irrigation on spiking and yield

In an attempt to study the factors influencing spiking in black pepper, irrigation of pepper vines during summer was included as one of the treatments. Irrigation was started during March II fortnight and continued till May II fortnight. The pepper vines were irrigated @ 50 litres/vine/day at 15 days interval. The results showed that in irrigated treatment, the spiking was uniform and the spikes emerged in July while in rainfed treatment, around 60 % spikes emerged in July and the rest emerged in September. Spiking was less under rainfed condition and the dry yield per vine was also reduced significantly under rainfed condition (Table 1.4)

Table 1.3. Economics of raising intercrops in black pepper garden of > 15 years old

Intercrop	Mean intercrop yield (kg)	Cost of cultivation (Rs)	Gross returns (Rs)	Net returns (Rs)	B:C ratio
BP+Tapioca	6000	80117	54000	Nil	0.6
BP+ Amorphophallus	7600	38820	121600	82700	3.1
BP+Coleus	2760	66614	55200	Nil	0.8
BP+Ginger	6970	22243	97580	75337	4.4
BP+Turmeric	7016	38893	70160	31267	1.8
BP+Hybrid napier	67150	15000	67150	52150	4.5
BP+C. signal grass	26060	15000	26060	11060	1.7
BP+Guinea grass	29413	15000	29413	14413	2.0

Shade regulation on yield

Shade regulation of pepper plantations during summer forms an integral part of cultural operations. Timing of shade regulation is very crucial to maintain the productivity of vines. The effect of shade regulation during April and June on spike production and yield was studied (Table 1.5). The results indicated that early shade regulation during April produced uniform, good spiking compared to July shade regulation which produced staggered low spiking. The dry yield per vine was also significantly higher in early shade regulation treatment.

Nutrient requirement for targeted production

In black pepper 5, 7.5 & 10 kg dry yield was targeted and fertilizer doses for the same based on soil fertility was calculated and imposed in two splits at Mrigarajendra Estate, Madapur, Madikeri. The yield targets could be achieved with a minimum deviation from the targets. The recorded yield levels were 5.5, 7.3 and 8.2 kg/vine in the targets of 5, 7.5 and 10 kg/vine, with a deviation of +11%, -2.2% and -18.0% respectively. The yield increase as compared to the control was 39 to 104%.

Targeted dry yield (kg/vine)	N	P_2O_5 (g/vine)	K_2O	Realized yield (kg/vine)	Deviation (%)
5	100	-	-	5.5	+10.80
7.5	200	30	350	7.3	-2.20
10	350	120	1200	8.2	-18.2

Table 1.4. Effect of summer irrigation on black pepper spiking and yield

Treatment	New spikes (September)	Old spikes (July)	New leaves	Old leaves	No of laterals	Spike length (Old)	Spike length (New)	Dry yield (kg/vine)
Irrigated	1.0	39.4	1.5	48	9.0	13.5	13.0	6.5
Rainfed	12.5	9.0	15	42	8.5	10.0	9.0	3.4

Table 1.5. Influence of timing of shade regulation on black pepper spiking and yield

Treatment	New spikes (September)	Old spikes (July)	New leaves	Old leaves	No of laterals	Dry yield (kg/vine)
Early shade regulation (April)	3.0	37.3	3.5	45	9.0	5.5
Late shade regulation (June)	13.0	11.0	17	36	10	2.7

Organic farming

The particle size distribution and aggregate analysis studies of soil samples from different management systems namely, organic, chemical and integrated systems in black pepper showed higher percentage distribution of soil aggregates with > 0.5 mm diameter under organic system. The organic carbon content of different size fractions (0.5 – 0.1 mm) also showed higher content in organic system compared to that of integrated and chemical systems. The mean weight diameter was also higher in organic (3.24 mm) system (Table 1.6).

Physiological and biochemical basis of productivity

A study was carried out to investigate the relationship between physiological and biochemical characters of rooted cuttings (during juvenile stage) with vine productivity during bearing stage so that probable high yielders could be identified during juvenile stage itself.

Various metabolite levels, isozymes and enzyme activities of photosynthetic and respiratory cycles such as malate dehydrogenase, glu 6 phosphate dehydrogenase, sucrose phosphate synthase, nitrate reductase, photosynthesis and gas exchange parameters *etc*. were analysed in rooted cuttings of a few selected high as well as low yielding accessions to characterize the parameters contributing to productivity and develop relationship between these parameters and productivity.

Among the various parameters studied, higher nitrate reductase activity, higher photosynthetic rate and higher total carbohydrate content were correlated with higher productivity. About 150 germplasm accessions were screened for higher productivity based on the identified parameters. Among the accessions screened, Acc. 1395 maintained high nitrate reductase activity, photosynthetic rate and total carbohydrates in leaves followed by Acc. 898.

Drought tolerance

Two hundred germplasm accessions were screened for drought tolerance based on relative water content, membrane leakage and chlorophyll fluorescence. Among the accessions screened, acc. 1476 followed by acc. 1086 showed tolerance characteristics. These two accessions maintained very high relative water content and low membrane leakage after 14 days of stress compared to other accessions. Protein profiles were also studied in a few relatively tolerant and susceptible accessions identified during previous screenings. Both the tolerant and the susceptible accessions showed similar banding pattern but the quantity of proteins was very less in susceptible accessions (as indicated by the intensity of bands).

Table 1.6. The particle size distribution in different management systems

Treatment/ Sieve size (mm)	Soil aggregates (%)				Organic carbon (%)				Mean wt diameter (mm)
	0.5	0.25	0.125	0.1	0.5	0.25	0.125	0.1	
Organic	71.40	18.97	4.29	0.32	3.23	2.73	3.33	3.78	3.24
Inorganic	63.69	21.13	5.42	0.42	2.63	2.66	2.35	2.80	3.04
Integrated	68.25	20.59	4.17	0.41	2.14	2.65	2.75	3.68	3.15

Biodiversity in *Piper* using GIS

Piper accessions collected from Karwar, Goa, Wynad, Idukki, Dapoli, Coorg and Palakkad were analysed for leaf oil constituents. It was interesting to note that the accessions having myristicin did not show nerolidol in the leaf oil (Table 1.7). The GIS study showed that only the higher latitude samples had myristicin. (14°12' to 17 °26') while the lower latitude (9 °to 12 °40') samples, especially the Kerala samples did not have myristicin in leaf oil.

Myristicin, a major compound present in nutmeg and is not yet reported in *P. nigrum* leaf oil, except a trace amount in *Piper nigrum* berry oil. In this study myristicin recorded an average of 46.5 % in leaf oil of *Piper nigrum* species.

Post harvest quality

Chemical quality profile under suitable storage atmosphere

Black pepper variety Panniyur-1 with a moisture content of 10.0% was stored for 360 and 480 days in three layered metalised polyester cover under vacuum,

Table 1.7. GCMS volatile oil profile of wild *Piper nigrum* leaves collected from different places of Kerala, Karnataka and Maharashtra

Acc no	Place of Collection	Lati tude	Longi tude	Neroli dol	Pinene	Caryoph yllene	Myris ticin	β elem ene	α hum elene	Germa crene	Safrole	Sabi nene	β seline
7067	Karwar	14°12'	74°52'	-	28.21	4.65	7.29	-	-	-	-	-	-
7084	Karwar	14°29'	74°59'	-	-	0.99	54.38	5.36	-	-	-	-	-
7081	Karwar	14°11'	74°61'	-	-	-	30.99	3.91	-	-	-	-	-
7075	Karwar	14°54'	74°63'	-	-	4.58	59.40	-	-	16.2	-	-	-
7087	Karwar	14°30'	74°75'	-	-	-	16.17	-	-	-	-	-	-
7075	Karwar	14°34'	74°72'	-	-	-	60.75	-	-	14.47	-	-	-
7076	Karwar	14°33'	74°67'	4.12	10.25	7.49	-	-	5.30	-	-	43.68	-
7073	Karwar	14°54'	74°70'	36.40	3.88	-	-	-	-	-	-	11.74	-
6480	Dapoli	17°26'	73°18'	-	26.81	1.67	20.25	3.69	1.14	2.60	3.61	-	-
6482	Goa	15°60'	73°95'	-	-	5.99	55.06	2.84	1.61	-	3.38	-	4.80
430	Wynad	11°36'	76°05'	1.12	-	5.18	-	-	5.99	3.58	-	-	15.49
327	Coorg	12°38'	75°34'	2.13	-	5.43	-	1.46	2.07	2.89	-	-	7.86
4586	Idukki	09°39'	77°04'	1.15	-	3.73	-	1.51	-	4.03	-	-	8.26
756	Palakkad	10°58'	76°35'	1.52	-	2.88	-	2.10	-	28.03	-	-	-

100%N_2 and 90%N_2+10%CO_2 atmosphere and the sample was compared with that of black pepper stored in ordinary gunny bag. Samples collected were powdered and evaluated for oil, oleoresin and piperine. No significant variation was observed in the oil, oleoresin, piperine and oil constituents. The appearance of the sample was cleaner in metalised containers compared to normal gunny bag packing.

Phytophthora foot rot and slow decline

Identification of resistant sources

Cultivars (35) and hybrids (32) of black pepper shortlisted earlier were screened against *Phytophthora capsici* by root inoculation method; however, none of the lines screened showed resistance to root infection. The lines that showed resistant reaction towards *P. capsici* in earlier screening (04 P24-1, HP 1533 (2), HP 1533 (3), HP 449, HP 490, HP 521, HP 1375 and Ç 1530) are being evaluated in the field.

Eight wild accessions (Accs. 3357, 692, 4381, 3030, 3362, 3296, 611 and 612) were screened against *P. capsici* and nematodes among which Acc. 3362 (*Piper ornatum*) showed resistance towards *Phytophthora* and both the nematodes (*Meloidogyne incognita* and *Radopholus similis*) (Fig 1.2).

Fig. 1.2 *Piper ornatum*, resistant to *Phytophthora capsici* and nematodes

The 15 *P. capsici* tolerant lines identified earlier were screened once again using stem, leaf and root inoculation methods with virulent isolate of *P. capsici*. All the lines showed susceptible reaction towards leaf and stem infection (Table 1.8) whereas on root screening, Accs. 1098, 847, 813 and 803 and 04-HP 1533 (3) showed no root infection till 45 days after inoculation.

The four transgenic plants (TGP 1, 3, 7 and 10) were subjected to stem, leaf and root inoculation. Stem and leaf inoculated plants of TGP 7 died by the 10th day of inoculation. TGP-1, 3 and 10 also took up infection by stem and leaf inoculation methods but the lesion extended only till the next node from where an abscission layer was formed and the infected portion

Table 1.8. Screening of promising tolerant lines against *Phytophthora capsici*

Acc.	Leaf infection (av. lesion length, mm)	Stem infection (av. lesion length, mm)	Index	Root infection (%) up to 45 days
P 339	22.9	15.4	4	20.0
HP 1533(3)	25.0	22.0	4	0.0
HP 1	25.3	34.2	4	80.0
1099	15.3	22.5	4	60.0
1098	18.1	27.0	4	0.0
1093	26.6	44.2	4	20.0
1052	28.1	44.0	4	40.0
1047	29.7	33.4	4	60.0
1038	29.3	35.5	4	20.0
894	19.7	37.0	4	20.0
884	19.4	39.6	4	60.0
847	22.6	32.2	4	0.0
813	34.0	24.6	4	0.0
803	33.4	31.0	4	0.0
816	21.5	16.2	4	20.0

got detached from the plant and the plants are still surviving. However, all the plants were susceptible to root infection (Table 1.9).

Evaluation of biocontrol agents

A field trial was undertaken at IISR Farm, Peruvannamuzhi, with endophytic and rhizosphere biocontrol agents (Bp 35, 25, 17, TC 10, IISR 853 and IISR 6) comprising of eight treatments and designed in such a way that chemical nematicide (phorate) was integrated with biocontrol agents (Bp 35, Bp 25 and IISR 6) which are antagonistic towards *P. capsici* and fungicide (metalaxyl-mz) was integrated with biocontrol agents (Bp 17, TC 10 and IISR 853) which are antagonistic to *R. similis*. A control treatment was included with the chemicals phorate and metalaxyl-mz. Three node cuttings from healthy vines of var. Panniyur-1 were treated with the chemical as well as the biocontrol agents before planting and the pits for planting were drenched with the respective biocontrol agents. The microbial load in the interspaces and rhizosphere, pH of the soil and moisture content are being recorded periodically. The treatments were imposed at the time of planting and repeated at 3 months interval twice. Observations on growth parameters were recorded at the end of sixth month (Table 1.10).

The data on growth parameters showed significant difference between control and treatments. Among the treatments, TC 10 + metalaxyl-mz and IISR 853 + metalaxyl-mz were promising with increased plant height and number of leaves. No disease incidence (yellowing or rotting) was noticed during the period. *P. capsici* population was very negligible, but *R. similis* population was present in the rhizosphere and was lower where nematicide was included in the treatments.

Evaluation of new chemicals

Five new chemicals (benzoic acid, salicylic acid, potassium bicarbonate, captan-hexaconazole and carbendazim-mancozeb) were tested *in vitro* against *P. capsici*. Carbendazim-mancozeb was highly inhibitory even at 500 ppm (Fig 1.3). *In vivo* experiments were also conducted with the inhibitory concentrations of these chemicals after challenge inoculation. Potassium bicarbonate showed disease control of 61.5% over control followed by captan-hexaconazole and benzoic acid (46.2%) when

Table 1.9. Screening of transgenic plants against *Phytophthora capsici*

Acc.	Leaf inoculation	Stem inoculation	Root inoculation	Present status
TGP 1	Lesion not extended to the stem	Lesion not extended to the stem downwards	Infection on the 7th day	Stem and leaf inoculated plants survived
TGP 3	Lesion not extended to the stem	Lesion not extended to the stem downwards	Infection on the 30th day	Stem and leaf inoculated plants survived
TGP 7	Lesion extended to the stem	Plants died on the 10th day	Infection on the 10th day	All plants died
TGP 10	Lesion not extended to the stem	Lesion not extended to the stem downwards	Infection on the 7th day	Stem and leaf inoculated plants survived

Table 1.10. Evaluation of chemicals and biocontrol agents for the management of *Phytophthora* foot rot and slow decline diseases

Treatment	Ht. of the plant (cm)	No. of leaves	No. of branches	Branch ht. (cm)
BP 35 + Phorate	32.79	6.17	0.0	0.0
BP 25 + Phorate	45.47	7.42	0.29	6.05
IISR 6 + Phorate	36.65	6.88	0.13	1.90
BP 17 + Metalaxyl-Mz	47.36	8.34	0.79	19.08
TC 10 + Metalaxyl	69.76	11.29	1.00	20.57
IISR 853 + Metalaxyl-Mz	67.31	11.75	0.88	15.90
Phorate + Metalaxyl	27.04	5.67	0.13	2.29
Control	17.00	3.92	0.21	1.42
CD (P=0.05)	7.09	1.166	0.26	4.805

compared to other chemicals. The results showed that the concentration which exhibited 100% inhibition *in vitro* was not sufficient for obtaining the same level of inhibition of the fungus in the soil (Table 1.11).

Disease management in the field

New refined disease management trial was initiated in sick plot with over 20 years of disease history on Panniyur-1 under coffee based mixed crop conditions. In this disease management trial, combination of fungicides (1% Bordeaux mixture, hexaconazole, carbendazim, potassium phosphonate, mancozeb) and biocontrol agents (*Trichoderma harzianum* and *Pseudomonas fluorescens*) were imposed during pre-monsoon and mid-monsoon periods. The data on disease index of anthracnose, spike shedding, foot rot incidence and yield were collected. The results indicated that the treatment with basal application of *T. harzianum* and aerial spray with 1% Bordeaux mixture was superior. No foot rot incidence was noticed in this treatment compared to 22.6 % mortality in untreated control.

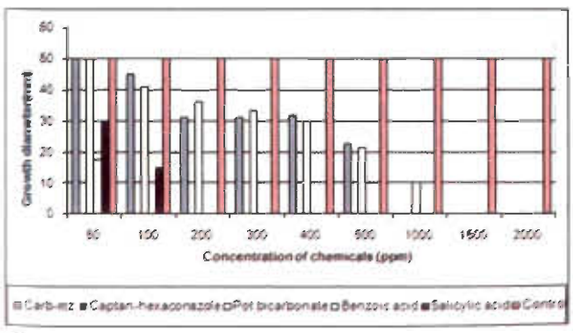


Fig. 1.3. *In vitro* evaluation of new chemicals against *Phytophthora capsici*

Table 1.11. *In vivo* evaluation of new chemicals on the incidence of *Phytophthora capsici*

Chemical	Conc. (ppm)	% disease incidence
Potassium bicarbonate	1500	25.0
Carbendazim-Mz	1000	55.0
Captan-hexaconazole	100	35.0
Benzoic acid	100	35.0
Salicylic acid	200	55.0
Control	-	65.0
CD (P=0.05%)	-	29.6

Carry over of anthracnose pathogen

The study was conducted under simulated field conditions by burying the infected debris around plant basin of 3 -5 year old Panniyur – 1 pepper plants and exposed for known period of rain (rain splash). The study indicated that the pathogen survives beyond 8 months in the debris and rain splash plays major role in rapid spread of disease to tender parts of the vine.

Virus indexing

Maintenance of virus-free mother vines

PCR based method was used in indexing black pepper plants representing 14 varieties for *Piper yellow mottle virus* (PYMoV). Total DNA isolated from 50 mg leaf tissue (from first fully opened leaf) was used as template in the PCR. Primers designed for the amplification of either 450 bp region of open reading frame (ORF) I or 400 bp region of ORF III were used. PCR was performed using two template volumes (0.5

and 1.0 µl). A plant was declared infected if it showed expected size amplicon in the PCR using either 0.5 or/ and 1.0 µl template. The identified virus-free materials were multiplied and maintained under insect proof glass house to serve as nucleus planting material which was then multiplied in another insect proof glass house to serve as foundation blocks of released varieties. Material from foundation block was multiplied in nurseries before distribution to farmers. In addition, black pepper mother plant samples received from Directorate of Arecanut and Spices Development, Calicut and State Department of Agriculture, Kerala, were indexed through PCR for the presence of virus and results communicated.

Preparation of Cucumber mosaic virus (CMV) coat protein gene construct

A 657 bp CMV coat protein gene sequence amplified through reverse transcription polymerase chain reaction (RT-PCR) using CMV CP specific primers was cloned in to TA cloning vector pTZ57R/T. Competent *E. coli* (strain DH5α) was transformed using Transform Aid bacterial transformation system. Positive recombinant clones were identified by restriction digestion and its nucleotide sequence determined by sequencing. The sequenced region contained a single ORF with 657 bases coding for a protein of 218 amino acids. One selected clone where CMV CP got cloned in sense orientation was restricted with *Bam* H1 and *Sac*1. The resulting fragment containing CMV CP region was isolated from the gel and ligated into binary vector, pBI 121 restricted with same enzymes (*Bam* H1 and *Sac* 1). Competent *E. coli* (strain DH5α) was used for transformation. The presence of recombinant pBI 121 containing CMV CP gene was confirmed by isolating the plasmid and subjecting it to restriction analysis and PCR using primer designed for CaMV 35S promoter region as forward and CMV CP as reverse primer. This was then mobilized into *Agrobacterium tumefaciens* strain EHA 105 by triparental mating with the help of helper plasmid pRK 2014. The transformants were selected on kanamycin and rifampicin plates. The presence of recombinant pBI 121 containing CMV CP gene (sense orientation) in *A. tumefaciens* was confirmed by isolating the plasmid and subjecting it to restriction analysis and PCR. The construct was designated as pBI121CMVS.

Transformation of black pepper explants

CMV CP construct in antisense orientation designated as pBI121CMVAS was used for transformation. Explants (leaf, internode and petiole) harvested from *in vitro* grown plants were co-cultivated with *Agrobacterium* harbouring the construct for 15 min, blot dried and kept in basal MS medium at 28°C for 48 h. Explants were then washed in cephataxime and streptomycin (both at 100 µg/ml) and kept in basal MS containing cephataxime and streptomycin (both 100 µg/ml) for 2-4 days to kill *Agrobacterium* and other bacterial contaminants. Among the different explants, leaf explants showed better survival (64.8%) followed by petiole (54.1%) and internode (45.8%). Other explants either died due to phenolic exudates from cut ends or were contaminated by bacteria and fungi.

After 15 days, the surviving explants were transferred to five different regeneration media containing different concentrations of BAP, NAA and TDZ along with selective marker, kanamycin. Callus formed readily from leaf explant within 30 days when they were cultured on SH medium supplemented with BAP, NAA and TDZ. Hormones @ 3 and 1 mg/l of BAP and NAA gave better response followed by hormones of BAP and NAA both at 1 mg/l while no response was seen with hormone BAP @ 3 mg/l. Two kinds of callus (creamish friable and white powdery) were observed. Many of the calli turned brownish even after continuous sub culturing and failed to give organogenesis.

Piper yellow mottle virus (PYMoV) ORF III construct containing 409 bp region in sense and antisense orientation designated as pBI 121 PYMoVS and pBI 121 PYMoVAS respectively were used for transformation of different explants like leaf, internode and petiole. Explants harvested from *in vitro* grown plants were co-cultivated with *Agrobacterium* harbouring respective constructs for 15 min, blot dried and kept in basal MS medium at 28°C for 48 h. Explants were then washed in cephataxime and streptomycin (both at 100 µg/ml) and kept in basal MS containing cephataxime and streptomycin (both 100 µg/ml) for 2-4 days to kill *Agrobacterium* and other bacterial contaminants. Among the different explants, leaf explants showed better survival (61.5 and 44%) followed by petiole (53 and 26%) and internode (45 and 11%) in sense and antisense constructs. About 38.5 to 89% of explants either died or got contaminated within 15 days. The death of explants is mainly due to phenolic exudates from cut ends while contamination was mainly due to bacteria and in a few cases with fungi.

After 15 days the surviving explants were transferred to 16 different regeneration media containing different concentrations of BAP, NAA, TDZ and kinetin along with selective marker, kanamycin. Callus formed

readily from leaf, internode and petiole within 30 days when they were cultured both on SH and MS media supplemented with BAP, NAA and TDZ. Types of callus observed in different phytohormone combinations were friable creamish, white powdery and hard callus (both green and creamy). Use of kinetin (1 mg/l) along with NAA (1-2 mg/l) in both SH and MS medium induced rooting in the leaf explants within 15 days of culture. Rooting as well as callusing was seen in leaf explants placed in MS medium added with both 3 and 1 mg/l of BAP and NAA or MS with 1mg/l each of kinetin and NAA. In the case of internode and petiole explants, 100% callusing was observed in SH media supplemented with 3 or 1 mg/l of BAP, 1 mg/l of NAA and 0.1mg/l of TDZ. While no response was seen in SH medium supplemented with 2 mg/l of BAP and 1 mg/l of NAA. In contrast, only 14-30% of petiole explants showed callusing in MS medium added with different hormones.

Seed transmission of *Piper yellow mottle virus (PYMoV)*

Berries collected from four varieties of black pepper (IISR-Sreekara, IISR-Subhakara, IISR Shakthi and Panniyur 1) infected with PYMoV (identified by PCR) were sown under insect proof conditions. The seedlings when checked for presence of symptoms, showed typical symptoms in a few plants indicating the presence of PYMoV. The highest number of symptomatic seedlings was in the var. IISR-Sreekara (26%) while in other varieties it ranged from 10% to 13%. When 50 seedlings of each variety (including both symptomatic and asymptomatic) were subjected to PCR using PYMoV specific primers, highest number of PYMoV infected seedlings were seen in var. IISR-Sreekara (30%) while in other varieties it ranged from 22% to 28%. Thus results of symptomatology and PCR clearly confirm the existence of seed transmission of PYMoV in black pepper and hence seeds can also serve as primary source of inoculum for the virus.

Screening of *Piper* germplasm against PYMoV

Four hundred eighty one accessions of *Piper* (290 accessions of cultivated black pepper and 191 accessions of wild *Piper* germplasm) were screened against PYMoV and all the 481 accessions tested were susceptible.

Nematodes

Black pepper - burrowing nematode interactions

Changes in three phenyl propanoid pathway enzymes namely, phenylalanine ammonia lyase (PAL), cinnamic acid-4-hydrolase (C4H) and caffeic acid-O-methyltransferase (COMT) were monitored in a susceptible (IISR-Sreekara) and resistant (HP 39) black pepper varieties consequent to *R. similis* infection. The PAL activity was constitutively high in HP 39 compared to the susceptible line. However, PAL activity increased in susceptible plants immediately after wounding or infestation by *R. similis* and subsequently reduced over a period of 30 days. However, *R. similis* infestation lowered PAL activity in the resistant plants. There was not much variation in the constitutive activity of C4H in susceptible as well as resistant black pepper plants. But on infestation with *R. similis*, the activity of C4H shot up in HP 39 plants (Table 1.12). Three-fold increase in COMT activity was noticed in susceptible Sreekara plants infested with *R. similis*. Preliminary assays indicated the presence of cellulose degrading enzymes in burrowing nematodes.

New host of root-knot nematode

The root-knot nematode, *Meloidogyne incognita* was recorded for the first time from a weed, *Achyranthes spra*, prevalent in black pepper gardens of IISR Experimental Farm, Peruvannamuzhi. Plants infested with root-knot nematode exhibited dense yellowish discoloration of leaves. The average nematode population was 11 adult females/g root and seven second stage juveniles/ 100 g soil. The species status was confirmed on the basis of morphological analysis and perineal pattern (Fig. 1.4).

Pollu beetle (*Lanka ramakrishnai*)

Identification of resistant sources

Cultivars (113) and hydrids (72) of black pepper were screened against pollu beetle (*Lanka ramakrishnai*) for identification of sources of resistance. Among the cultivars, Acc. 35 recorded the highest berry damage (36.5%) and the lowest damage was observed on Acc. 1636 (1.8%). Among the hybrids the damage was highest on Acc. 861 (44.4%), and lowest damage on Acc. 1388 (4.5%).

Erythrina Gall Wasp (*Quadrastichus erythrinae*)

Infestation

Surveys were conducted in 276 black pepper gardens in 13 taluks in 4 districts (Idukki, Kozhikode, Kannur and Wayanad) in Kerala and 3 taluks in 1 district (Kodagu District) in Karnataka, to study the damage and incidence of *Erythrina* gall wasp (*Quadrastichus erythrinae*), an invasive species on *Erythrina* spp., used as standards for trailing black pepper vines.

The incidence of *Erythrina* gall wasp was observed in all the locations surveyed and the percentage of trees

Table 1.12. Changes in the activities of phenylalanine ammonia lyase and cinnamic acid-4-hydrolase enzymes in susceptible and resistant black pepper lines in response to *R. similis* infestation

Treatment	Resistant line (HP 39)				Susceptible line (IISR-Sreekara)				Gen.
	2d	7d	30d	Mean	2d	7d	30d	Mean	Mean
Activity of phenylalanine ammonia lyase (PAL) – units x 10^{-3}									
Control	18.65b	18.53c	18.58b	18.59b	6.0a	6.08a	6.08	6.08a	12.34b
R.similis inoculated	12.54a	8.78a	1.70a	7.67a	12.97b	12.05b	11.8a	12.27b	9.97a
Wounded	22.89b	14.97b	17.75b	18.54b	21.00c	9.03b	11.2a	13.73b	16.13c
Mean	18.03	14.09	12.67	14.93	13.35	9.05	9.68	10.69	
LSD variety – NS ; LSD variety x interval – 2.32									
Activity of cinnamic acid-4-hydrolase (C4H) - units x 10^{-3}									
Control	0.93a	0.93	0.93	0.93ab	0.98a	0.98	0.98	0.98a	0.95b
R.similis inoculated	1.57a	2.49b	0.66a	1.57b	0.84a	3.80b	0.00	1.54b	1.56c
Wounded	1.07a	1.11a	0.60a	0.93a	0.64a	0.60a	0.24	0.50a	0.71a
Mean	1.19	1.51	0.73	1.14	0.82	1.79	0.41	1.01	-
LSD variety – NS ; LSD variety x interval – 0.33 (Means followed by the same letter are not significantly different at p = 0.01)									

(a) (b) (c)

Fig 1.4. Root knot nematode infestation in *Achyranthes spra.* (a) Root galls (b) Root-knot nematodes inside the root (c) Adult female of *M. incognita.*

infested by the pest was significantly higher in Wayanad District (59.6%) that was on par with Idukki (53.4%), Kodagu (51.8%) and Kannur (39.1%) district. The percentage of twigs infested by the pest was also significantly higher in Wayanad District (39.7%) that was on par with Idukki (35.5%), Kodagu (33.4%) and Kozhikode (31.6%) districts (Table 1.13). The severity of incidence varied on various species / types of *Erythrina* and was significantly higher in *E. variegata* (white-thorn type) wherein a mean of 91.8% trees and 66.8% twigs were infested by the pest. The pest was recorded for the first time on *E. subumbrans*.

Damage

The larvae of the *Erythrina* gall wasp induced the formation of galls in leaflets, petioles and tender stems. As the infestation progresses, the leaves curl and appear deformed while the petioles and tender stems become swollen, forming many thick-walled globular galls. Heavily galled leaves and stems resulted in loss of growth and vigour of the tree and severe infestations caused defoliation and death of trees as observed in Wayanad District (Fig. 1.5).

Table 1.13. Infestation of *Quadrastichus erythrinae* on *Erythrina* spp. in major black pepper growing districts of Kerala and Karnataka

District	No. of taluks surveyed	No. of locations surveyed	No. of gardens surveyed	Mean per cent infestation	
				Tree	Twig
Idukki	4	29	87	53.4 (47.0) ab	33.7 (35.5) ab
Kozhikode	3	19	65	32.9 (35.0) a	27.4 (31.6) ab
Kannur	3	27	61	39.1 (38.7) ab	17.2 (24.5) a
Wayanad	3	22	60	59.6 (50.5) b	40.8 (39.7) b
Kodagu	3	39	63	51.8 (46.0) ab	30.3 (33.4) ab

(Figures in parentheses are arcsine transformed values; Means followed by the same letter are not significantly different at P=0.01)

(a) (b)

Fig 1.5. (a) Tender leaves and stem of *Erythrina* sp. infested with *Erythrina* gall wasp (b) Severely infested plantation

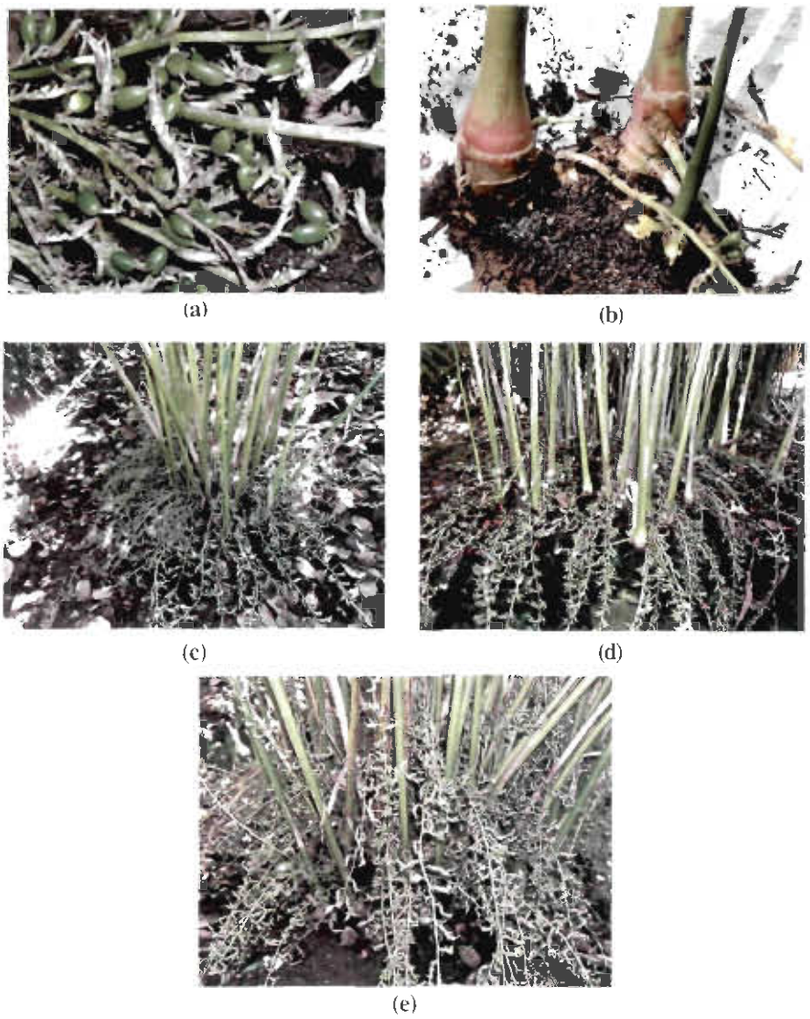
CARDAMOM

Genetic resources

Collection of germplasm

Five new unique collections *viz.*, Pacchaikai, Pink stem, Parrot green, Nattu Vazhukka, and Kodai Mysore (Fig. 2.1) were collected from Megamalai area of Tamil Nadu.

The present *ex-situ* gene bank consists of 447 collections, hybrids and disease resistant selections. Fifty accessions have been characterized for morphological and yield characters based on IPGRI descriptor (Table 2.1). Variability was found to be the maximum for capsule wet weight (84.95 %) followed by number of capsules (83.49 %) and minimum for



(a) (b) (c) (d) (e)

Fig. 2.1. Unique collections made during 2008-09. a. Pachaikai, b. Pinkstem, c. Parrot green, d. Nattu Vazhukka, e. Kodai Mysore

Table 2.1. Variability for morphological and yield characters in breeding lines

Character	Range	Mean	S.D	C.V	Promising genotype
Plant height (cm)	105-290	179.8	41.78	23.32	IC 349630
Total tillers	5.5-27	15.38	4.85	31.54	IC 547146
Bearing tillers	4.25-23	11.29	4.08	36.10	IC 547142
Leaf length (cm)	32-55.2	44.89	5.04	11.24	IC 349630
Leaf width (cm)	5.5-11.8	7.65	1.18	15.48	IC 547223
No. of panicles	3- 35	12.41	6.17	49.73	IC 547160
Panicle length (cm)	24.5 – 56.2	36.28	6.95	19.17	IC 547144
Internode length (cm)	2 – 5.48	3.56	0.78	21.96	IC 547146
Capsule length (cm)	1.14-1.9	1.47	0.15	10.00	IC 349653
Capsule width (cm)	0.99-1.38	1.17	0.09	7.33	IC 349627
No. of seeds	9.4-24.2	15.83	3.31	20.89	IC 547147
No. of capsules/plant	16-1275.8	331.05	276.38	83.49	IC 547167
Capsules wet weight(g)	10-1125.5	289.78	246.17	84.95	IC 547167, IC 547222 and IC 547146

capsule characters (capsule length 8.92% and capsule width 6.78%). Three promising accessions (IC349633, IC547146 and IC 349650) were identified with desirable yield contributing characters. IC547219 was found to be bold with maximum capsule length and breadth.

Characterization for biotic stress

Fifty eight cardamom accessions were screened for resistance against leaf blight (*Colletotrichum gloeosporioides*), rhizome rot (*Rhizoctonia solani* and *Pythium vexans*) and leaf blotch (*Phaeodactylium alpiniae*) under natural conditions. The screening was carried out to identify resistant sources of cardamom accessions against leaf blight, rhizome rot and leaf blotch by recording natural incidence of the diseases under field conditions.

The accessions were screened for leaf blight resistance using 1 to 6 disease rating scale. The disease rating scale was formulated based on the extent of symptoms developed on leaves, pseudostems and panicles. Disease scoring was done based on the rating scale values and percent disease index (PDI) was calculated. Based on PDI, the cardamom accessions were further grouped into different categories like highly resistant, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible. None of the accessions exhibited highly resistant reaction while one accession was found to be resistant to leaf blight infection (Table 2.2).

For the screening of accessions against rhizome rot, 1 to 5 disease rating scale was employed which is based on the number of infected tillers in a clump. Percent disease index was calculated based on the rating scale and the accessions were classified into five groups *viz.*, highly resistant, resistant, moderately susceptible, susceptible and highly susceptible. Some accessions exhibited resistant reaction while one accession was found to be susceptible to rhizome rot (Table 2.3).

To identify accessions with dual resistance to both leaf blight and rhizome rot diseases, accessions exhibiting resistant reaction to both these diseases were selected and the yield data was also used for comparison (Table 2.4).

However, leaf blotch was not found to be a serious disease. The damage caused by this disease was less and the symptoms were mostly confined to the senile leaves.

Breeding

Considerable extent of heterosis for yield and yield contributing characters in cardamom has been demonstrated and cardamom being vegetatively propagated crop, the heterosis advantage can be exploited at F_1 generation. The superior hybrids evolved thus, can be multiplied either through rapid clonal multiplication or tissue culture techniques to produce large number of true to type planting materials. Large number of hybrids between high yielding and disease resistant selection have been evaluated under various trials for yield and disease resistance, to exploit the heterosis for yield and disease resistance.

Preliminary yield evaluation trial (PET 1)

The PET I was laid out during 2004. Among the 16 hybrids, the highest two year mean yield per hectare was recorded in the hybrid combinations RR1 x CCS1

Table 2.2. Grouping of cardamom accessions based on reaction against leaf blight

Disease index (%)	Classification	Accession nos.
< 10 %	Highly resistant (HR)	Nil
11 – 20 %	Resistant (R)	IC 349646
21 – 30 %	Moderately resistant	IC 547223, IC 547221, IC 547220, IC 547219, IC (MR) 547218, IC 547165, IC 547159, IC 547158, IC 547222, IC 349650, IC 349649, IC 349648, IC 349645, IC 349637, IC 349636, IC 349629, IC 349627
31 – 40 %	Moderately susceptible	IC 547217, IC 547166, IC 547164, IC 547163, IC (MS) 547162, IC 547160, IC 547156, IC 547140, IC 349657, IC 349652, IC 349639, IC 349634, IC 349633, IC 349632, IC 349631, IC 349630, IC 349628
41 – 50 %	Susceptible (S)	IC 547167, IC 547161, IC 547152, IC 547149, IC 547147, IC 547146, IC 547144, IC 547143, IC 547142, IC 547141, IC 547139, IC 349659, IC 349655, IC 349654, IC 349644, IC 547138,
> 50 %	Highly susceptible (HS)	IC 547157, IC 547153, IC 547137, IC 349658, IC 349656, IC 349653, IC 547154

Table 2.3. Grouping of cardamom accessions based on reaction against rhizome rot

Disease index (%)	Classification	Accession nos.
0.0 – 5.0	Highly resistant (HR)	IC 547223, IC 547166, IC 547159, IC 547158, IC 547156, IC 547154, IC 547153, IC 547143, IC 547142, IC 547141, IC 547138, IC 349659, IC 349658, IC 349657, IC 547222, IC 349653, IC 349650, IC 349649, IC 349645, IC 349637, IC 349636, IC 349630, IC 349628
5.1 – 10.0	Resistant (R)	IC 547217, IC 547161, IC 547160, IC 547157, IC 547152, IC 547149, IC 547146, IC 547144, IC 547140, IC 547137, IC 349655, IC 349652, IC 349646, IC 349644, IC 349634, IC 349632, IC 349629, IC 349627
10.1 – 25.0	Moderately susceptible	IC 547221, IC 547220, IC 547219, IC 547218, IC (MS) 547167, IC 547165, IC 547164, IC 547162, IC 547147, IC 349656, IC 349654, IC 349648, IC 349639, IC 349633, IC 349631, IC 547139
25.1 – 50.0	Susceptible (S)	IC 547163
> 50.0	Highly susceptible (HS)	Nil

and CCS1 x RR1 with 1081 and 970 kg/ha, respectively (Table 2.5).

PET II

To get desirable recombinants having high yield, superior quality and mosaic resistance, hybridization was carried out between two mosaic resistant selections (NKE 12 and NKE 19) and most popular high yielding farmer variety Green Gold (GG) during 2005. The crosses were effected in four combinations (both direct and reciprocal). Among the crosses, GG x NKE 19 recorded significantly higher mean yield of 1057 kg/ha. (Fig. 2.2; Table 2.6).

Fig. 2.2. Hybrid crosses with higher yield

Table 2.4. Cardamom accessions with dual resistance against leaf blight and rhizome rot

Accession no.	Reaction		Mean fresh yield (g plant^{-1})
	Leaf blight	Rhizome rot	
IC 349650	MR	HR	1024.17
IC 547222	MR	HR	882.75
IC 547223	MR	HR	529.60
IC 547159	MR	HR	394.50
IC 349629	MR	R	287.57
IC 349645	MR	HR	285.00
IC 349627	MR	R	243.30
IC 349646	R	R	170.65
IC 349636	MR	HR	160.00
IC 349649	MR	HR	129.80
IC 547158	MR	HR	95.40
IC 349637	MR	HR	37.50

Table 2.6. Performance of hybrids (mosaic resistant and most popular farmer variety) for yield

Entry	Dry yield per hectare (kg)		
	2007	2008	Mean
GGXNKE-12(APG499)	934.76	174.51	554.64
GGXNKE-19(APG500)	1635.35	479.83	1057.59
NKE-12XGG(APG501)	1746.75	157.29	952.02
NKE-19XGG(APG502)	1212.23	355.54	783.89
GG (seedlings) (APG 326S)	1413.03	295.04	854.04
GG (suckers) (APG326)	1206.93	94.44	650.69
NKE-12(APG306)	75.00	43.5	59.25
NKE-19(APG310)	1120.04	43.56	581.8
CCS-1(seedlings) (APG296)	1723.38	190.85	957.12
ASH (seedlings) (APG453)	1930.9	825.21	1378.06
Mean	1299.83	265.98	
SEd	535.92	79.66	
CV(%)	41.23	29.95	
CD(p=0.05)	168.89	7.57	

Table 2.5. Evaluation of promising hybrids for yield in PET I

Entry	Dry yield per hectare (kg)		
	2007	2008	Mean
GGXMB-5	585.5	246.38	415.94
GGXCCS-1	558.63	513.53	536.08
GGXRR-1	687.38	78.14	382.76
GGXNKE-12	1350.35	167.20	758.78
RR-1XMB-5	547.84	401.26	474.55
CCS-1XGG	1208.92	398.13	803.52
RR-1XGG	75	149.00	112.00
GGXNKE-19	325.44	75.34	200.39
NKE-12XMB-5	1499.59	440.04	969.81
RR-1(S)	47.73	87.40	67.57
NKE-12XGG	99.44	130.08	114.76
NKE-19XGG	1312.84	43.54	678.19
MB-5XNKE-12	682.04	155.29	418.66
MB-5XNKE-19	1461.63	384.45	923.04
CCS-1(S)	415.22	91.38	253.30
MB-5XGG	80.78	763.75	422.27
GG(S)	320.63	132.19	226.41
MB-5(S)	740.98	487.63	614.30
RR-1XCCS-1	1245.41	917.51	1081.46
CCS-1XRR-1	919.44	1022.25	970.85
Mean	708.23	334.22	521.23
SEd	492.31	289.96	
CV(%)	49.51	56.75	

Evaluation of promising selections (for MLT)

To get desirable recombinants having high yield and superior quality, MLT was laid out during 2006. Among them, significantly higher yield of 631 and 622 kg/ha were recorded in CP-4 and SAM, respectively (Table 2.7).

Screening short listed hybrids against diseases

Twenty-nine elite accessions have been planted for clonal multiplication for field screening.

Studies on genetics of katte

Four hundred and thirty one seedlings raised from selfed and back cross progenies are under final stage of artificial screening.

Drought tolerance

Mechanism of drought tolerance

Three genotypes (RR1, CL-893, Green Gold) relatively tolerant to moisture stress and CCS-1, a susceptible genotype were crossed to develop drought tolerant

Table 2.7. Evaluation of promising selections under MLT

Entry	Plant height (cm)	No. of tillers	Leaf length (cm)	Leaf breadth (cm)	Panicle length (cm)	Nodes per panicle	Dry yield/ha (kg)
MA-18	208.00	29.80	46.67	7.97	36.4	12.00	516.75
MA-28	204.00	30.00	48.67	7.30	34.67	12.93	333.23
SAM	184.33	22.53	49.60	8.07	39.6	13.27	622.06
HY-3	226.00	26.93	47.13	8.27	37.4	12.33	429.80
NHY-35	176.33	18.93	44.73	7.87	43.43	14.80	365.38
OP-27	146.33	13.73	40.40	7.20	25.07	9.00	108.00
RR-1XMB-3	241.33	25.73	50.40	8.63	59.93	14.87	580.28
MA-29	161.00	20.00	47.20	7.77	32.42	10.57	164.17
SKP-170	163.33	24.87	42.47	7.23	25.6	11.73	218.54
AMB-2	224.67	26.73	45.60	8.23	36.73	15.27	500.76
CP-4	238.67	31.40	45.53	8.27	49.33	18.93	631.34
VA-1	198.00	22.93	48.33	9.33	30.47	13.73	344.04
OP-11	204.00	19.13	47.60	8.13	32	10.13	161.19
NHY-10	212.33	32.00	43.80	6.50	32.33	10.40	595.00
PC	184.67	28.33	45.47	8.13	48.07	17.93	498.12
RR-1	220.67	21.93	45.80	8.30	44.27	15.87	386.75
GG	236.67	26.20	50.33	10.27	30.53	14.07	355.12
CCS-1	202.67	31.33	47.40	8.60	36.13	14.67	449.08
Mean	201.83	25.14	46.51	8.11	37.47	13.47	403.31
SEd	29.26	5.39	4.59	0.71	8.63	3.22	19.61
CV(%)	17.76	26.26	12.09	10.81	28.22	28.69	5.95
CD(p=0.05)	59.49	10.95	9.33	1.46	17.55	6.54	39.86

variety with good yield and quality characters. Crosses were evaluated for growth and yield parameters by withholding two irrigations compared to control. Growth parameters such as plant height, number of tillers per clump, yield parameters such as number of panicles per clump, panicle length (cm) and dry capsule yield (kg/ha) were recorded. Plant height, number of shoots per clump, number of bearing shoots, number of panicles per clump, number of capsules per panicle recorded significant variation and reduced under moisture stress. Dry yield (kg/ha) recorded significant reduction under moisture stress. It ranged from 131.2 kg/ha -218.5 kg/ha with a mean of 177.8 kg/ha in control and 71.5 kg/ha to 171.3 kg/ha with a mean yield of 110.3 kg/ha in stress treatment. CCS1x GG recorded maximum yield under stress followed by RR1 OP. GG x RR1 recorded higher yield in control followed by CCS1 x GG.

Soil moisture content was recorded gravimetrically in summer months. Soil moisture content reduced under stress. Relative water content (percent reduction over stress) ranged from 7.81 to 20.3 per cent. Stomatal intensity ranged from 25.8 to 38.6 per microscopic field at 40 x in twenty cross combinations. Specific leaf weight ranged from 4.3 to 6.1 mg/cm^2.

Gas exchange parameters were recorded using photosynthesis system in control and stress treatments in selected cross combinations. Stress recorded reduced assimilation rate compared to control. Assimilation rate was not consistent between genotypes in control and stress treatments.

Leaf rolling test

In cardamom, under moisture stress conditions plant starts folding its leaves. Fourth and fifth cardamom leaves from above twenty crosses were collected and exposed to open sunlight on concrete ground to find

out time taken by different genotypes for leaf folding. 893 x RR1, GG x RR1, CCS1 x GG, GG x 893 and CCS1 x GG took longer time to fold than other genotypes.

Enzyme studies

Peroxidase activity was assayed in control and stress treatments in different crosses (Table 2.8). Peroxidase activity increased under stress. CCS-1 selfed recorded higher activity under stress followed by RR1 self. 893 x GG recorded decreased activity in stress followed by GG x 893. Isozymes of peroxidase were also assayed. Three distinct bands with Rm values of 0.07, 0.50 and 0.60 in both control and stress treatments were observed.

Viral diseases

Collection and maintenance of *katte* and *kokke kandu* isolates

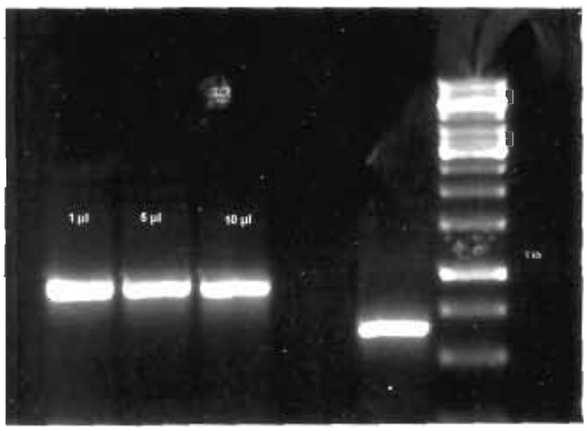
Eighteen *katte* isolates (12 from Karnataka and 6 from Kerala) (Fig. 2.3a) and six *kokke kandu* isolates (all from Karnataka) (Fig. 2.3b) were collected and established under insect- proof glass house conditions.

Table 2.8. Peroxidase activity in different cross combinations

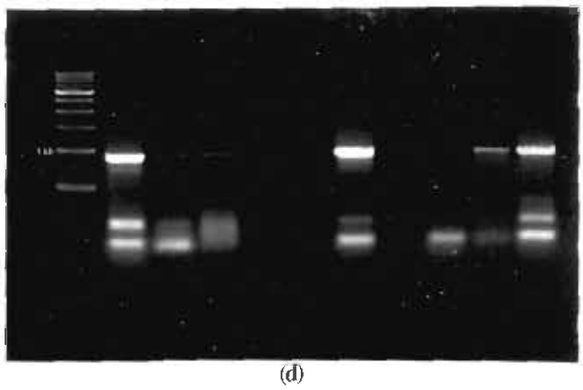
Genotype	Peroxidase activity (a.u./mg protein)		% increase/ decrease over control
	Control	Stress	
893 *self*	0.167	0.194	16.51
893 x GG	0.191	0.162	-15.14
893 xRR1	0.251	0.253	0.96
GG self	0.230	0.289	25.30
GG x 893	0.200	0.182	-9.04
GG x RR1	0.210	0.229	9.03
CCS1 self	0.127	0.236	86.46
CCS1x 893	0.198	0.254	28.68
CCS1 x RR1	0.170	0.237	39.35
RR1 self	0.185	0.267	44.55
RR1 x GG	0.186	0.258	38.66
RR1 x 893	0.195	0.261	33.90

(a)

(b)



(c)



(d)

Fig. 2.3. Samples with viral infection and *the detection* by RTPCR (a) *Katte* infection; (b) *Kokke kandu* infection; (c, d) - Detection of *Cardamom mosaic virus by* RT-PCR

Purification of *Cardamom mosaic virus*

Protocol for purifying the causal virus (*Cardamom mosaic virus*) of *katte*/mosaic disease of cardamom was standardized.

Development of nucleic acid based diagnostics

Protocols for RNA isolation and Reverse Transcription-Polymerase Chain Reaction (RT-PCR) for detecting *Cardamom mosaic virus* from the leaves obtained from *katte* affected cardamom plants were standardized. RNA isolated (using RNA isolation kit and a standardized protocol) from the infected leaf sample (Appangala isolate) was subjected to RT-PCR reaction using forward primer (CACCGCTTGCACCAATGAC) and reverse primer (GAAAACCCACAAAAACTCCC) yielded amplicon of 1 kb size. The virus could be detected at 1, 5 and 10 µl template concentrations using RNA isolated by kit (Fig. 2.3c) while the standardized protocol could detect the virus at 2 and 7 µl template concentrations from the samples (Fig. 2.3d).

Identification of resistant sources

Five planting units each of nine cardamom land races namely, Kalarickal White, Green Gold, Hombale Long Green, Palakudi, Wander Cardamom, Ashok (ASH), Sampaje, MB –3 and AMB were established in the green house. The plants were inoculated with mosaic virus using viruliferous aphids following the standard inoculation method. All the land races were found susceptible to the mosaic disease though there were variations in infection percentage and incubation period among the land races. The symptoms induced by the virus (Appangala isolate) on different land races were also varied (Fig. 2.4) indicating that, these land races could be used as differential hosts for identifying strains among the *katte* isolates.

(a) (b)

Fig 2.4. Symptoms induced by mosaic virus (Appangala isolate) on different land races (a)-Njallani Green Gold, (b)-Palakudi

Leaf spot

Differential pathogenicity of *Colletotrichum* isolates

Five predominant black pepper (Appangala, Idukki, Anamalai, Byakaravally and Cooverkolly) and cardamom (Appangala, Idukki, Anamalai, Byakaravally and Pollibetta) isolates of *Colletotrichum gloeosporioides* and 1 turmeric isolate (*C. capsici*) (Appangala) were inoculated on three varieties/ cultivars of black pepper (Panniyur 1, Panniyur 5 and Chomala) and cardamom (IISR Kodagu Suvasini, IISR Vijetha and Njallani Green Gold) and local cultivar (Bhavanisagar Local) of turmeric. The results indicated that, the host range of *Colletotrichum* isolates infecting black pepper, cardamom and turmeric have the potential to infect the varieties/ cultivars of crops other than their natural host (Fig. 2.5 a & b) (Table 2.9).

Fig.2.5. Differential pathogenicity of *Colletotrichum* isolates: (a). Cardamom isolate (Appangala) on Panniyur-1; (b)-Black pepper isolate (Byakaravally) on IISR Vijetha

In order to identify the compatible groups among the isolates, selfing and crossing of predominant *Colletotrichum* isolates infecting black pepper (Appangala, Idukki, Anamalai, Byakaravally and Cooverkolly), cardamom (Appangala, Idukki, Anamalai, Byakaravally and Pollibetta) and turmeric (Appangala) in all possible combinations was made. The results indicated that, all the isolates were heterothallic (lack of perithecial formation when the isolates were selfed). Similarly, when the isolates were crossed in all possible combinations perithecial formation was not observed in any of the combinations. The crosses either resulted in the formation of a barrage at the point of contact between two colonies (barrage reaction – Fig. 2.6 a) or merging of both the colonies (merging reaction – Fig. 2.6 b) (Table 2.10).

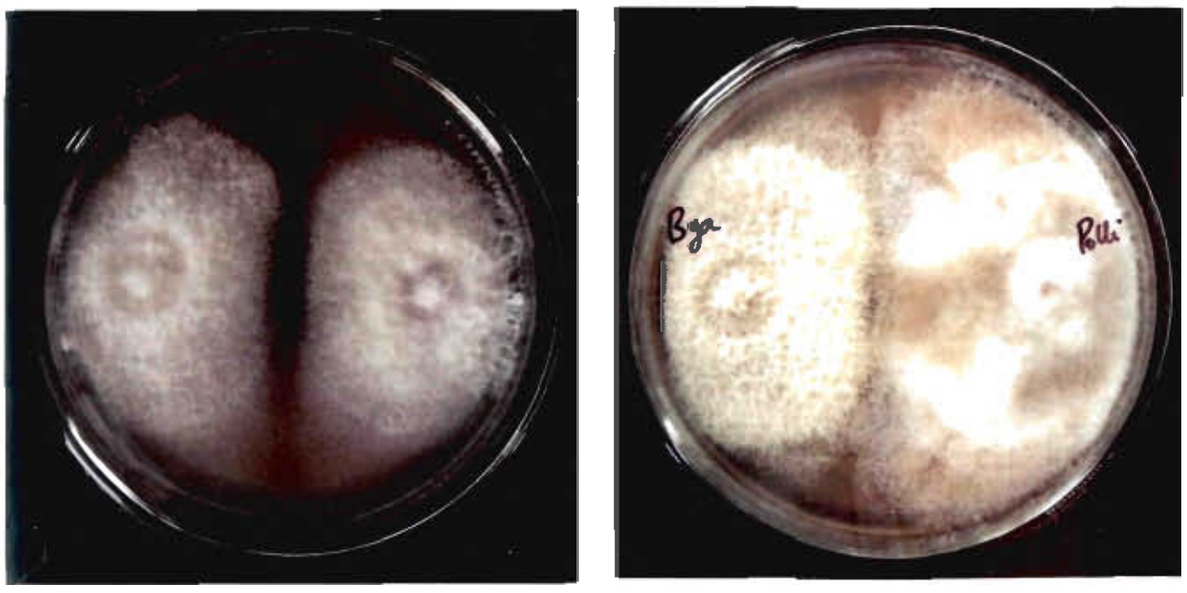
Survival of pathogen

The survival of *Colletotrichum gloeosporioides* infecting black pepper and cardamom was studied by conducting pot experiments. Leaves exhibiting typical

Table 2.9. Pathogenicity and cross inoculation of cardamom, black pepper and turmeric isolates of *Colletotrichum*

Isolates →		Black pepper					Cardamom					Turmeric
Cultivars/ Var. ↓		Bya	Coov	Ana	APG	Idk	Bya	Polli	Ana	APG	Idk	APG
Black pepper	Panniyur-5	+	+	+	+	+	+	+	+	+	+	+
	Chomala	+	+	+	+	+	+	+	+	+	+	+
	Panniyur-1	+	+	+	+	+	-	-	+	+	+	-
Cardamom	Njallani Green Gold	-	-	-	-	+	+	+	+	+	+	+
	IISR Vijetha	+	-	+	+	-	+	+	+	+	+	+
	IISR Kodagu											
	Suvasini	+	+	-	-	+	+	+	+	+	+	-
Turmeric	Bhavanisagar Local	-	+	-	+	-	-	-	-	-	-	+

Bya = Byakaravally, Coov = Cooverkolly, Ana = Anamalai, APG = Appangala, Idk = Idukki, Polli = Pollibetta



(a) (b)

Fig. 2.6. Selfing and crossing of *Colletotrichum* isolates infecting black pepper and cardamom: (a) - barrage reaction; (b)- merging reaction.

leaf blight/ anthracnose symptoms were used for the study. The leaves were placed on the soil surface (0 cm) and buried at a depth of 30 cm. The results indicated that, *C. gloeosporioides* infecting black pepper survived for 90 (24.15% recovery) and 105 (20.51% recovery) days at 30 and 0 cm respectively. *C. gloeosporioides* infecting cardamom survived for 90 (20.76% recovery) and 105 (8.15% recovery) days at 30 and 0 cm, respectively. In comparison with *Colletotrichum* infecting black pepper and cardamom, survivability of *C. capsici* infecting turmeric was found to be low both at 0 cm (60 days) and 30 cm (45 days) with a recovery percentage of 12.77 and 7.22 %, respectively (Table 2.11).

Quality profile

Sixty two accessions of cardamom germplasm including 5 hybrids, were analyzed for seed content, essential oil yield and essential oil composition. The seed content in the cardamom capsule varied from 55.25 to 82.45%. The cardamom accessions recorded 4.0 to 6.5% essential oil content in capsules. Sixteen

Table 2.10. Selfing and crossing between cardamom, black pepper and turmeric isolates of *Colletotrichum*

Isolates		Black pepper					Cardamom					Turmeric
		Bya	Coov	Ana	APG	Idk	Bya	Polli	Ana	APG	Idk	APG
Black pepper	Bya	- (B)	- (M)	- (B)	- (B)	- (M)	- (B)	- (B)	- (B)	- (B)	- (B)	- (B)
	Coov	- (M)	- (M)	- (M)	- (M)	- (M)	- (B)	- (M)	- (B)	- (B)	- (M)	- (B)
	Ana	- (B)	- (M)	- (M)	- (B)	- (B)	- (B)	- (M)	- (M)	- (M)	- (M)	- (M)
	APG	- (B)	- (M)	- (B)	- (B)	- (M)	- (M)	- (M)	- (M)	- (B)	- (M)	- (B)
	Idk	- (M)	- (M)	- (B)	- (M)	- (M)	- (M)	- (M)	- (M)	- (B)	- (M)	- (B)
Cardamom	Bya	- (B)	- (B)	- (B)	- (M)	- (M)	- (B)	- (M)	- (B)	- (M)	- (B)	- (B)
	Polli	- (B)	- (M)	- (M)	- (M)	- (M)	- (M)	- (M)	- (M)	- (M)	- (M)	- (M)
	Ana	- (B)	- (B)	- (M)	- (M)	- (M)	- (B)	- (M)	- (B)	- (M)	- (M)	- (M)
	APG	- (B)	- (B)	- (M)	- (B)	- (B)	- (M)	- (M)	- (M)	- (M)	- (M)	- (B)
	Idk	- (B)	- (M)	- (M)	- (M)	- (M)	- (B)	- (M)	- (M)	- (M)	- (M)	- (B)
Turmeric	APG	- (B)	- (B)	- (M)	- (B)	- (B)	- (B)	- (M)	- (M)	- (B)	- (B)	- (M)

B = Barrage reaction, M = Merging reaction, + = Perithecia present, - = Perithecia absent

Table 2.11. Survival of *Colletotrichum* spp. infecting black pepper, cardamom and turmeric in soil

Crop	Position in relation to soil surface (cm)	Percentage recovery after different time intervals (days)							
		15	30	45	60	75	90	105	120
Black pepper	0	92.83	83.76	72.92	66.42	55.54	50.40	20.51	0.00
	30	91.93	80.33	64.98	54.21	40.75	24.15	0.00	
Cardamom	0	88.93	80.83	52.77	44.29	41.19	31.69	8.15	0.00
	30	85.27	77.14	53.81	41.64	36.78	20.76	0.00	
Turmeric	0	84.44	62.23	37.22	12.77	0.00			
	30	75.55	31.18	7.22	0.00				

accessions recorded above 6% oil yield. The accessions having 6.5% oil content (VA-1, MA-18, IC 391657, IC 547147, IC 547144, IC 349652, IC 349633, IC 547153, and IC 547220) had 66 to 74% seed content. Based on the chemical composition of the essential oil, the accessions were classified into 1, 8-cineole-rich and α-terpinyl acetate rich types. The accession numbers, GG x NKE 12, NKE 19, OP27, MA 29, IC 547147, IC 547154 and IC 547144 were identified as 1, 8-cineole-rich accessions (>35%) and PC, CP-4, NKE12 x GG, NKE19 x GG, GG x NKE 19 and GG Suckers were rich in α-terpinyl acetate (>45%).

GINGER

Genetic resources

Six hundred and eighty accessions of ginger are being maintained in the field germplasm conservatory. Twenty ginger accessions were added to the germplasm repository during 2008-09. Fifty ginger accessions were characterized based on morphological and yield characters. Maximum variability was recorded for the character tillers/plant (32.33%) followed by yield/plant (25.80%).

Breeding

High oil ginger germplasm

The trial was laid out with 13 high oil ginger accessions along with a check, IISR Varada (replications 2, design RBD). The ginger accessions were evaluated for morphological and yield characters. Among the genotypes, yield (kg/3m^2 bed) ranged from 5.26 to 8.74 and the maximum yield was recorded in Acc. 162, followed by Acc. 217 and Acc. 209 (Table 3.1).

Exotic ginger germplasm

Twelve selected exotic (Nepal) accessions along with control IISR Varada were evaluated for morphological and yield characters. Among the characters, significant difference between genotypes was observed for tillers/clump and yield (Table 3.2). Maximum rhizome yield per plant was recorded in Acc 578 with 9.82 kg/3m^2 which was on par with check (9.63 kg/3m^2).

Table 3.1. Performance of high oil ginger accessions for yield and yield contributing characters

Accession	Plant height (cm)	No of leaves/main tiller	No. of tillers	No. of leaves	Yield/ plant (g)	Yield/ 3 m^2 bed (kg)
Acc. 57	43.61	19.90	7.50	93.30	238.7	7.161
Acc. 228	55.97	22.10	7.90	98.60	229.2	6.876
Acc. 162	49.55	22.60	7.60	108.30	291.4	8.742
Acc. 197	56.68	21.60	7.20	94.40	175.2	5.256
Acc. 209	57.45	23.90	7.30	98.60	278.5	8.355
Acc. 420	49.19	20.10	8.80	90.60	229.5	6.885
Acc. 225	58.98	23.00	9.70	104.70	198.5	5.955
Acc. 50	46.90	20.40	7.70	90.40	263.3	7.899
Acc. 99	58.30	22.60	7.80	83.20	211.8	6.354
Acc. 411	55.67	21.90	7.90	96.90	232.8	6.984
Acc. 217	55.64	22.00	9.80	115.40	280.3	8.409
Acc. 95	52.65	23.60	7.90	104.00	254.3	7.629
Acc. 156	55.39	23.20	11.10	145.60	254.7	7.641
Varada	54.71	20.30	8.60	108.20	277.9	8.337
Mean	53.62	21.94	8.34	102.30	244.01	
SEd	3.09	1.19	0.91	23.22	32.98	
CD(p=0.05)	6.68	NS	1.95	NS	71.26	
CV (%)	5.77	5.41	10.84	22.70	13.42	

Table 3.2. Performance of exotic ginger accessions for yield and yield contributing characters

Entry	Plant height (cm)	Leaves/ main tiller	No. of leaves	No. of tillers	Yield/ plant (g)	Yield/ 3 m^2 (kg)
Acc. 597	54.87	22.07	108.53	9.40	194.20	5.83
Acc. 552	61.03	22.60	86.33	6.47	277.67	8.33
Acc. 591	54.82	20.93	122.73	9.93	283.60	8.51
Acc. 592	56.43	20.73	116.40	9.87	227.80	6.83
Acc. 593	59.53	22.73	109.53	8.07	300.87	9.03
Acc. 574	58.22	20.55	107.60	8.27	287.00	8.61
Acc. 573	60.40	22.00	126.27	9.13	264.87	7.95
Acc. 598	59.76	21.30	101.00	7.30	222.00	6.66
Acc. 589	57.17	20.60	99.00	7.47	242.87	7.29
Acc. 581	53.10	21.07	108.80	8.40	260.20	7.81
Acc. 553	60.79	22.80	106.40	7.07	235.67	7.07
Acc. 578	54.23	21.33	119.20	11.60	327.40	9.82
Varada	56.51	21.27	115.00	9.53	321.07	9.63
Mean	57.45	21.54	109.75	8.65	265.02	7.95
SEd	4.14	1.30	14.05	1.09	38.05	
CD (p=0.05)	NS	NS	NS	2.25	78.53	
CV (%)	8.83	7.38	15.9	15.27	17.95	

Cytogenetics

Pollen fertility and pollination studies

Pollen fertility was assessed in 50 cultivars by pollen stainability. *In vitro* and *in vivo* pollen germination studies were completed in 27 of them. One collection with comparatively higher pollen fertility (>50%) was identified. Ginger Acc. No 195 was found to have mean pollen fertility of 67.73% by glycero-carmine staining and 60.31% by *in vitro* germination. Pollen germination was observed on stigmatic surface also on self pollination. The genotype is suitable for future studies on induction of seed set in ginger.

Mutation studies

M3 and M2 generation plants were raised from the rhizomes of cultivars irradiated with different doses during 2006 and 2007 respectively. A total of 122 M3 generation plants and 230 M2 generation plants were maintained in bags. Morphological characters and yield were recorded. Variation in morphology and yield was observed. No flowering was observed in any of them.

Phenology

Ginger varieties *viz*., IISR-Rejatha, IISR-Mahima, Himachal, IISR-Varada and Maran planted during 30 April, 15 May, 30 May and 15 June took on an average 30.9, 25.3, 25.7, 23.9 days for emergence and 74.8, 46.8, 46.4 and 42.6 days for producing first tiller, respectively. The dry matter distribution between root, rhizome, pseudo-stem and leaf was estimated by destructive sampling of ginger at fifth month after planting. Ginger varieties *viz*., IISR-Rejatha, IISR-Mahima, Himachal, IISR-Varada and Maran on an average recorded 12.35%, 65.34%, 7.69% and 14.61% dry matter content in root, rhizome, pseudo-stem and leaf, respectively (Table 3.3).

Nutrient requirement

Targeted production

Based on the initial soil availability of major nutrients, nutrient required for targeted rhizome production (NR), contribution of nutrient from soil (CS) and contribution from fertilizer (CF) were calculated for ginger and fertilizer doses to obtain yield targets of 25, 35, 45 kg/ bed was calculated and applied. The highest yield of

Yield target (kg/bed)	Yield (kg/bed)	Deviation (%)
25	21.7	-13
35	28.2	-19
45	29.0	-36

Table 3.3. Dry matter distribution of ginger varieties at 150 days after planting

Variety	Root	Rhizome	Pseudostem	Leaf	Total
Varada	2.47	13.29	1.65	3.20	20.62
Rejatha	3.42	18.07	2.16	4.55	28.20
Mahima	2.51	14.22	1.79	2.71	21.23
Himachal	3.97	25.26	2.00	4.36	35.59
Maran	2.93	9.98	1.91	3.25	18.08
Mean	3.06	16.17	1.90	3.62	24.74
Percentage share to total	12.4	65.3	7.7	14.6	100.0
SEd	-	3.45	-	0.61	
CD(P=0.05)	NS	7.52	NS		

24 kg/bed was obtained for the target 25 kg/ bed and the deviation from the target was -8 to -24%. The yield targets could be achieved with a mean deviation of -13 to -36% from the targets. The mean recorded yield levels were 21.7, 28.2 and 29 kg/ bed against the targets of 25, 35 and 45 kg/bed, with a deviation of -13%, -19% and -36%, respectively.

Organic farming

Ginger was grown organically by applying FYM, vermi compost, ash and rock phosphate, *Azospirillum* and phosphobacteria and *Trichoderma* & *Pseudomonas* sp. (IISR-6 & 853) as bio control agents for disease control. The mean yield recorded was (var. IISR-Varada and IISR-Mahima) 4.3 kg/3 m^2 under integrated system which was on par to organic system (4.1 kg/bed). Under organic management var. IISR-Varada and IISR-Rejatha yielded higher compared to that of IISR-Mahima. The overall yield levels were low due to heavy incidence of rhizome rot disease. Soil nutrient buildup and microbial biomass carbon were observed to be high in organic and integrated managements as compared to conventional system. The rhizome rot incidence was 40-51% in all the ginger varieties and in all the three management systems. Among the endophytic bacteria tried, GEB17 & GEB18 and GRB57 recorded < 20% rhizome rot incidence compared to other treatments which recorded 33-63% incidence.

Quality profile

Drying methods

Ginger is traditionally dried after peeling the outer skin. Peeling involves human labour and it is a kind of skilled job to prevent volatile oil loss as hard peeling may lead to loss of volatile oil. However drying without peeling require double the time for complete drying compared to peeled samples. The objective of the study was to compare the difference in chemical quality due to the two different processes.

Ginger IISR-Varada collected from Experimental Farm Peruvannamuzhi was used for the study. The peeled and unpeeled ginger rhizomes were dried on a clean concrete floor for sun drying and sun drying in poly bag. Another set of six samples of each group were also dried in hot air oven at 60°C and RRL reverse flow drier. Peeled samples dried in sun or poly bag or hot air oven took about 12-13 days for complete drying. RRL drier took about 15 days for drying. Unpeeled samples took 22-26 days for complete drying in all techniques. The oil, oleoresin, total gingerol and total shogaol did not show any variation in peeled and unpeeled samples.

Flavour profiling of *Zingiberaceae* spices

Volatile flavour constituents of ginger and turmeric rhizomes were studied. Fresh ginger rhizomes contained 0.2-0.4% essential oil where as the oil yield was 1.1- 2.2% in dry rhizomes. The Accn. nos 2, 111, 127, 225 recorded >2% oil yield.

A study conducted on 20 accessions indicated that the essential oil from fresh rhizomes of ginger and turmeric was rich in monoterpenes whereas the dried rhizomes contained higher levels of sesquiterpenes. The oil from fresh rhizomes of ginger contained higher levels of camphene, 1,8-cineole, phellandrene and citral compared to dried rhizomes. Among these constituents the content of citral was markedly high (35-44%) in fresh rhizome oil. The oil from dried rhizomes was dominated by the sesquiterpenes, zingiberene (24-30%), farnesene (11-20%) and sesquiphellandrene (3-14%) as against 2-5% representation of these constituents in fresh rhizomes.

Shoot borer (*Conogethes punctiferalis*)

Life cycle

The life cycle of shoot borer (*Conogethes punctiferalis*) was studied on five resistant accessions (Accs. 31, 247, 409, 430 and 631) and six susceptible

accessions (Accs. 17, 43, 70, 190, 191 and 514). In the resistant and susceptible accessions, the pupal period varied from 6-21 and 7-11 days, respectively. The adult longevity was 2-3 and 2-4 days on resistant and susceptible accessions, respectively.

Isolation of entomopathogenic nematodes (EPNs)

Seventy one soil samples were collected from the rhizosphere of ginger, turmeric and black pepper from Peruvannamuzhi (Kozhikode District), Ambalavayal (Wayanad District), Adimali, Peerumedu, Udumbanchola and Devikulam taluks (Idukki District) and Settiputhoor and Satyamangalam villages (Coimbatore District). Entomopathogenic nematodes (EPNs) were baited out and multiplied on host insects, greater wax moth, *Galleria mellonella* and rice moth, *Corcyra cephalonica* . Out of these, only six samples were found to be positive to entomopathogenic nematodes. Among the new strains of EPNs, only one species each of *Heterorhabditis* sp. and *Steinernema* sp. were identified on the basis of morphometric analysis. Both species were obtained from IISR Experimental Farm, Peruvannamuzhi (Kozhikode District) while the remaining four strains were found from Idukki District. Identification of these strains are in progress (Fig. 3.1).

(a) (b)

Fig. 3.1. Isolation of EPNs from ginger (a) White trap (b) Emergence of IJS from *Galleria* larva

TURMERIC

Genetic resources

One thousand twenty six accessions of turmeric are being maintained in field germplasm conservatory. Thirty four turmeric accessions were added to the germplasm repository during the period under report.

Development of microsatellite markers

A total of 135 microsatellite containing genomic DNA fragments were isolated from turmeric (*Curcuma longa* L.) adopting the selective hybridization method with di and trinucleotide biotinylated probes. Expressed sequence tags (EST's) of turmeric hosted in the NCBI database were screened for the presence of Class I (hypervariable) simple sequence repeats (SSR's). Fifteen primers were designed for amplifying EST-SSR's, of which eight turned out to be polymorphic (Fig.4.1a & b). These primers were transferable to 13 *Curcuma* species analyzed. AE HPLC analysis of *Curcuma* rhizome proteins was standardized. Thirteen *Curcuma* species were characterised based on the elution profiles of water soluble rhizome proteins obtained by AE HPLC at wavelength of 260 nm (Fig. 4.2). The thirteen species were grouped in six clusters based on UPGMA analysis (Fig. 4.3). The biologically active peptide turmerin was isolated from thirteen species of *Curcuma* with a highest concentration of 320 mg/100 gm fresh tissue in *C. sylvatica*.

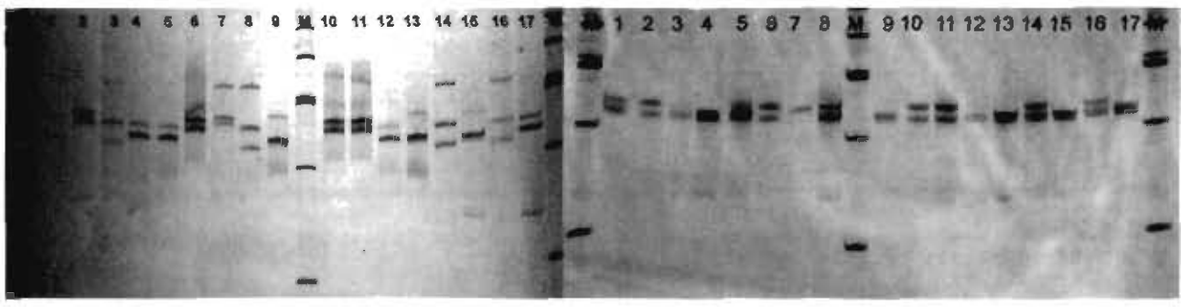
Morphology and yield of seedling progenies

Seedling progenies (260 nos.) and 23 mother plants were evaluated in pot culture. Morphological characters such as plant height, leaf length, leaf breadth, number of tillers and flowering status were recorded. The yield was recorded at the end of the season and majority of the progenies showed multiplication rate above 10 times. Eight progenies showed multiplication rate above 20 times (Table 4.1)

Seventy one second generation seedling progenies were raised using OP seeds of five seedling progenies namely 138/23, 138/74, 138/76, 435/7 and 69/10. All the advance generation progenies showed vigorous growth and nine of them flowered in the first year itself. Weight of first rhizome produced by the progenies was recorded.

Cytological analysis of seedling progenies

Cytological analysis has been completed in 4 mother plants and 36 seedling progenies. Mother plants showed chromosome numbers such as 2n=63 and 2n=84.



(a) (b)

Fig. 4.1. Successful amplification of EST derived microsatellite marker in turmeric accessions revealed in 10.0% polyacrylamide gel. Lane M- 50bp DNA ladder, Lane 1-17- turmeric accessions. (a) CLEST-ssr01 (b) CLEST-ssr02

Table 4.1. Yield range among progenies of a few mother plants*

Mother plant no.	Yield of mother plant (g)	Number of seedling progenies	Yield range of progenies (g)	No. progenies showing multiplication rate above 10	No. progenies showing multiplication rate above 20
18	773.33	29	346.67 - 993.33	25	0
20	813.33	11	100.00 - 807.04	5	0
65	900.00	22	120.0 - 905.67	11	0
69	673.33	10	300.00 - 1056.67	7	3
126	630.00	15	486.67 - 1046.67	14	2
138	1133.33	76	100.00 - 1120.00	69	4
300	660.00	4	333.33 - 706.67	3	0
354	83.0.00	5	346.67 - 613.33	2	0
399	360.0	12	100.00 - 666.67	3	0
414	453.33	3	400.00 - 700.00	1	0
415	646.67	13	340.0 - 800.00	10	0
417	580.00	3	160.00 - 433.33	0	0
421	313.33	10	280.00 - 652.33	6	0
426	733.33	4	200.00 - 733.33	2	0
434	573.33	14	200.00 - 700.00	7	0
435	553.33	7	320.00 - 633.33	4	0
442	213.33	2	240.00 - 320.00	0	0
447	733.33	2	340.00 - 606.67	1	0
449	413.33	10	320.00 - 893.33	9	0

* (50 -60 g seed material used for planting per pot)

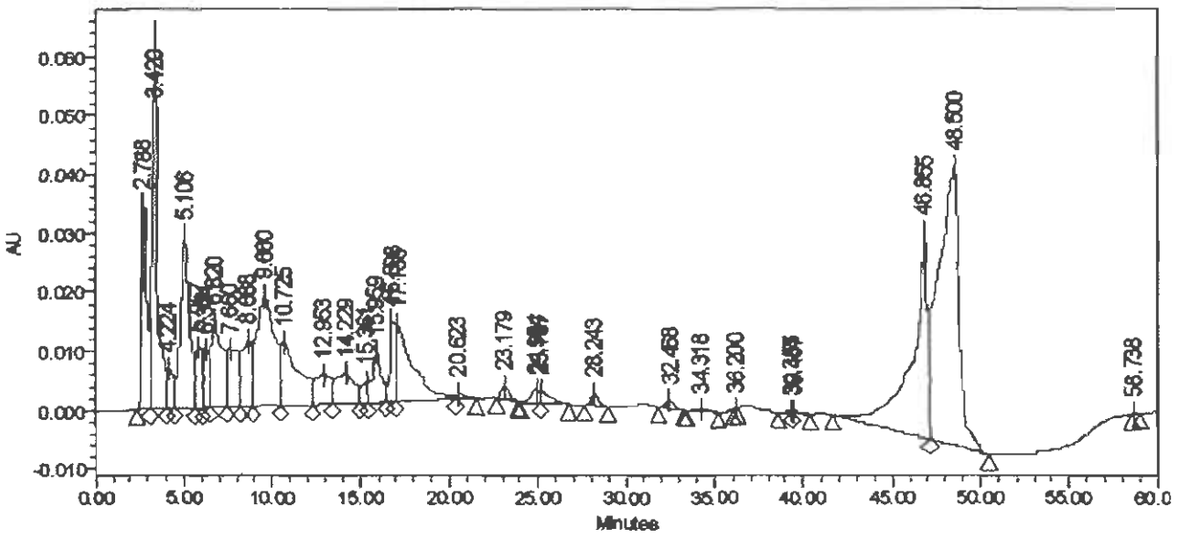


Fig. 4.2. AE-HPLC profile of water soluble rhizome proteins of *Curcuma sylvatica*

Majority of the seedling progenies showed 2n=84 while a few showed chromosome numbers such as 2n=82, 72, 74 *etc.* (Table 4.2).

Quality analysis of seedling progenies

Preliminary analysis for curcumin, oil and oleoresin among 25 seedling progenies of 10 mother plants showed wide variation for curcumin compared to oil and oleoresin (Table 4.3).

Phenology

Turmeric varieties *viz.*, IISR-Prathibha, IISR-Alleppey Supreme, IISR-Suguna, IISR-Prabha, IISR-Kedaram planted during 30 April, 15 May, 30 May and 15 June

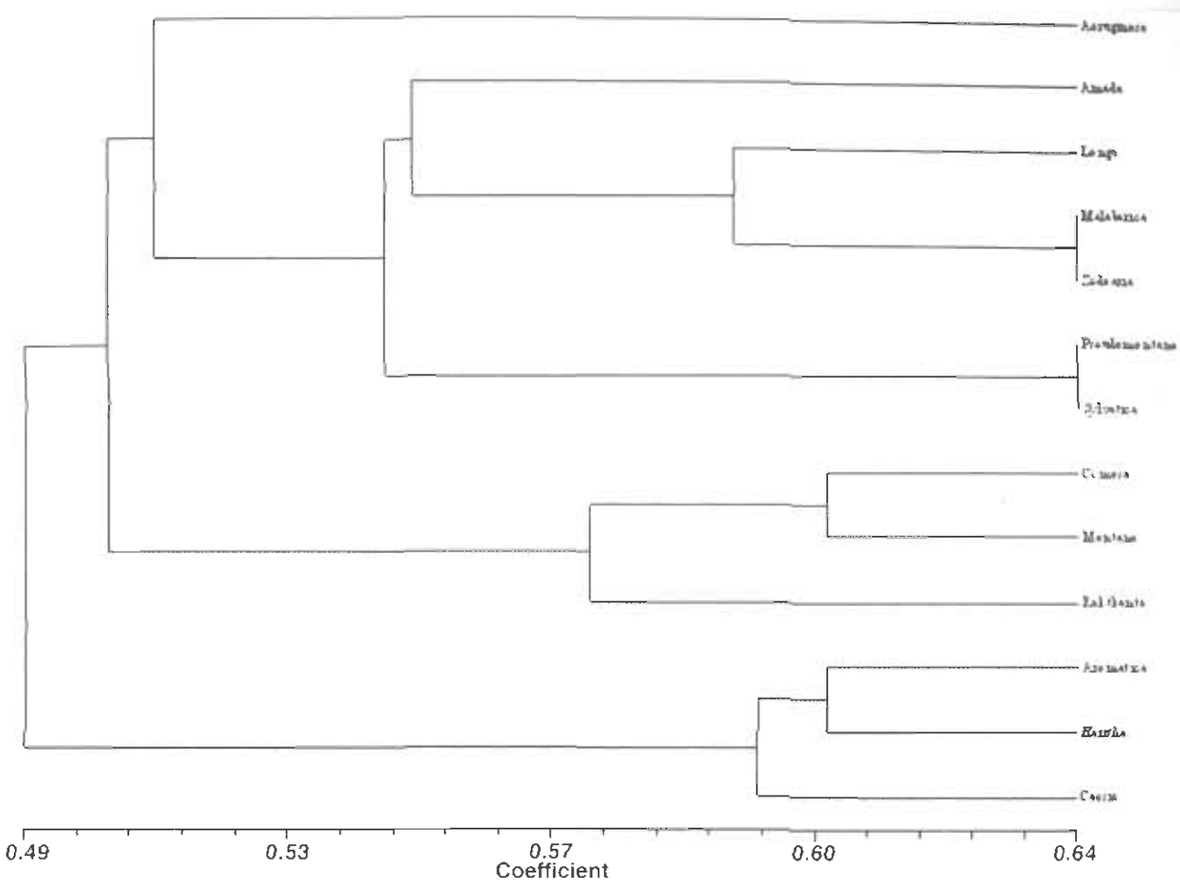


Fig 4.3. UPGMA dendrogram showing genetic similarity between different *Curcuma* species calculated by AE HPLC data of water soluble rhizome proteins using Jaccard's similarity coefficient

Table 4.2. Chromosome number among mother plants and seedling progenies

Chromosome No.(2n)	Mother plant/ Seedling progeny
84	395, 359, 18/10, 18/27, 138/52, 138/49, 138/42, 138/3, 138/33, 138/9, 138/31, 138/75, 138/14, 138/23, 138/5, 138/63, 138/7, 69/5, 65/3, 449/10, 300/4, 399/4, 415/1, 415/2, 415/9, 415/11, 449/6, 449/8
63	447, 431, 138/26
82	18/23, 18/29, 138/13
72	18/6, 421/4
76	138/67
78	138/15
74	421/9
75	399/6

took on an average 23.5, 18.5, 16.5, and 12.3 days for emergence and 98.4, 59.9, 56.7 and 48.5 days for producing first tiller respectively. The dry matter distribution between root, rhizome, pseudo-stem and leaf was estimated by destructive sampling at fifth month after planting. On an average turmeric varieties *viz.*, IISR-Prathibha, IISR-Alleppey Supreme, IISR-Suguna, IISR-Prabha, IISR-Kedaram recorded 8.10%, 60.7%, 8.90%, 22.29% dry matter in root, rhizome, pseudo-stem and leaf, respectively (Table 4.4).

Table 4.3. Quality analysis of OP seedling progenies of turmeric

Progeny No.	Oil (%)	Oleoresin (%)	Curcumin (%)
138/13	3.5	7.53	1.93
138/17	2.7	7.79	2.37
138/18	3.7	9.82	3.06
138/31	3.7	8.87	2.88
138/41	3.2	7.76	1.19
138/42	3.6	7.17	0.75
138/47	3.5	8.16	1.98
138/61	3.07	8.51	1.83
138/63	2.0	7.32	1.6
138/65	3.1	10.79	3.19
138/69	3.2	8.74	2.72
138/70	3.3	12.85	2.74
18/15	3.3	7.59	1.07
18/19	3.2	6.355	0.88
18/26	2.67	5.38	0.96
18/29	3.5	6.9	1.38
415/2	4.4	7.58	2.17
421/4	4.4	9.57	1.62
435/8	2.5	6.48	1.04
449/7	3.73	6.50	1.05
126/5	3.73	8.84	3.2
126/9	3.47	10.52	1.46
65/2 R1	3.2	5.7	1.05
69/9 R1	3.5	10.21	2.45
20/3	3.6	8.61	1.58

Table 4.4. Dry matter distribution of turmeric varieties at 150 days after planting

Variety	Root	Rhizome	Pseudostem	Leaf	Total
Prabha	2.60	19.71	2.05	8.04	32.40
Prathibha	4.14	10.27	4.46	9.53	28.41
Alleppey Supreme	1.93	28.04	2.61	4.91	37.49
Suguna	1.89	12.12	2.02	7.18	23.20
Kedaram	2.74	29.47	3.47	6.92	42.59
Mean	2.66	19.92	2.92	7.32	32.82
Percentage share to total	8.1	60.7	8.9	22.3	100.0
SEd	0.63	3.26	0.62	-	
CD (p=0.05)	1.39	7.12	1.34	NS	

Input use efficiency

Micronutrients influence

The role of micronutrient elements *viz.*, boron (B) and zinc (Zn) were studied at IISR Experimental Farm, *Peruvannamuzhi*. Turmeric was raised with six levels of Zn *viz.* 0, 5, 10, 15 kg/ha and one and two foliar sprays (0.5%) with and without application of P (50 kg/ha). The boron levels were 0, 0.5, 1 and 2 kg/ha and one and two sprays of borax (0.25%) with and without application of lime.

Higher soil P availability was recorded in 0 level Zn with P application and the soil Zn availability was significantly higher in soil Zn application (5, 10 and 15 kg/ha) without P. Among the treatments, foliar application of Zn twice recorded highest rhizome yield. The mean yield of rhizome was higher in 10 kg soil Zn application on par with foliar spray twice. Application of 1.0 kg B per ha after liming increased the yield up to 9.44 kg/ bed. Higher concentration of both Zn and B reduced the growth of turmeric (Table 4.5).

Table 4.5. Effect of Zinc without and with Phosphorus on P & Zn availability (mg/kg) and yield of turmeric

Zn level (kg/ha)	Soil P			Soil Zn			Yield (kg/bed)		
	+P	-P	Mean	+P	-P	Mean	+P	-P	Mean
0	17.1	5.4	11.3	0.8	0.6	0.68	6.2	7.7	6.97
5	7.6	5.8	6.7	3.9	4.7	4.28	7.3	8.5	7.91
10	7.4	5.6	6.5	4.6	5.9	5.27	8.6	8.7	8.62
15	3.7	4.0	3.9	3.7	6.5	5.13	7.0	7.3	7.1
1 foliar spray– 0.5%	7.3	7.0	7.1	0.6	0.6	0.57	6.7	7.1	6.9
2 foliar spray– 0.5%	3.5	7.3	5.4	0.6	0.6	0.60	7.7	9.1	8.4
Mean	7.77	5.85		2.36	3.1		7.23	8.07	
CD (p=0.05) Zn levels	1.4				0.71			1.28	

Organic farming

Turmeric was grown organically by applying FYM, vermi compost, ash and rock phosphate. Azospirillum and phosphobacteria, *Trichoderma* & *Pseudomonas* sp. (IISR-6 & 853) as bio control agents for disease control. The integrated system recorded highest yield which was on par to that of organic system of management. The yield in integrated system was 6.9 and 7.1 kg/ 3 m^2 bed followed by organic system (6.2 and 6.0 kg/ bed for var. IISR-Alleppey Supreme and IISR-Prathibha, respectively). Soil nutrient buildup and microbial biomass carbon were observed to be high in organic and integrated managements as compared to conventional system. FYM (15t), neem cake (2t) and vermicompost (4t) applications showed higher nutrient buildup and yield.

Quality profiling

Influence of drying and storage methods

Turmeric is generally dried after curing (boiling) for 45 to 90 minutes. Curing reduces drying time and enhances keeping quality of dried rhizome. Turmeric IISR-Prathibha and IISR-Alleppey Supreme were evaluated in different mechanical driers to study the effect of curing and drying, on chemical quality. Cured and uncured turmeric rhizomes were dried in hot air oven, sun dried, sundried in poly bag and also in a reverse flow RRL drier. All the dried rhizomes had a moisture content of 8-10%. No variation was observed in oil, oleoresin and curcumin content among the different drying methods.

Turmeric variety IISR-Prathibha was also stored for 360 and 480 days under similar storage atmosphere in three layered metalised polyester cover under vacuum, 100% N_2 and 90% N_2 + 10% CO_2. The curcumin content of stored samples varied from 5.0 to 5.8%. No significant variation was observed in the quality constituents oil, oleoresin and curcumin content compared to control which was stored in ordinary gunny bag.

Influence of biochemical factors on curcuminoid levels

Three hundred and one samples have been analyzed for total curcuminoids, 255 of which have also been analyzed for oil and oleoresin content. Assay of phenylalanine ammonia lyase (PAL), cinnamate-4-hydroxylase (C4H) and caffeic acid-O-methyl transferase (COMT) completed in leaves for 13 accessions planted at Peruvannamuzhi farm and 19 accessions planted at Chelavoor farm.

IISR-Sudarsana with high PAL and IISR-Prathibha with low C4H activities both had high curcumin content. Released varieties of turmeric, IISR-Prathibha, IISR-Sudarsana and IISR-Alleppey Supreme were high in secondary metabolites.

Flavour profiling

The oil from fresh and dried rhizomes of turmeric was dominated by sesquiterpenes. However fresh oil contained higher level of the monoterpene and 1, 8-cineole (2-13% as against 1-5% in dry). The oil from dried rhizomes was richer in zingiberene (2-12% as against 1-5% in fresh). The contents of turmerone, curlone, ar-turmerone and other minor components were on par in fresh and dried rhizomes. The study indicated the loss of high-volatile constituents during drying of rhizomes.

Cloning of *pal gene*

Twenty five sequences of pal genes of monocots (ginger, banana, rice, maize) from NCBI site were used for multiple sequence alignment using CLUSTAL W and conserved regions were used for designing four degenerate primers. Template DNA was isolated by

the CTAB method. PCR amplification of pal gene III in *Curcuma longa* was optimized, to yield a 350 bp fragment: PCR mix: 10x assay buffer – 2.5 µl; dNTP - 0.5 µl; Forward primer - 2.0 µl; Reverse primer - 2.0 µl; Taq polymerase - 0.33 µl; DNA (50 ng) - 5.0 µl; Water to – 25 µl. PCR conditions: After an initial 94°C – 4 min; 30 cycles of 94°C – 1 min; 50°C – 1 min; 72°C – 1 min; and extension at 72°C – 10 min. The sequence of the primers used for pal III are:

Forward primer: 5′-CCGGCTCGTTATATAAAAGCTCCAGACTTG-3′

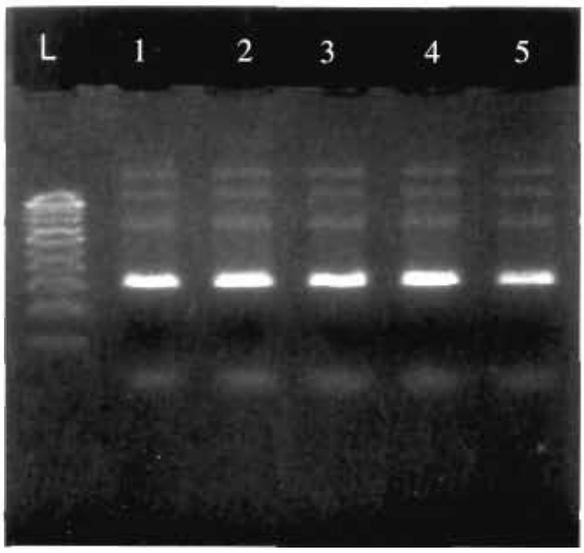


Fig. 4.5. Amplification of pal gene III in *Curcuma longa* L (L - 100 bp DNA ladder; Lane 1-5: *C. longa*)

Reverse primer: 5′-CCCGAGCCTCCTCAGAAAGCTCCACTGTCG-3′.

Shoot borer (*Conogethes punctiferalis*)

Identification of resistant sources

Nine hundred and fifteen accessions of turmeric were screened against the shoot borer in the field. Maximum shoot damage (80%) was observed on Accs. 345, 525 and 882. Forty four accessions remained free from the shoot borer attack.

Documentation of natural enemies

Apanteles taragamme? (Braconidae) and an unidentified hymenopteran were observed to parasitize larvae of the shoot borer throughout the crop season at Peruvannamuzhi.

Evaluation of insecticides

Four insecticides *viz.*,, malathion 0.1%, carbosulfan 0.075%, imidacloprid 0.0125% and lamda cyhalothrin 0.0125%, promising in the greenhouse were evaluated against the shoot borer in the field. The insecticides were sprayed at 3 week intervals during July to November. The trials indicated that among the insecticides, malathion 0.1% and lamda cyhalothrin 0.0125% were promising.

VANILLA

Genetic resources

Characterization of germplasm

Morphological characters such as leaf length, leaf breadth, Internode length and girth were recorded from 3.5 year old plants of 37 germplasm collections planted in the field. Morphology of *V. tahitensis* was contrastingly different from the collections of *Vanilla planifolia*. Twenty three collections flowered during this season. Self pollination was done @ 5-10 flowers per inflorescence to raise seedling progenies of these collections.

Flowering of *Vanilla tahitensis*

Vanilla tahitensis, the second commercially important species of vanilla after *V. planifolia* flowered at IISR Farm, Peruvannamuzhi, for the first time, after 4 years of growth. The flowering occurred in two phases unlike in *V. planifolia* planted in the same field. The first phase started in the month of September and ended by October. Second phase stared in the month of February and ended by March. The flowers were self pollinated to produce seedling progenies and reciprocal crosses were made with *V. planifolia* to produce interspecific hybrids. *V. tahitensis* is reported to have more relative tolerance to root diseases compared to *V. planifolia*.

Breeding

Establishment of interspecific hybrids

Inter specific hybrids between *V. planifolia* x *V. pilifera* and *Vanilla* sp.(A&N islands) x *V. pilifera* were established *in vitro*. Additional crosses were performed between these species and seeds were put in cultures.

Induced mutation in vanilla

Fruit samples of vanilla (5 months after pollination) were irradiated with 1kr, 2kr and 4kr doses of γ-radiation and inoculated on solid SH medium, after 24 hrs. Germination of seeds was affected by radiation dose. Profuse germination was observed in seeds derived from fruits irradiated with 1kr and sparse germination in the case of fruits treated with 4kr.

In vitro seed germination cultures (3 months old) were treated with 0.5kr, 1.0kr, 2.0kr and 3.0 kr doses of γ-radiation and sub-cultured to fresh media in 15 replicates after 15 days. Untreated cultures were maintained as control. Plants formed from treated cultures of all doses. In cultures treated with 3.0 kr poor conversion and stunted growth of plantlets were observed. One albino plant was recovered from cultures treated with 1.0 kr (1.0 kr = 100 gray).

Detection of viruses

A total RNA isolation method based on acid guanidium phenol chloroform was developed for vanilla. RT-PCR based method was developed for the detection of all the four viruses (*Bean common mosaic virus, Bean yellow mosaic virus, Cucumber mosaic virus* and *Cymbidium mosaic virus*) known to infect vanilla in India.

PAPYJKA

Genetic resources

Collection, characterization, evaluation and maintenance

Five collections (two from YSPUHF, Solan, Himachal Pradesh, two from Kerala and one from Tamil Nadu) were added to the germplasm. Fifty four germplasm accessions, which include 21 Bydagi collections and six exotic collections, were raised and multiplied. Twenty seven new germplasm accessions were purified by single plant selection and by selfing.

Crop improvement

Morphological and quality characterization of germplasm revealed maximum variability in fruit weight (31.26% CV) followed by yield per plant (30.88%). Least variability of 3.34% was recorded for the character pericarp thickness. Among the indigenous germplasm, ICBD11, ICBD 23 and ICBD 10 registered the highest color value of above 300 ASTA units. In case of exotic lines high colour value was recorded in EC 71, EC 6, EC 490 and EC 18. The capsaicin content among germplasm accessions varied from 0.0081 to 0.513. Over all, the lines ICBD 10, Kt-pl-19 and EC 18 were found promising with high colour value and low pungency.

Tree spices

Genetic resources

Evolving high yielding and high quality clones

Evaluation of high yielding nutmeg lines: The progenies of high yielding nutmeg lines are being maintained. Elite line A9/185 recorded maximum mean height (592 cm), width (582 cm), no. of main branches (63.2) and girth at 30 cm above ground level (50.3cm), while elite line A9/150 recorded the maximum mean number of fruits per plant (28).

Grafts of four elite lines (A9/4(3), A9/4(11), A4/17 and A4/20) having high myristicin and elemicin in nutmeg and mace oils were field planted in RBD with 5 replications and a plot size of 4 grafts/treatment/ replication.

Grafts of 4 elite nutmeg lines (A4/22, A9/71, A9/95 and A9/102) having low myristicin, elemicin and safrole and high sabinene in nutmeg and mace oils were field planted in RBD with 5 replications and a plot size of 4 grafts / treatment / replication.

Canopy management

Induction of orthotropic shoots in plagiotropic grafts

An experiment was initiated to study the possibility of inducing orthotropic shoots from plagiotropic grafts of nutmeg, so as to get an erect canopy as that of a seedling raised plant. Grafting was done on nutmeg with scions from four accessions namely, A9-20, A4-22, A9-4 and A11-10 with an average success of 85%. These grafts would be used in the coming season for imposing various treatments to see whether it is possible to induce orthotropic shoots in the plagiotropic grafts.

In order to study the difference in the plagiotropic and orthotropic shoots, various metabolites in the leaves and twigs of plagiotropic and orthotropic shoots located at three levels of the tree were analyzed in two different accessions. The proteins, total carbohydrates, reducing sugars, starch, phenols and nitrate reductase in leaves of nutmeg (A-9-76 and A-4-22) were estimated. All these parameters were higher in leaves from orthotropic branches when compared to the leaves from plagiotropic branches except for NR activity which was slightly less in leaves from orthotropic branches compared to the leaves from plagiotropic branches. There were no significant differences in metabolite content between leaves from top, middle and bottom portions of the tree.

The proteins, total carbohydrates, reducing sugars, starch, and phenols in twigs of two nutmeg accessions namely, A-9-76 & A-4-22, were estimated. All these parameters were higher in orthotropic twigs when compared to plagiotropic twigs. There were no significant differences in metabolite content between twigs from top, middle and bottom portions of the tree.

Improvement of Chinese cassia (*Cinnamomum cassia*)

Evaluation of elite cassia lines

Significant differences were observed among the 4 elite lines for plant height, width and number of main branches. Elite line D1 recorded the maximum plant height of 296.9 cm and width (234.8 cm) and no. of main branches/plant (14.6). The elite lines did not show significant difference for other morphological characters namely, no. of main shoots and girth at 30 cm above ground level. Elite line D1 recorded the maximum no. of main shoots (3.08) and plant girth (35.2 cm). Thus elite line D1 is found to be the best with regard to the different morphological characters (Table 7.1).

The cassia elite line A1 (IC No. 370400) has been registered with NBPGR, New Delhi for high

cinnamaldehyde content in bark oil (81.5%) and leaf oil (80.5%), registration No. (INGR 08045).

Morphological characters for fifteen accessions namely A2, A6, A7, A8, B2, B4, B8, C1, C4, D1, D2, D3, D5, D6 and D7 were recorded at Appangala. Biochemical characters namely bark oil, oleoresin and cinnamaldehyde for these fifteen accessions have been recorded. Bark oil ranged from 1.2% (D1) to 3.71% (B2). Percentage of oleoresin varied from 7.52 (B8) to 14.14 (B2). Percentage of cinnamaldehyde varied from 65.07 (B8) to 89.63 (D1) (Table 7.2).

Table 7.1. Evaluation of elite cassia lines grown at IISR Experimental Farm, Peruvannamuzhi

Elite line	Height (cm)	Canopy (cm)	Girth (cm)	No. of main shoots	No. of main branches
A2	216.5	178.2	29.1	1.9	8.3
C1	275.6	193.4	31.2	2.7	11.2
D1	296.9	234.8	35.2	3.1	14.6
D3	172.6	138.0	29.2	2.3	6.7
SE	30.1	21.7	2.7	0.87	1.4
CV (%)	27.9	26.1	19.4	78.2	30.7
CD @ 5%	92.6	66.9	-	-	4.3

Chemical characterisation

Cinnamomum germplasm

A study was conducted to chemically finger print the *Cinnamomum* germplasm mainly, in terms of its volatile constituents. During the period under report the constituents of essential oil of bark of *Cinnamomum sulphuratum* were determined. Linalool and tetradecanal were the chief constituents (both 15-16%) in the oil. The oil contained a large number of constituents in <2% concentration. Another aspect of the study was to find out the best period of harvest to obtain maximum essential oil from leaves. Variation in the oil content of leaves of *C. malabatrum* during different months indicated that the highest leaf oil yield could be obtained by harvesting leaves during Feb-March. The contents of cinnamaldehyde, caryophyllene and benzyl benzoate showed wide variations compared to other components, during this period. A crystalline constituent isolated from the leaf extract of *C. malabatrum* was identified as β-sitosterol.

Table 7.2. Biochemical characterization of cassia lines grown at Cardamom Research Centre, Appangala

Accession	Essential oil (%)	Oleoresisn (%)	Cinnamaldehyde (%)
A_2	3.06	14.02	74.18
A_6	3.26	11.37	66.15
A_7	2.37	9.97	84.20
A_8	1.23	11.92	67.01
B_2	3.71	14.14	81.58
B_4	2.63	12.05	69.62
B_8	2.65	7.52	65.07
C_1	3.12	10.76	78.77
C_4	1.41	10.28	75.60
D_1	1.20	8.87	89.63
D_2	2.52	8.58	83.71
D_3	2.56	11.58	77.93
D_5	3.28	9.48	75.45
D_6	3.37	9.33	73.39
D_7	1.58	9.02	73.40

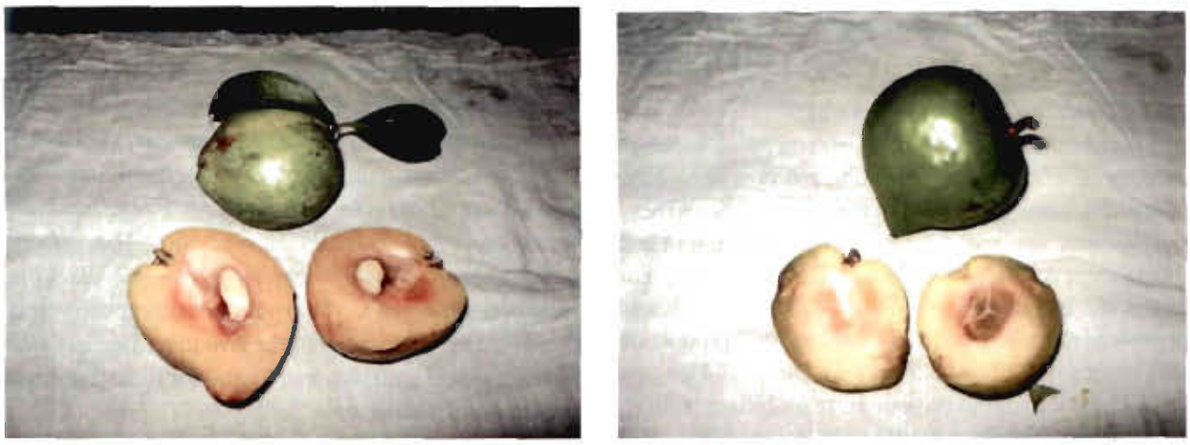
Garcinia

Two varieties each of *G. kydia* and *G. tinctoria* were collected from West Khasi hills of Meghalaya (Fig 7.1) and their HCA % was compared with the Western Ghats samples (Table 7.3).

DNA was extracted from four species collected from western ghats and amplified with eight established RAPD primers. The heterogenetic index was 0.43 – *G. gummigutta*, 0.48 – *G. indica*, 0.32 – *G. cowa* and 0.41 – *G. tinctoria*. The results indicated that the genetic variability within the species is lower than the out crossing wind pollinated woody plants which is 0.53.

Table 7.3. HCN content of samples from different geographical locations

Species	(%) HCA
Dry fruit samples from Western Ghats	
G. gummigutta	15.16
G. indica	10.12
G. tinctoria	0.07
G. cowa	3.60
Dry fruit market samples from Assam	
Bara thekara	4.54
Kuchi thekara (*G. cowa*)	4.36
Fresh fruit samples from Meghalaya	
G. kydia (red)	10.97
G. indica (yellow)	8.37
G. tinctoria	Nil



(a) (b)

Fig. 7.1. *Garcinia sp.* collected from West Khasi hills of Meghalaya; (a)- *G. kydia*; (b)- *G. tinctoria*.

BIOLOGICAL CONTROL

Rhizobacteria

Isolation

One hundred and seventy four rhizobacteria were isolated from black pepper (74) and ginger (100) from Peruvannamuzhi and Wayanad in Kerala and Kodagu in Karnataka.

Characterization of rhizobacteria

One hundred and seventy-four isolates were tested *in vitro* for beneficial traits, *viz.*, mobilization of phosphate, potassium, zinc, silica and ammonia production. These isolates were also tested for growth promotion trait and indole acetic acid (IAA) production. Out of the 174 strains tested, 72 isolates were positive for both IAA and phosphate solubilization (41%) and ammonia production was observed in 124 isolates (71%). Out of 174 isolates only 35 were found to be potassium mobilizers (20%), 26 were zinc mobilizers (15%) and 9 were silica (5%) solubilizers.

One hundred and seventy-four isolates were tested for the production of primary and secondary metabolites. These isolates were tested for phenazine -1- carboxylic acid (PCA). Only two isolates of black pepper namely, BRB 5 and BRB 28, were positive. The primers were synthesized and tested for the detection of diacetylphloroglucinol (DAPG), pyrolnitrin, pyoluteorin, and chitinase, and none of the short-listed isolates were positive.

Evaluation of rhizobacteria

In vitro screening of isolates indicated that seven black pepper (BRB 5, BRB 24, BRB 28, BRB 49, BRB 53, BRB 60 and BRB 72) and eight ginger (GRB 25, GRB 35, GRB 36, GRB 57, GRB 58, GRB 68, GRB 72 and GRB 91) isolates showed more than 50% inhibition against *Phytophthora capsici*, *Pythium* sp. and *Fusarium* sp..

Evaluation of six (GRB 25, GRB 35, GRB 36, GRB 57, GRB 58 and GRB 68) of the short-listed isolates of ginger for biocontrol and growth promotion in the greenhouse indicated that among the various isolates, GRB 35 reduced symptom expression due to *Ralstonia solanacearum* and also enhanced growth of plants compared to control.

Identification of rhizobacteria

The identity of eight of the promising isolates from black pepper and ginger was confirmed by molecular characterization using 16s rDNA sequencing. The black pepper strains belonged to *Pseudomonas aeruginosa* and *Serratia marcescens*. The ginger strains belonged to *Burkholderia pyrrocinia*, *Bacillus amylolequifaciens*, *Serratia marcescens* and *Klebsiella* sp. Sequences of the five identified isolates were deposited with National Centre for Biotechnology Information Database.

Isolation and evaluation of anti-microbial compounds

Bio-surfactants from different endophytic bacteria were extracted. *P. aeruginosa* IISR BP35 produced 88-90 µg of bio-surfactant per ml which was inhibitory to *P. capsici*. Maximum production of bio-surfactants was observed in 48-72 h old cultures. Among the eight bacteria screened, the highest production of the bio-surfactant was noticed in *P. aeruginosa* IISR GB 9. The bio-surfactants from different bacteria were identified as massetolide A using RP-HPLC studies. *In vitro* studies using this cyclic lipopeptide showed biocidal activity against zoospores and mycelium of *P. capsici* (Fig. 8.1). It also inhibited mycelial growth of *Pythium myriotylum*. *In vivo* studies using stem cuttings of black pepper treated with the bio-surfactant also proved its bioefficacy against *P. capsici* (Fig. 8.2).

Protease enzyme present in crude extracts of *P. aeruginosa* IISR 853 was purified by RP-HPLC and tested against *R. similis* for its nematicidal activity.

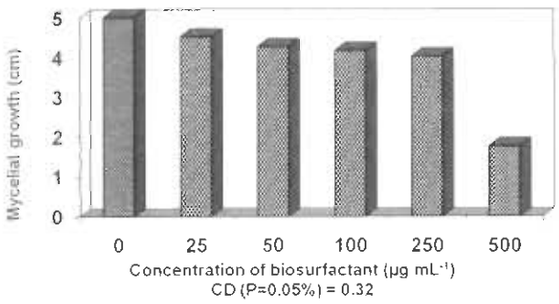


Fig. 8.1. Effect of massetolide-A on mycelium of *Phytophthora capsici*

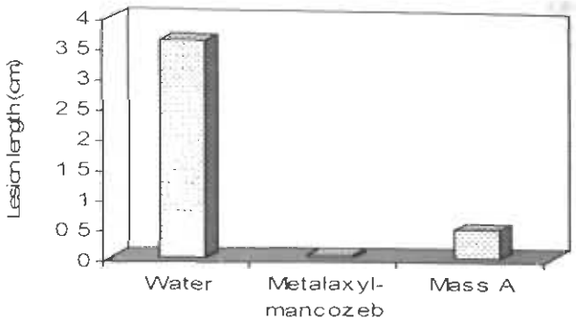


Fig. 8.2. Effect of prophylactic treatment of black pepper single-node cuttings with bio-surfactants against *Phytophthora* infection

Fraction 2 was found to contain maximum enzyme and nematicidal activities.

Collection of VAM isolates

Rhizosphere soil was collected from black pepper from 38 locations distributed in four taluks of Idukki namely, Thodupuzha, Devikulam, Udumbanchola and Peermade. Isolation and identification of mycorrhizal spores is in progress.

STUDIES ON THE NUTRACEUTICAL PROPERTIES OF BIOACTIVE COMPOUNDS IN SPICES

The antioxidant property of the spice extracts - essential oil, water and ethanol extracts of black pepper (IISR-Thevam), ginger (IISR-Rejatha), turmeric (IISR-Alleppey Supreme) and cinnamon (IISR-Nithyashree) - were compared after extraction, and quantified using the following methods: total antioxidant capacity by the phosphomolybdenum method, DPPH radical scavenging ability, Fe(III) to Fe(II) reducing activity. The results indicated that,

- Cinnamon extracts had greater DPPH radical scavenging activity (~80.6% over control, irrespective of other variables) and Fe(III) to Fe(II) reducing activity (~117.5 mmoles ascorbic acid equivalents/g)
- The DPPH radical scavenging activity was less in water extract compared to the other extracts (~36.3% over control, irrespective of other variables)
- Total antioxidant capacity as measured by the phosphomolybdenum method (~236.4 mmoles ascorbic acid equivalents/g, irrespective of other variables) was more in water extracts
- Turmeric ethanol extract was more stable in its antioxidant character over a year (~160.0 mmoles ascorbic acid equivalents/g)
- Fe(III) to Fe(II) reducing activity (~118.3 mmoles ascorbic acid equivalents/g, irrespective of other variables) was more in ethanol extracts
- All the above three parameters reduced in all the extracts on storage
- The total phenol content of the extracts was directly correlated to the Fe(III) to Fe(II) reducing activity, and was the most in the ethanol extracts of cinnamon
- The chemoprofiling of the essential oils was done using GC-MS to reveal the major components; in black pepper, caryophyllene decreased from 18-11% while caryophyllene oxide increased from 0.24 to 9.6% over a year.

'PASSCOM', a database on predicted activity spectrum of spice compounds, is under construction for the compounds of black pepper, cinnamon, clove, nutmeg, garcinia and allspice. Work on compounds with promising antimicrobial properties from spices is complete and has been integrated with the existing 'PassCom' database. From docking studies using AutoDock, two spice phytochemicals, 1,8-cineole and eugenol showed promise as lead compounds that can bind by H-bonding with VacA virulence factor of *Helicobacter pylori*, and thus may be used to treat peptic ulcer caused by *H. pylori*.

ASSESSMENT OF QUALITY OF SOILS UNDER SPICES BASED CROPPING SYSTEMS

Soils under ginger:

Soil microbial biomass carbon (C_{MIC}) varied significantly among the treatments, with the maximum levels in INM treatment (480 mg g^{-1}) followed by organic treatment (462 mg g^{-1}). Similarly, microbial biomass N (N_{MIC}) levels were markedly higher in the organic and integrated sites (48 and 51 mg g^{-1} respectively) compared to the chemically managed sites (27 mg g^{-1}) and microbial biomass P (P_{MIC}) did not vary markedly among the sites (11-14 mg g^{-1} respectively). Soil basal respiration (measured as CO_2 evolution) ranged from 25-36 mg CO_2-C g^{-1} day^{-1} and was greatest in organic and INM treatments (35 and 36 mg CO_2-C $g^{-1}day^{-1}$ respectively) and least in the chemical treatment (25 mg CO_2-C $g^{-1}day^{-1}$).

Soils under turmeric:

Soil microbial biomass carbon (C_{MIC}) varied significantly among the treatments, with the maximum levels in organic treatment (498 mg g^{-1}) followed by integrated treatment (491 mg g^{-1}). Higher N_{MIC} levels were observed in soils under organic and INM treatments (51 and 48 mg g^{-1} respectively). However, P_{MIC} did not vary markedly among the sites (11-15 mg g^{-1} respectively). Soil basal respiration ranged from 19-29 mg CO_2-C $g^{-1}day^{-1}$ and was greatest in organic and INM treatments (28 and 29 mg CO_2-C $g^{-1}day^{-1}$ respectively) and least in the control treatment (19 mg CO_2-C $g^{-1}day^{-1}$). The soils from both ginger and turmeric sites were also assayed for enzymes involved in C, N, P and S cycles. Results revealed that variation in activities was not consistent among the sites, however, the organic and INM treatments registered greater activities of most of the enzymes assayed.

To study the relationships among the properties in soils under ginger and turmeric, principal component analysis (PCA) was applied. The analysis revealed that 83% of the variance was explained by three factors. The first, which accounted for 37% of the total variance, was defined by available N and the measured biochemical parameters like C_{MIC}, dehydrogenase, BAA-protease, casein-protease and phosphodiesterase activities. This reflects the size and activity of the microbial biomass and possibly reflected the strong relationship between the availability of labile and easily mineralisable organic matter and the activity of microbial populations. The positive part of the second factor (31% of the variance) was defined by the soil respiration, P_{MIC}, phosphomonoesterase, ß-glucosidase, urease, cellulase, invertase and the negative part by qCO_2. This indicates the strong relationship between microbial activity and N/ P cycles in soils. Also the higher loadings of ß-glucosidase, invertase and CM-cellulase suggested that in soils relying solely on chemical fertilizers the potential to mineralise organic matter, and so the activity of the C-cycle, is reduced. The negative loading of qCO_2 in this factor suggests a decrease in substrate use efficiency in plots with low organic matter especially the chemical and control plots. The third factor with 15% of the variance was defined by Bray P and exchangeable K possibly due to the logical dependence of microbial biomass on available P and K in the soil. The fact that organic C content is included with high loadings in more than one factor indicates the effect of the different nutrient management regimes on the composition of soil organic matter and the typical interactions among the properties involved in the C, N, P and S cycles.

ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

The All India Coordinated Research Project on Spices (AICRPS) is vested with the mandate to conduct and coordinate research in 12 spice crops with its headquarter at Indian Institute of Spices Research, Calicut. AICRPS has at present 34 centres which includes 19 regular centres, 7 co opting and 8 voluntary centres located in 21 states of India under State/ Central Agricultural Universities (SAUs)/ Research Institutes. The XI Plan budget of AICRPS is Rs. 1400 lakhs with Rs 456 lakhs (State share) during 2008-09. About 115 research programmes covering the mandate spice crops are being conducted at various centres.

Black pepper

Five hundred and eighty five accessions of black pepper germplasm consisting of cultivated, exotic, wild and related species is maintained under different AICRPS centres. The characterization of germplasm resulted in identification of high yielding accessions *viz*., KM III , Angamali , KM II and Valiyaramundi with more than 2 kg /vine of green berry yield from Panniyur centre. Panniyur -1 (2.63 kg dry/vine) and PN-57 (4 kg dry/vine) were identified as high yielders from Sirsi and Yercaud centres respectively. Among the intervarietal hybrids developed at Panniyur centre, the hybrid P6 x P5 was found to be promising with a fresh yield of 2.5 kg/vine and was proposed for release. Among the different cultivars of pepper evaluated at Amhalavayal in CVT, cul. 5308 recorded the highest wet weight of berries/standard (3.01 kg) followed by Panniyur-1 (2.79 kg). At Panniyur centre maximum yield/vine was recorded in cul. 5489 (3.8 kg green berry/vine) followed by cul. 1041 and HP 105 with 2.5 kg/vine. Rooting of orthotropic shoot of black pepper cuttings at Dapoli centre indicated that the treatment combination 3-node + PGPR (*Pseudomonas fluorescens*-10^8 cfu) recorded maximum rooting success (97.33%) followed by 2-node + PGPR (*Pseudomonas fluorescens*-10^8 cfu) (94.66%). Integrated nutrient management treatment recorded maximum yield at Panniyur and Sirsi centres when compared to organic and inorganic treatments whereas inorganic and integrated nutrient management treatments were found to be on par at Pechiparai centre. Among the current technologies available for foot rot management all the treatments were found to be significant in reducing the foot rot incidence at Pampadumpara centre. Spraying potassium phosphonate (0.3%) and application of *Trichoderma harzianum* @ 50 g/vine with 1 kg of neem cake was found to be the best treatment in controlling the disease at Chintapalle, Panniyur and Pampadumpara centres whereas, Bordeaux mixture (1%) spray and COC (0.3%) drenching was found to be effective at Mudigere centre. Among the biorationals evaluated, neem gold (0.5%) was found to be effective in the suppression of mussel scale (*Lepidosaphes piperis*) population and the least scale population was recorded on vines treated with dimethoate (0.05%).

Cardamom

Three hundred and five germplasm accessions have been maintained by two (Pampadumpara and Mudigere) AICRPS centers. Among the cardamom germplasm evaluated at Mudigere centre, the accession Pothamedu recorded highest green capsule yield (208 kg/ha) followed by D-141 and CI-730. Under CVT, entries CL-722, PS-27, MCC-309 and MCC-246 were found promising for dry capsule yield (347.96 kg/ha) at Mudigere centre and entries SKP 170 (706.1 kg/ ha), SKP 165 (627.7 kg/ha) from Sakleshpur centre. Based on the yield trial PS-27 and MHC-26 were identified as promising entries from Pampadumpara centre. The yield of cardamom treated with inorganic P alone or with P-solubilizer was significantly superior over other treatments. Panicle and clump infections due to capsule and rhizome rot disease were found to be minimum in plots treated with *T. harzianum* and consortium of bacteria @ 50 g/plant. The efficacy of four insecticides *viz*., phorate, fipronil, thiamethaxam and imidacloprid and three organic insecticides *viz*., neem cake, fish oil rosin soap and neem seed kernel extract were compared for the management of shoot

fly in newly planted cardamom plantation and it was found that phorate, imidacloprid, thiamethaxam and neem cake were found superior in recording lowest number of dead hearts per clump compared to other chemical treatments. Significant reduction of cardamom root grub was observed in plots treated with combined application of imidacloprid (0.006%) and *Heterorhabditis indica* (100 IJ/grub).

Ginger

Ginger germplasm consisting of 659 accessions have been maintained under various AICRPS centers. The experimental results at various centers revealed that foliar spray of 0.5% zinc sulphate (60 and 90 DAP), 0.2% of borax (60 and 90 DAP) and 1.0% ferrous sulphate (60 and 90 DAP) increased the yield and quality parameters. In an IET at Raigarh, maximum yield was obtained in IG 5-1 and IG 5-24 (3.81 t/ha) followed by IG-5-2 (3.61 t/ha).

Turmeric

One thousand three hundred and twelve turmeric germplasm accessions have been maintained by eight centers under AICRPS. Out of the 267 germplasm accessions screened for resistance against leaf spot, accessions *viz*., CL- 3, 14, 20 and 91, registered low PDI (10 to 12) indicating moderate field resistance to the disease. TCP-11 registered resistance against *Colletotrichum* leaf spot and *Taphrina* leaf spot at Raigarh. CL-101 was identified as a high yielder at Coimbatore and was proposed for release. PTS-39 recorded maximum fresh rhizome yield (32.44 t/ha) followed by TCP-11 (27.44 t/ha) at Chintapalle. Quality evaluation of turmeric resulted in short listing accessions with high curcumin content (CL 101 with 3.63%), highest oleoresin content (CL -213 with 12.5%) and high essential oil content (CL.20 with 4.14%). Soil application of FYM (30 t/ba) + vermicompost (20 q/ha) + neem oil cake (8 q/ha) produced maximum plant height, number of tillers per plant, number of leaves per tillers and yield per plot (15.20 kg/3m^2) followed by soil application of FYM (30 t/ha) + vermicompost (15 q/ha) + neem oil cake (8 q/ha) at Dholi center. In an experiment to study the genotype x environment interaction on the quality of turmeric it was observed that the yield of genotypes varied from 18.61 (IISR-Prathibha) to 32.13 t/ha (IISR-Alleppey Supreme); curcumin content from 2.87 (IISR-Prathibha) to 6.07% (Narendra Haldi); and oleoresin content from 7.70 (IISR-Alleppey Supreme) to 15.30% in Roma at Coimbatore centre; where as the variety Rajendra Sonia produced significantly more yield (24.83 kg/3m^2) when compared to other genotypes in Bihar conditions. At Chintapalle, Roma (30.11 t/ha) recorded maximum fresh rhizome yield followed by Rasmi (28.78 t/ha), whereas BSR-2 recorded lowest yields (8.78 t/ha).

Tree spices

A total of 38 clove, 119 nutmeg, 39 cinnamon and 10 cassia germplasm accessions have been maintained under three AICRPS centres. Characterization of cinnamon germplasm at Pechiparai led to the identification of sel.65 with a bark yield of 469 g of dried bark/tree and leaf yield of 6.3 kg/tree. A local collection from Pechiparai was also identified for high leaf yield of 6.2 kg/tree and bark yield of 464.5 g/tree.

Coriander

One thousand nine hundred and eleven germplasm accessions of coriander have been conserved at various AICRPS centres for further evaluation and characterization. At Guntur, LCC-147 (11.95 g) recorded maximum per plant yield followed by LCC-246 (9.39 g), LCC-189 (9.1 g), LCC-194 (9.0 g) and LCC-221 (8.98 g). RCr-728 from Jobner, LCC-170 from Guntur, DH-206 from Hisar were identified as promising entries and proposed for release. The promising entries UD- 475 and UD-801 from Jobner, LCC-237, LCC-236 from Guntur, DH-220, DH-233 from Hisar and NDCor- 30 and NDCor-49 from Kumarganj were identified as promising accessions in IET and promoted to CVT. For production of leafy type coriander in off-season at Guntur, two accessions LCC-244 (6.9 t/ha) and LCC-234 (6.18 t/ha) were identified. Studies on the effect of bioregulators on coriander at Jobner recommend two foliar sprays of 50 ppm NAA or 1.0 ml/l triacontanol at 40 and 60 DAS for obtaining higher seed yield as well as net returns. Among the fifty high yielding genotypes evaluated for drought tolerance at Coimbatore, the genotype CS-127 was found to be promising. Seed treatment *with Pseudomonas fluorescens* (IISR-6) at the rate of 10 g/kg of seed followed by foliar application at 10^8 cfu on 60 days after sowing was found to be effective in reducing the powdery mildew intensity in coriander. Seed treatment and soil application of rhizobacterial strain FL-18 gave an yield of 1779 kg/ha in coriander followed by the application of *Trichoderma* MTCC- 5179 (1611 kg/ha). Rhizobacteria (seed treatment + soil application with FK 14 & FL 18) recorded maximum yield (1283 kg/ha) followed by seed treatment + soil application with FK14 (1269 kg/ha). Soil solarization + soil application of *Trichoderma* (1 kg/plot) + spray with calixin (0.1%) after 60 DAS was found to be superior among all the treatments followed by seed treatment and

drenching with calixin (0.1%) + spray with calixin (0.1%) 60 DAS and spray with wettable sulphur (0.2%).

Cumin

Jobner and Jagudan centres hold 526 accessions of cumin germplasm. The germplasm accessions UC-275, UC-294, UC-276, UC-281, UC-315, UC-340, UC-339, UC-343, UC-320 and UC-338 were identified as high yielders from Jobner centre. UC-331 and UC-225 were identified as resistant entries against wilt, blight and powdery mildew at Jobner. The entries UC- 239 and UC-299 from Jobner were identified as promising in IET and promoted to CVT. Spraying mancozeb @ 0.25% at 40, 50, 60 and 70 DAS was found to be effective in controlling blight. Soil solarization + soil application of *Trichoderma harzianum* + spraying mancozeb @ 0.25% at 60 DAS and application of vermicompost + soil application of *Trichoderma harzianum* + spraying mancozeb @ 0.25% at 60 DAS were also effective for controlling the disease.

Fennel

Six hundred and twenty five accessions are conserved in different centres under AICRPS. UF-205 from Jobner, LFC -84 from Guntur and HM-219 from Hisar were identified as promising and recommended for release. The entries RF-21 & RF-31 from Dholi, NS-63, NS-46 from Jobner, NDF-16, NDF-24 from Kumargang and HF-131, HF-143 from Hisar were identified as promising entries from IET and promoted for further evaluation in CVT. The maximum volatile oil of 3.20% was recorded in NS-63 followed by 2.93% in NS-37, 2.87% in NS-45 and 2.73% in NS-32, whereas minimum of 2.37% was recorded in NS-11. The entries NS-63, NS-46, RF-125 and NS-45 have shown better performance as compared to local check with respect to volatile oil yield in terms of litre per hectare. Application of inorganic nitrogen (100%) + FYM 5 t/ha + *Azospirillum*, inorganic nitrogen (75%) + *Azospirillum* + FYM 5t/ha and inorganic nitrogen (50%) + *Azospirillum* + FYM 5t/ha were found significantly superior as compared to control regarding number of umbels per plant, number of umbellets per umbel, number of grains per umbellet and grain yield.

Fenugreek

AICRPS centres maintain 978 germplasm accessions of fenugreek. The entries RMt-361 from Jobner, LFC-84 from Guntur and HM-219 from Hisar were identified as promising and were proposed for release. The germplasm accessions UM-11, UM-16, UM-27, RMt-1, RMt-305, UM-17, UM-13, UM-32, UM-28, UM-7, UM-8, UM-33, UM-6 and UM-20 were identified as tolerant to limited moisture condition from Jobner centre. The entries UM-330, UM-364, UM-366 and UM-365 from Jobner, LFC 105, LFC-103 from Guntur, HM-348, HM-355 from Hisar and NDH-25, NDH-19 from Kumarganj were identified as promising and promoted for CVT. Studies on the effect of bioregulators in fenugreek at Coimbatore indicated that spraying tricontanol 0.5ml/l at 40, 60 and 80 DAS recorded an yield of 522.9 kg/ha. At Jobner, two foliar sprays of 50 ppm NAA at 40 and 60 DAS has been recommended for obtaining higher seed yield as well as net returns. Treatment of seeds with rhizobacterial strain FL-18 was effective in increasing yield and yield attributing characters in fenugreek at Dohli centre. Among the treatments to study the effect of biofertilizers on yield of fenugreek, inorganic nitrogen 100% + *Azospirillum* + 5t/ha FYM recorded the maximum number of pods per plant (72) and yield (2.18 t/ha) followed by inorganic nitrogen 75% + *Azospirillum* + 5 t/ha FYM (2.00 t/ha).

BIOINFORMATICS CENTRE

Developing and updating databases

The Bioinformatics Centre has developed the following new databases during the period under report:

- **SpicEST:** A database of ESTs of two major spices, turmeric and ginger was developed and hosted (www.spices.res.in/spicest). SpicEST contains all ESTs of these plants, their annotation, and information on SSRs and SNPs (Fig. 12.1).
- **PASSCOM:** A database on predicted activities of spice compounds is being developed. The module on black pepper has been completed (Fig. 12.2).

The black pepper germplasm data in the database Spice Genes was updated with several additional features. Cardamom germplasm database was developed for the first time.

Organizing training programmes

The Bioinformatics Centre has organized the following training programmes during the year

- 'Agri-bioinformatics: Tools and applications' (20-24 October 2008): Fifteen candidates from various ICAR institutions and agricultural universities participated in this programme.
- '*In silico* analysis and annotation of spice ESTs' (17-19 December 2008): The three day programme was attended by 11 trainees from different institutions.

The Centre also assisted other training programmes organized in the institute. These include

- Summer Training in Biochemistry, Biotechnology and Bioinformatics, 12 May to 11 June 2008, 24 trainees.
- ICAR sponsored Winter School on Flavours, Nutraceuticals and Food Colours from Horticultural Crops, 7 – 28 January 2009

During the period, traineeship was offered to two candidates while studentship was offered to four bioinformatics students.

Biological activities of spice compounds

During the period the Centre has worked out biological and druggability properties of various phytochemicals from major tree spices like clove, nutmeg, allspice, cinnamon, garcinia *etc*. The data were updated in the PASSCOM database.

In silico identification of miRNAs

In silico tools were used to identify miRNAs in ginger, turmeric, paprika and a nematode *Radopholus similis* from the publically available EST data. Presence of several novel miRNAs was proved and their structures were predicted using bioinformatics tools.

Fig. 12.1. SpicEST, a database of ESTs in spices

Fig 12.2. PASSCOM, a database of predicted activities of spice compounds

ARIS CELL

Modifications in ARISoft

ARISoft, the IISR office automation software was further modified and several new features *viz.* payroll as per the 6th pay commission report, stock numbering/ barcode facility, tools for auctioning of unserviceable articles *etc.* were incorporated.

Software development

e-office, a software for computerizing DDG's office was developed and implemented at ICAR headquarters (Fig. 13.1).

Development of new websites and other e-resources

Action has been initiated to redesign and modify the IISR website. The bioinformatics website has been revamped with several new features. PhytoFuRa, a new website (www.phytofura.net.in) was developed and launched for the new outreach programme on *Phytophthora*, *Fusarium* and *Ralstonia* (Fig.13.2). Services were also extended for designing websites for National Academy of Biological Sciences (NABS) and Confederation of Horticulture Associations of India (CHAI). Technical write up (in Malayalam) on 'Nursery management in black pepper', 'Black pepper varieties and their maintenance' and 'Integrated pest management in black pepper' were added to the touch screen facility available in ATIC.

Training

A personal training on website management was given to the technical personnel from ASRB, New Delhi during 15-20 Feb. 2009.

Fig. 13.1. e-office, the software tool developed for computerization of DDG's office

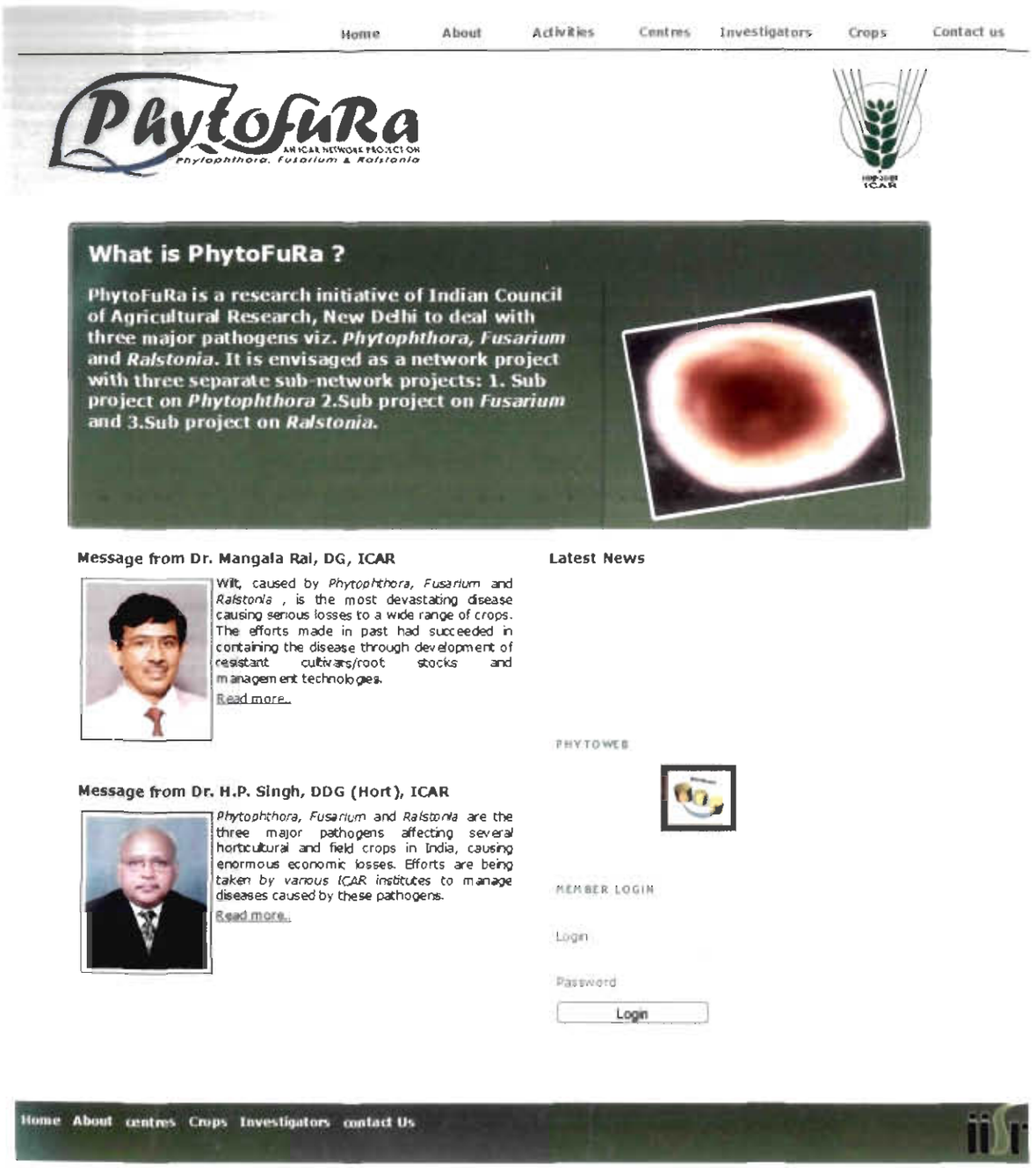


Fig. 13.2. PhytoFuRa, the web portal of the ICAR outreach programme on *Phytophthora*, *Fusarium* and *Ralstonia*.

LIBRARY

During 2008-09, IISR library significantly improved its infrastructure as well as technical resources. New computer systems, printers and library furniture were added and Wi-Fi connectivity was established in the library for better and smooth network connectivity. The library has added 155 reference books, 18 technical reports, 12 project reports and three theses during this period. Twenty eight foreign journals and 115 Indian journals were subscribed. IISR library has become a part of CeRA, the E-journal consortium of ICAR under the NAIP. In view of the availability of CeRA resources and the library resource sharing programme existing among CPCRI and NRCC, the library funds were utilized for subscribing online databases like CAB Abstracts Online, Academic Search *etc*. Access to these databases was extended to CRC, Appangala and IISR Experimental Farm, Peruvannamuzhi. The digital institutional repository, DSpice@IISR, was updated with more research publications of scientists. To enhance the usage of library resources by IISR staff and students, two training programmes were organized *viz*., EBSCO online databases on 14 July 2008 & 12 Feb. 2009 and use of CeRA resources on 26 July 2008.

KRISHI VIGYAN KENDRA

Training programmes

The Kendra has conducted 81 training programmes on various subjects during the period under report. A total of 2464 persons have benefited out of the programmes. The details of the training programmes are furnished in Tables 15.1, 2 and 3.

Revolving fund programme

Under this programme, quality planting materials of various crops are produced and made available to public at affordable rates. Presently, bush pepper, allspice seedlings, garcinia grafts, mango grafts, guava layers, arecanut seedlings of Mohitnagar *etc*. are produced

Table 15.1. Training programmes conducted

Sl. No.	Category	No. of courses	No. of participants			No. of SC/ST participants
			Male	Female	Total	
1.	Practising farmers, farm women and rural youth	61	1038	748	1786	91
2.	Rural youth	12	183	239	422	19
3.	Extension functionaries	8	197	59	256	7
	Total	81	1418	1046	2464	117

Table 15.2. Discipline-wise training programmes conducted

Sl. No.	Discipline	No. of courses	No. of participants			No. of SC/ST participants
			Male	Female	Total	
1.	Crop production	42	837	377	1214	35
2.	Horticulture	9	56	137	193	38
3.	Animal science	30	547	510	1057	44
	Total	81	1440	1024	2464	117

Table 15.3. Training programmes organised for women SHG members

Sl. No.	Title of the programme	Period	No. of participants
1.	Goat rearing	7.6.08	26
2.	Milch cow management and fodder cultivation	9.6.08 to 14.6.08	41
3.	Milch cow management and fodder cultivation	23.6.08 to 28.6.08	43
4.	Milch cow management and fodder cultivation	14.7.08 to 19.7.08	30
5	Milch cow management and fodder cultivation	11.8.08 to 16.8.08	33
6	Milch cow management and fodder cultivation	31.1.09 to 4.2.09	22
8	Milch cow management	4.2.09 to 6.2.09	5
	Total		200

under this programme. During the period an amount of Rs. Five lakh has been realised through sale of planting materials, chicks and the activities of Plant & Animal Health Centre and the resource generation under revolving fund was Rs. 2,35,050/-

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. Cases treated/ advisory services - 1110
2. AI carried out in cattle using exotic frozen semen - 233
3. AI in goats - 46
4. Animal health campaign / infertility camps - 3
5. Video conference - 2
6. Animals vaccinated against Foot and mouth disease *etc.* - 15035
7. Field days - 6
8. Layer chicks produced - 1964
9. Broiler chicken - 746.2 kg
10. Sale of pregnant heifers - 4

Other extension activities

Kisan mela and exhibitions

KVK is regularly participating in exhibitions and seminars within the district. During the period under report, KVK participated in the exhibition conducted during Malabar Fest, 2008 at Calicut.

Farmers' study tours

Two study tours of gardeners trainees were conducted to Malabar Botanical Garden, Olavanna and to KAU, Trichur benefiting 49 trainees. Six study tours were carried out to Veterinary College, Pookode and Dhoni Farm as part of animal husbandry training benefiting 159 farmers and farm women.

Seminar

The KVK conducted a seminar on Preservation and feeding of fodder crops and care during pregnancy at Naduvannur with 58 participants.

Maintenance of demonstration blocks/units

The KVK is maintaining the following model demonstration blocks/units in its farm for 'seeing and learning' by the farmers.

- Medicinal plant unit
- Model Homestead garden
- Demonstration plot of improved varieties in black pepper
- Model arecanut seed garden
- Nutmeg scion bank
- Guava block
- Sapota block
- Vermicompost unit (newly constructed)
- Poultry demonstration unit
- Dairy demonstration unit
- Mango scion bank
- Quail demonstration unit
- Goatary unit (under construction)

Other activities

Collaborative activities: KVK is conducting its many mandatory activities in association with NGO's such

Human Resources Development

Sl. No.	Name of the person	Training programme/ workshop	Period of training	Place of training
1.	S Shanmugavel	Web site design and development	21.7.08 to 1.8.08	TNAU, Coimbatore
2.	K M Prakash	Web site design and development	4.8.08 to 16.8.08	TNAU, Coimbatore
3.	P S Manoj	Web site design and development	18.8.08 to 29.8.08	TNAU, Coimbatore
4.	P A Mathew	Web site design and development	1.9.08 to 12.9.08	TNAU, Coimbatore
5.	K M Prakash	Lan-Wan connection –Ernet training	18.10.08 to 24.10.08	TNAU, Coimbatore
6.	S Shanmugavel	Lan-Wan connection –Ernet training	27.10.08 to 31.10.08	TNAU, Coimbatore
7.	K M Prakash	Seminar on Protection of Plant Varieties & Farmers Right Act.	23.3.09	KAU,Trichur
8.	K M Prakash	Trainers training on commodity futures	27.3.09	CTI, KAU, Trichur

as Centre for Overall Development (COD), The Vikas Volunteer Vahini club (VVV), INFAM *etc.*

Visitors, field visits, advise on telephone, film shows: A total of 704 farmers visited KVK during the period for consultation, purchase of planting materials and other inputs. One hundred and fifteen field visits to farmers' plots were made benefiting 281 farmers. Five hundred and fifty one advise on telephone were rendered. Eighteen film shows were carried out on various technologies to create awareness among farmers.

Technologies transferred

Front line demonstrations

In this programme, technologies are demonstrated by the scientists, before being fed into the main extension system of State Department of Agriculture. The results of various FLD programmes conducted by the Kendra during the period are detailed below:

1. Introduction of high yielding varieties of ginger
   The percentage increase in yield of *Varada* was 25.5%, *Rejatha* and *Mahima* 14.7% respectively over the local variety with a B:C ratio of 1.38 indicating the superiority of the varieties.
2. Demonstration of HYVs of black pepper
   IISR varieties are being demonstrated and the growth of the vines are satisfactory.
3. Introduction of HYV of oyster mushroom *Hypsizygus almaricus (CO2)*
   The CO2 variety is capable of yielding 40% (980g/kg bed) over the oyster mushroom varieties with better keeping quality.
4. Demonstration on milk production performance in dairy cattle by feeding with silage under scarcity conditions
   It has been found to be a good technology for Kerala where fodder is scarce during summer months. Silage not only increased milk yield in cows but also increased fat content and reduced the cost on concentrate feed.
5. Demonstration of bush pepper production technology is in progress.
6. Management of budrot in coconut
   The latest technology of using satchet containing 3g of Dithane-M-45 was demonstrated in 10 ha in Moorikuthi village with the help of ATMA.
7. *In situ* green manuring with cowpea in coconut
   Successful demonstration of this technology has indicated that 25 kg of green manure/coconut basin can be produced with 200 g of cowpea sown during rainy season and this can meet the N requirements of coconut.

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.

FLD on HYVs of pepper at Koorachund

Study tour for gardener's trainees to KAU

The major OFT programmes carried out during the period are listed below:

1. Performance of *Pseudomonas fluorescens* and Vermicompost for Foot rot management in Black pepper.
   The results indicated that application of 5 kg vermicompost/vine/year either mixed with 50 g of *Pseudomonas fluorescens* alone or drenching with 1-2% solution of the same biocontrol agents at the onset of monsoon and mid season gave the lowest incidence of 1.3% foot rot in black pepper. It also helped to improve the vigour of the vine and yield. This is better than application of *Trichoderma* alone.

2. Fertility management in repeat breeder cows and goats following double PGF2 alpha injection.
   PGF2 alpha injection at 11 days interval followed by fixed time breeding at 72 and 96 hours enhanced conception rate in cows upto 84% and in goats upto 65.35%.

AGRICULTURAL TECHNOLOGY INFORMATION CENTRE

Technology inputs and advisory services

The technology inputs distributed from the centre include quality planting material of improved varieties of spices, bio control agents, vermi compost, fresh whole spices and scientific publications including extension literature. During the year 2008-09 planting material worth Rs. 51231 was distributed from the centre. The proceeds from sale of publications amounts to Rs. 112980. The total income generated was Rs. 176634. An amount of Rs. 5250 was realized through soil and manure sample analysis. *Trichoderma* and *Pseudomonas* formulations worth Rs.11823 were distributed to farmers.

Two hundred and fifty seven farmers from Calicut district, 127 farmers from outside Calicut, but within the state and 265 farmers from out side state availed advisory services. Students (1663 nos.) from educational institutions spread across the country visited the centre on study tour. The total visit recorded to the centre was 2368. The total visits to ATIC by various stake holders registered an increase of 13.5% over the visits recorded during 2007-08. The number of queries through different modes by the farmers over a period of five years has showed that queries through personal visit by farmers was highest followed by queries through letters, phone calls and emails (Fig. 16.1). From the secondary data recorded on the

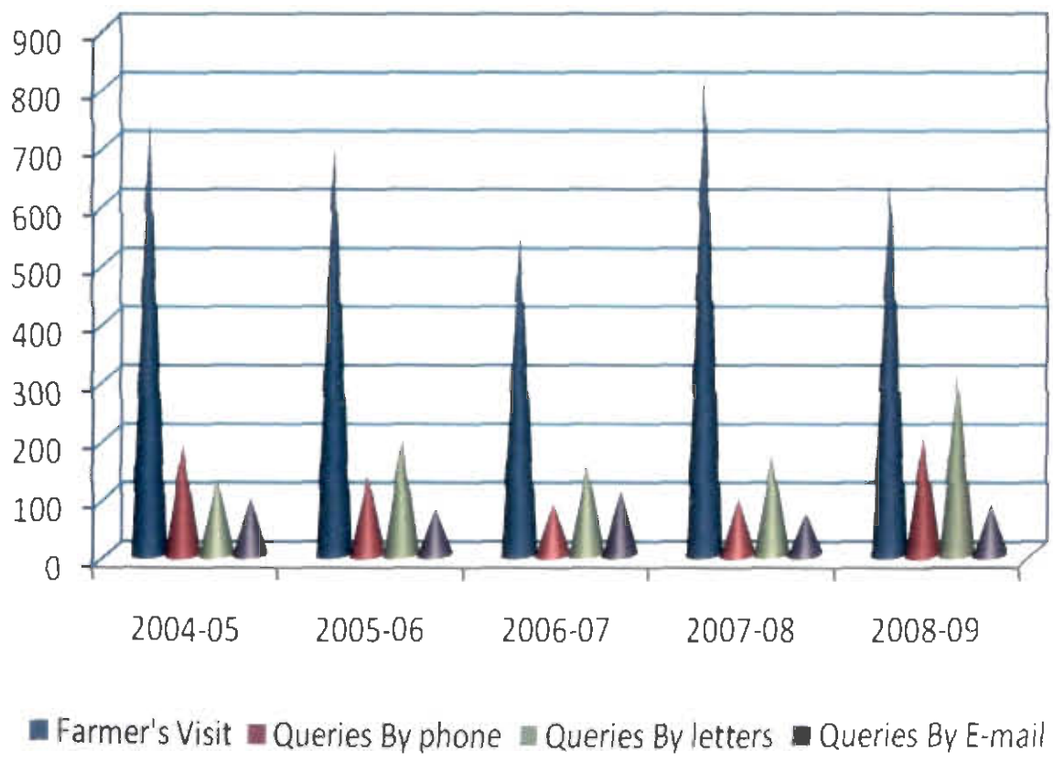


Fig.16.1. Mode of queries made by farmers through ATIC

visit of farmers to the institute the pattern of advisory services delivered by the institute was detailed using frequency scores.

Out reach extension services

Front line demonstration programme on Performance of improved varieties of black pepper released from IISR was laid out in 18 farmers' plots in three villages Anakkampoyil, Koorachund and Thalayad in Calicut district. The A multi-disciplinary team of scientists visited these plots as per a schedule to follow up and provide advisory services. Under the progarmme, each farmer was given with planting material for gap filling along with other critical inputs. A total of 14 visits were carried out to these fields. The institute participated in 2 exhibitions, 1 at national level and one at district/ state level.

Satellite technology based Village Resource Centre (VRC)

The Satellite Technology based Village Resource Centre (VRC) Scheme under the Rashtriya Sam Vikas Yojana (RSVY) sponsored by the Kerala State Planning Board has been commissioned by ISRO in 2007. The scheme envisages interactions between experts in identified knowledge centers and farmers enrolled in Village Resource Centres (VRCs) in Wayanad district of Kerala through video conferencing. During the year, 11 conferencing lessons were broadcast to the 4 Village Resource Centers in Wayanad district of Kerala in which 369 farmers participated.

Training for development

The partnership services offered by the institute include training, consultancy and contract research. The Institute offers training programme on demand from various agencies targeted for field extension functionaries of departments, research workers of other ICAR institutes and State Agricultural Universities (SAU). 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.

This year, 6 training courses were offered in which 168 trainees participated. Two of the programmes were carried out off campus under the Technology Mission for Integrated Development of Horticulture in NE States including Sikkim, Uttarakhand and Jammu and Kashmir, MM-I scheme. In these two programmes, 126 officers participated. On an assessment and research mode, all the training programmes conducted were subjected to an evaluation study to study the effectiveness of the training programmes manly in terms of knowledge transfer and record feedback from the participants on the organization of the programme. In general, the mean knowledge score of the participants increased from 8.9 before the training to 17.5 after the training.

List of training programmes offered

- Production and Processing Technology of Spices - for Department of Horticulture and Food Processing, Uttarakhand, 1-6 May 2008 - 15 officers of the state department participated.
- Spices Production - Potentials and Prospects under the Central Sector Scheme on Technology Mission for Integrated Development of Horticulture in NE States, Department of Horticulture, Tripura, Agarthala, 3-5 Feb 2009.
- Orientation training programme on Research and Development in Spices - Field officers of Spices Board - 21-24 May 2008 - 8 officers of the state department participated.
- Production and Procesiing Technology of Ginger and Turmeric - Agricultural assistants, Department of Agriculture, Kerala, Palakkad district - 17-20 August 2008 - 17 officers of the state department participated.
- Training programme on Production and Processing Technology of Major Spices under the State Horticulture Mission, Commercial Horticulture Development Scheme - 23-25 March 2009 - 12 officers of the state Department of Horticulture and Food Processing, UP participated.

EDUCATION AND TRAINING

Post graduate studies

Ph.D

Vijaya P, Studies on characterization and variability of *Phytophthora* species pathogenic to black pepper (*Piper nigrum*), University of Calicut.

Yamuna George, Studies on cryopreservation of spices genetic resources, University of Calicut.

Syamkumar S, Molecular, biochemical and morphological characterization of selected *Curcuma* accessions, University of Calicut.

M.Sc. projects

Twenty seven students from various universities undertook their M.Sc. project work in biotechnology, biochemistry, microbiology, bioinformatics and plantation development under the guidance of the scientists of the institute.

Post M.Sc. training

Eight post M.Sc. candidates underwent hands on training in various techniques of microbiology and biotechnology

Summer training for M.Sc. students

One month summer training course on Biochemistry, biotechnology and bioinformatics for 24 M.Sc. students was jointly organized by HRD cell and CPC during 12 May to 11 June 2008 and coordinated by Dr. R. Dinesh and Dr. R. Ramakrishnan Nair. There were lectures and practicals on the advanced techniques in the field of training and on instruments handling. The trainees were evaluated based on pre and post evaluation tests, term papers and surprise test and the best trainees were awarded with a merit certificate.

Trainings / Meetings organized by the Institute

ICAR sponsored Winter School/Short course

Winter School on Flavours, Nutraceuticals and Food Colours from Horticultural Crops: This was organized from 7th to 28th January 2009. The Course Director was Dr. B. Chempakam, Head, Division of

Crop Production & PHT and was co-ordinated by Drs. A. Shamina and K.N. Shiva. The Winter School was inaugurated on 7th January 2009 by Dr. G.R.C. Reddy, Director of NIT, Calicut, and presided over by Dr. V.A. Parthasarathy, Director. There were 16 participants. There were lectures (including guest speakers) and practical exercises on flavor and color principles and nutraceuticals present in horticultural crops.

Application of GIS in Plant Biodiversity and Horticulture: This was conducted from 25th February to 6th March 2009. Dr M. Tamil Selvan, Director, DASD, Calicut inaugurated the training programme. The training was attended by 15 participants. Dr. T. John Zachariah and Dr Utpala Parthasarathy co-ordinated the training programme. The most attractive

Training programmes/workshops attended by the staff

Name of the staff	Name of the training	Duration	Organized by
S Devasahayam & T K Jacob	Interactive Workshop on Microbial Interactions for Food Security	29-30 September 2008	NABS, Chennai
S Devasahayam	Workshop on Production and Post-harvest Technology of Ginger and Turmeric for Uttaranchal, Dehradun	5-7 March 2009	IISR & Uttaranchal State Department of Agriculture
T K Jacob	ICAR Training-cum-workshop on Intellectual Property and Technology Management	30 October to 01 November 2008	Central Tuber Crops Research Institute, Sreekariyam, Trivandrum
D Prasath V Srinivasan MS Madan	National Workshop on Spices Statistics	22-23 May 2008	DASD, Calicut, Kerala
K Kandiannan & D Prasath	National Workshop cum Seminar on Status and Future Strategies for Horticulture Development in A&N Islands	23-25 January 2009	CARI, Port Blair, A&N Islands
Rashid Pervez & S Hamza	Winter School on Flavours, Nutraceuticals and Food Colours from Horticultural Crops	7-28 January 2009	IISR, Calicut
R Senthil Kumar K Jayarajan	Application of GIS in Plant Biodiversity and Horticulture	25 February to 6 March 2009	IISR, Calicut

part of the training was hands on sessions on GIS and lectures on GIS application in various fields.

Bioinformatics training

Two Bioinformatics training programmes viz., Agri-Bioinformatics: Tools and Applications, 20-24 October 2008 and *In silico* analysis and annotation of ESTs, 17-19 December 2008 were held during the year for scientists/research fellows.

National Seminar on Piperaceae was held at IISR, Calicut during 21-22 November 2008 to discuss the problems faced by farmers in black pepper and betelvine cultivation and to educate farmers on the latest technologies available to improve production.

Visits abroad

S Devasahayam

Third Meeting on Good Agricultural Practices for Pepper, Ho Chi Minh City, Vietnam, 21 November 2008.

Second Meeting on Integrated Pest Management for Pepper, Ho Chi Minh City, Vietnam, 22 November 2008.

Awards

J S Pruthi award 2008 for the best research paper awarded to Hamza S, Srinivasan V and Dinesh R for the research paper "Nutrient diagnosis of black pepper (*Piper nigrum* L.) gardens in Kerala and Karnataka" published in the *Journal of Spices and Aromatic Crops*, 2007, 16 (1): 77-81.

Bulletin & Training Manuals

Application of GIS in Plant Biodiversity and Horticulture, ICAR sponsored short course, 25 Feb-6 Mar 2009. [Utpala Parthasarathy and John Zachariah, T. (Eds.)]. IISR, Calicut. 2009. 210 p.

Flavours, nutraceuticals and food colors from Horticultural Crops, ICAR sponsored Winter School, 7-28 Jan 2009. [Shamina, A., Krishnamurthy, K.S., Shiva, K.N., Leela, N.K. and Chempakam, B. (Eds.)]. IISR, Calicut. 2009. 238 p.

CONSULTANCY PROCESSING CELL

During 2008-09, the Consultancy Processing Cell (CPC) took up various analytical services such as analysis of soil, plant, manure and fertilizer samples for major, secondary and micronutrients, analysis of samples for microbes like *Trichoderma*, *Pseudomonas*, Phosphobacteria, *Azospirillum etc.* for both public and private entrepreneurs. Based on planter's requests, scientists provided technical guidance on cultivation and management aspects of spices on consultancy basis. Technology for large scale multiplication of *Trichoderma* was sold to entrepreneurs. The know-how on biocontrol agent *Pseudomonas* sp. (IISR-6) with toxicological data was transferred to District Agricultural Farm, Kottukkal, Anchal, Kerala.

One month summer training course on Biochemistry, biotechnology and bioinformatics for 24 M.Sc. students was jointly organized by HRD cell and CPC during 12 May to 11 June 2008. During the year, the total receipt through consultancy was around Rs 5.17 lakhs. Like previous years, this year also the major share (46%) was from analysis of samples for nutrients (NPK) and biocontrol agents know-how transfer (25%) (mainly *Trichoderma* and *Pseudomonas*). Other consultancy services like summer training to M.Sc. students (23%), visits of scientists to private farms based on requests (6%) and analysis of biocontrol agents *etc.* also contributed to the CPC revenue.

OFFICIAL LANGUAGE IMPLEMENTATION COMMITTEE ACTIVITIES

The Official Language Implementation Committee (OLIC) meetings were held four times during the year 2008-09. During the year four Hindi Workshops were conducted on "Noting and Drafting" and "Use of Computer in Hindi". Four quarterly progress reports, two half yearly reports and One Annual report on official language implementation were prepared.

Hindi Week was observed during September 2008. Hindi Day/Hindi Week was inaugurated on 15.09.2008. Various competitions (extempore speech, hindi song, hindi recitation, noting and drafting, calligraphy, memory test, Hindi quiz *etc.*) were conducted and prizes were distributed to the winners. Hindi word/phrase and the equivalent english word/phrase were displayed both on white board and in the IISR website.

Sri B. Krishnamoorthy, Hindi officer and Ms. N. Prasannakumari, Hindi translator attended Town Official Language Implementation Committee (TOLIC) meetings on 17.04.2008 and 23.09.2008. Ms. N. Prasannakumari attended two days Hindi Computer Training conducted by TOLIC, Calicut and visited Cardamom Research Centre, Appangala on 4th April 2008 to monitor the implementation of Official Language. All the name boards and sign boards were newly prepared in bilingual and institute's name in trilingual.

During this period one Scientist was nominated for Hindi Prabodh training through correspondence course. Nominated Mr. E. V. Ravindran and Ms. P. V. Sali for attending Hindi Workshop conducted by TOLIC, Calicut. Sri. B. Krishnamoorthy, Ms. N. Prasannakumari, and Ms. P. V. Sali attended valedictory function of joint Hindi competitions of TOLIC, Calicut and Ms. N. Prasannakumari attended TOLIC sub committee meeting on 20.02.2009 at State Bank of Travancore, Calicut.

Hindi versions of the half yearly publication of Spices News volume 19(1) January- June 2008 and 19(2) July - December 2008 were published as Masala Samachar. Executive summary of project coordinator's report and executive summary & preface of annual report were translated in Hindi and incorporated in annual report of AICRPS and IISR. Research Highlights 2007-08 was translated and published in Hindi.

INSTITUTE MANAGEMENT COMMITTEE

Members

1. Dr. V A Parthasarathy, Director, IISR, Calicut
2. Assistant Director General (Hort. II), ICAR, New Delhi
3. Dr. George V Thomas, Director, CPCRI, Kasaragod
4. Dr. S Devasahayam, Head, Crop Protection, IISR, Calicut
5. Mr. P A Mathew, Programme Coordinator, KVK, Peruvannamuzhi
6. Dr. K V Nagaraja, Principal Scientist, Directorate of Cashew, Puttur
7. Mr. M J Ummen, Mangalath Parambil House, Arivilanjapoil P O, Alakkode (Via), Kannur
8. Sri. G Rathikumar, Deepthi, Kizhakkekara, Kottarakkara, Kollam
9. Mr. C Padmanabhan, Assistant Administrative Officer, IISR, Calicut

RESEARCH ADVISORY COMMITTEE (2007-10)

Dr. N. Mohanakumaran (Formerly Director of Research, KAU) Chirakkara Palace Pappanamcode Thiruvananthapuram – 695018	Chairman
Dr. Umesh Srivastava Asst. Director General (Hort. II) ICAR, Krishi Anusandhan Bhavan–II New Delhi–110012	Member
Dr. I. Irulappan (Formerly Dean, Horticulture, TNAU) 28, Abhirami Nagar, Narayanapuram, 1st Main Road Narayanapuram West, Madurai - 625014	Member
Dr. M. Udaya Kumar Formerly Professor & Head Department of Crop Physiology University of Agricultural Sciences G.K.V.K. Campus, Bangalore - 560 065, Karnataka	Member
Dr. K.U.K. Nampoothiri Director, Biju Patnaik Medicinal Plants Garden and Research Institute M. S. Swaminathan Research Foundation, Phulbad Jeypore R.S.(P. O.) 764 002, Koraput Dt. Orissa	Member
Dr. N.S. Rao (Formerly Principal Scientist) N-109, Innovative Natura, Vinayaka Layout, Puttanahalli, Yelahanka, Bangalore - 560064	Member
Dr. V.A. Parthasarathy Director Indian Institute of Spices Research Calicut - 673 012, Kerala	Member
Mr. M.J. Ummen, Mangalath Parambil House, Arivilanjapoil P O, Alakkode (Via), Kannur - 670571	Member
Sri. G. Rathikumar, Deepthi, Kizhakkekara, Kottarakkara, Kollam	Member
Dr. B. Chempakam Head, Division of Crop Production in PHT Indian Institute of Spices Research Calicut - 673 012, Kerala	Member Secretary

RECOMMENDATIONS OF RAC 2009

Sl.No.	Recommendation	Action Taken
1	The work on *in vitro* conservation of germplasm may be undertaken with DBT funding (Action: K Nirmal Babu)	Project on *in vitro* conservation will be submitted to DBT.
2	Results should be presented with suitable statistical analysis (Action: All Scientists)	Results will be presented with suitable statistical analysis in future.
3	KAU Panniyur has produced two interspecific hybrids between *Piper colubrinum* and *P. nigrum*. The performance of these hybrids may be observed for their consistency before taking up incompatibility studies in the above cross (Action: BK Moorthy)	The reason for incompatibility is due to difference in ploidy level. *P.colubrinum* is 2n:26 while *P.nigrum* is 2n:52. It has been studied and reported in Euphytica. Hence, the recommendation may be dropped.
4	Organic package may be developed for various spices including varieties (Action V Srinivasan)	This will be done under the Network Project on Organic Farming which is in progress. The objective of the project is to develop a package for organic farming in major spices.
5	Sample size may be increased for the estimation of biochemical parameters (Action: KS Krishnamurthy)	Sample size will be increased for the analysis of biochemical parameters as suggested.
6	A status paper on ideotype of black pepper may be circulated to RAC members before 31st July 2009 (Action: K S Krishnamurthy).	Status paper on ideotype of black pepper will be circulated to RAC members before 31st July 2009.
7	Acceptance of uncured and dried turmeric in the market and use of turmeric as salad are to be assessed (Action: TJ Zachariah)	Turmeric samples will be prepared as suggested to study the market acceptance in the coming season. Use of low curcumin rhizomes for application as salad will also be attempted in the coming season during October.
8	Linkage with spice industry may be strengthened (Action: TJ Zachariah).	A letter will be sent to Director (Marketing) Spices Board, Kochi seeking his opinion regarding the services of IISR in Spice Industry.
9	Quality analysis of stored samples under various atmospheric conditions may be presented along with that of fresh samples. Increase the number of samples with statistical analysis (Action: TJ Zachariah)	Fresh sample of Panniyur-1 will be collected in the coming season for quality analysis under various atmospheric conditions and the data will be subjected to statistical analysis.

10	Factors contributing to plagiotropy and orthotropy in nutmeg and laterals and runners/ top shoots in black pepper may be studied (Action: J Rema and CK Thankamani)	The work on nutmeg and black pepper would be studied in the respective projects.
11	During release of varieties, nutraceutical properties and chemical composition of the variety may also be furnished wherever data are available. (Action: A Shamina)	The nutraceutical parameters (*viz.*, the antioxidant potential) and chemical composition of the varieties to be released will be quantified and made available.
12	The RT-PCR method standardized for the detection of *cardamom mosaic virus* may be validated by testing large number of field samples (Action: CN Biju & AI Bhat)	The RT-PCR method for the detection of cardamom mosaic virus will be validated by testing field samples from different cardamom growing regions.
13	The number of locations and observations may be increased in plots planted with virus indexed black pepper plants for recording the incidence of viral diseases (Action: AI Bhat & CN Biju)	The farmers from Kerala and Karnataka who have taken virus indexed black pepper plants will be visited for recording the incidence of viral diseases.
14	The yield data of promising *Phytophthora* and nematode tolerant lines may be collected (Action: R Suseela Bhai & SJ Eapen)	The available data will be compiled and presented in the next IRC.
15	Studies may be made on the bionomics of shoot borer on resistant and susceptible accessions separately with increased population with suitable statistical analysis (Action: TK Jacob)	Studies on bionomics of shoot borer on resistant and susceptible accessions would be made with increased population and suitable statistical analysis during the current crop season.
16	Efforts may be made to document natural enemies of *Erythrina* gall wasp and simultaneously to find out the feasibility of introducing promising exotic natural enemies may be explored with the help of NBAII, Bangalore (Action: TK Jacob & S Devasahayam)	Collections of infested galls would be made regularly to document natural enemies of *Erythrina* gall wasp during the current flushing season. Attempts would also be made to find out the feasibility of introducing promising exotic natural enemies with the help of NBAII, Bangalore.
17	In addition to the baiting method used to collect EPNs, exploration may be made to collect naturally infested shoot borer larvae with EPNs (Action: Pervez Rashid & SJ Eapen)	Attempts will be made to collect EPNs from naturally infested shoot borer larvae.
18	Primary data from Govt. nurseries may be collected to analyse the impact of varietal spread (Action: MS Madan).	Data from Govt. sources of nursery material in black pepper will be collected and incorporated in analysis of impact of research investment on pepper research.
19	Data on investment and return in research may be re-visited and confirmed at least for one crop (Action: MS Madan).	The analysis will be repeated with the new data.

20	Consolidate the data on impact analysis and present the salient findings (Action: P Rajeev)	Data in case of impact assessment in ginger and turmeric will be collected and all the data will be consolidated to arrive at indicator based impact of technologies/ improved varieties
21	Questionnaire may be developed after obtaining inputs from all the concerned scientists (Action: P Rajeev)	All the questionnaires will be developed in consultation with subject matter specialists.
22	Feedback may be obtained from those who got training for evaluation purpose and presented in mid term IRC and next RAC. (Action: P Rajeev)	Regular feed back using questionnaires and open forums will be collected and recorded for all the training programmes.
23	Component of expert system may be included in the project on development of softwares and expert system and interaction may be made with Dr. Ganesan of KAU (Action: SJ Eapen)	Efforts to develop an expert system for diagnosis of black pepper diseases and pests have been initiated. Detailed discussions will be held with Dr.Ganesan, Dean, KAU.
24	Explore the possibility of using Agrl. officers as master trainers by KVK (Action: KVK/ATIC).	As this is one of the mandatory activities of KVK, KVK is routinely training extension functionaries including agricultural officers in agriculture and allied fields.
25	Data pertaining to prices may be obtained from Spices Board and updated in touch screen (Action: M S Madan)	Suitable software will be developed to be loaded in touch screen to provide updated price data.
26	In view of labour shortage, collaboration with CIAE may be explored to develop various labour saving devices (Action: HD, Crop Production)	A research project on development of machine for making potting mixture has already been started with CIAE Regional Station, Coimbatore. One Senior Scientist (Agronomy) is an associate in the project.
27	Obtain feedback on adoption of various technologies for their refinement when surveys are undertaken for impact analysis (Action: All HDs)	Feedback will be obtained and passed on to concerned Heads for refinement.
28	All the presentations should be highly focused with minimum number of slides. Use of softwares for enhancing the effect of presentation using style manuals for presentation styles, tables with statistical analysis and internationally accepted units may be followed (Action: All Scientists)	Noted for future guidance.
29	ATR should be circulated along with agenda notes at least one week before RAC (Action: Member Secretary, RAC)	This suggestion will be followed.
30	Where ever possible projects should have transferable technologies, if any, with clear conclusion of each year's findings (Action: All Scientists)	Transferable technologies if any, will be identified.
31	Patentable areas of research may be briefly presented (Action: All concerned)	Patentable areas of research will be presented briefly in future.
32	RAC felt that yield in black pepper may hence forth be expressed as yield/standard with definition of number of vines/standard. Project Coordinator, Spices may discuss this matter in the next workshop and take a decision (Action: PC, B K Moorthy).	The matter would be discussed during the ensuing AICRPS workshop with all research workers during June 2009 and decision will be taken.

RESEARCH PUBLICATIONS

1. Anandaraj, M., Chandran, S., George, R.S., Bhat, A.I. and Bhai, R.S. (2008) Development of SCAR marker for *Phytophthora* resistance in black pepper (*Piper nigrum* L.). *Journal of Spices and Aromatic Crops* 17(3): 215-222.
2. Ankegowda, S.J., (2008) Optimum leaf stage for transplanting small cardamom seedlings from primary nursery to polybag nursery. *Indian Journal of Horticulture* 65 (2): 252-254.
3. Asish, G.R., Utpala Parthasarathy, Zachariah, T.J., Gobinath, P., Mathew, P.A., Johnson George, K. and Saji, K.V. (2008) A comparative estimation of Hydroxycitric acid in different species of *Garcinia*. *The Horticultural Journal* 21(1): 26-29.
4. Bhadramurthy, V., Bhat, A.I., George, J., Thankamani, C.K. and Mathew, P.A. (2008). Variation in the concentration and indexing black pepper plants for PYMoV and CMV through DAS-ELISA. *Journal of Spices and Aromatic Crops* 17: 197-201.
5. Bhai, R.S. and Jythya Dhanesh (2008) Occurrence of fungal diseases on vanilla (*Vanilla planifolia* Andrews) in Kerala. *Journal of Spices and Aromatic Crops* 17(2): 140-148.
6. Bhat, A.I., Jiby, M.V., Anandaraj, M., Bhadramurthy, V., Patel, K.D., Patel, N.R., Jaiman, R.K. and Agalodia, A.V. (2008) Occurrence, Identification and Characterization of a Phytoplasma associated with Phyllody Disease of Fennel (*Foeniculum vulgare* Mill) in India. *Journal of Phytopathology* 156: 758-761.
7. Hareesh, P.S. and Bhat, A.I. (2008) Detection and partial nucleotide sequence analysis of *Piper yellow mottle virus* infecting black pepper (*Piper nigrum* L.) in India. *Indian Journal of Virology* 19: 160-167.
8. Kandiannan, K. and Chandragiri, K.K. (2008) Phenology and dry matter distribution in turmeric (*Curcuma domestica* Valeton. syn. *C. longa* L.). *Journal of Medicinal and Aromatic Plant Sciences* 30(2): 117-121.
9. Kandiannan, K., Thankamani, C.K., and Mathew, P.A. (2008) Analysis of rainfall of the high rainfall tract of northern agro-climatic zone of Kerala. *Journal of Spices and Aromatic Crops* 17 (1): 16"20.
10. Kandiannan, K., Utpala Parthasarathy, Krishnamurthy, K.S., Thankamani, C.K. and Srinivasan, V. (2009) Modeling individual leaf area of ginger (*Zingiber officinale* Roscoe) using leaf length and width. *Scientia Horticulturae* 120: 532-537.
11. Kumar, A., Reeja Susan Thomas, Jooju, B., Bhai, R.S. and Shiva, K.N. (2008) Distribution of *Pythium myriotylum* Drechsler causing soft rot of ginger (*Zingiber officinale* Roscoe.) *Journal of Spices and Aromatic Crops* 17(1): 5-9.
12. Leela, N.K. and Madhavan Pillai, P. (2008) Flavones from *Piper colubrinum* leaves. *Journal of Medicinal and Aromatic Plant Sciences* 30(2): 105-108.
13. Leela, N.K., Prasath, D. and Venugopal, M.N. (2008) Essential oil composition of selected cardamom (*Elettaria cardamomum* Maton) genotypes at different maturity levels. *Indian Journal of Horticulture* 65(3): 366-369.
14. Leela, N.K., Vipin, T.M., Shafeekh, K.M., Priyanka, V. and Rema, J. (2009) Chemical composition of essential oils from aerial parts of *Cinnamomum malabatrum* (Burman f.) Bercht & Presl. *Flavour and Fragrance Journal* 24(1): 13-16.
15. Minoo Divakaran, Jayakumar, V.N., Veena, S.S., Vimala, J., Basha, A., Saji, K.V., Nirmal Babu, K. and Peter, K.V. (2008) Genetic variations and relationships in cultivated *Vanilla planifolia* and few related species using RAPD polymorphism. *Genetic Resources and Crop Evolution* 55:459-470.
16. Prasath, D., Venugopal, M.N., Senthilkumar, R. and Leela, N.K. (2008) Hybrid performance for yield and yield components in cardamom (*Elettaria cardamomom* Maton). *Euphytica* 168: 49-60.
17. Prasath, D., Venugopal, M.N. and Senthilkumar, R. (2009) Evaluation of high yielding cardamom selection in Karnataka for yield and quality. *Indian Journal of Agricultural Sciences* 79(3): 207-209.

18. Prasath, D. and Ponnuswami, V. (2008) Screening of chilli (*Capsicum annuum* L.) genotypes against *Colletotrichum capsici* and analysis of biochemical and enzymatic activities in inducing resistance. *Indian Journal of Genetics and Plant Breeding* 68(3): 344-346.

19. Prasath, D. and Ponnuswami, V. (2008) Heterosis and combining ability for yield, its component and quality characters in paprika type chilli (*Capsicum annuum* L.). *Indian Journal of Horticulture* 65(4): 441-445.

20. Rema, J., Mathew, P.A. and Krishnamoorthy, B. (2008) Vegetative propagation of allspice (*Pimenta dioica* (L.) Merr.) *Indian Journal of Horticulture* 65 (1):65-68.

21. Sangeeth, K.P., Suseela Bhai, R. and Srinivasan, V. (2008) Evaluation of indigenous *Azospirillum* isolates for growth promotion in black pepper (*Piper nigrum* L.) rooted cuttings. *Journal of Spices and Aromatic Crops* 17(2): 128-133.

22. Sibi, M.C., Anandaraj, M., Eapen, S.J. and Devasahayam, S. (2008) Effect of carrier media on population fluctuation of *Trichoderma harzianum* (MTCC 5179) in black pepper (*Piper nigrum* L.) rhizosphere and their interaction with soil microflora and fauna. *Journal of Biological Control* 22: 25–32.

23. Sheeja, T.E., Johnson George, K., Jessy Jerome, Sandeep Varma, R., Syamkumar, S., Krishnamoorthy, B. and Parthasarathy, V.A. (2008) Optimization of DNA isolation and PCR parameters in *Myristica* species and related genera for RAPD and ISSR analysis. *Journal of Spices and Aromatic Crops* 17(2): 91-97.

24. Thankamani, C.K., Mathew, P.A., Srinivasan, V., Krishnamurthy, K.S., Kandiannan, K. and Hamza, S. (2008) Granite powder as substitute for sand in nursery mixture of black pepper (*Piper nigrum* L). *Journal of Plantation Crops* 36(2): 117-122.

25. Thankamani, C.K., Dinesh, R., Eapen, S.J., Kumar, A., Kandiannan, K. and Mathew, P.A. (2008) Effect of solarized potting mixture on growth of black pepper rooted cuttings (*Piper nigrum* L.) in the nursery. *Journal of Spices and Aromatic Crops* 17(2): 103-108.

26. Thankamani, C.K., and Sreekala, K. (2008) Growth and nutrient uptake of black pepper (*Piper nigrum* L.) varieties in nursery as influenced by the application of *Pseudomonas fluorescens* and *Trichoderma harzianum*. *Journal of Medicinal and Aromatic Plant Sciences* 30 (1): 69-72.

27. Utpala Parthasarathy, Asish, G.R., Zachariah, T.J., Saji, K.V., Johnson, K.G., Jayarajan, K., Mathew, P.A., and Parthasarathy, V.A. (2008) Spatial influence on the important volatile oils of *Piper nigrum* leaves. *Current Science* 94 (12): 1632-1634.

28. Utpala Parthasarathy, Asish, G.R., Zachariah, T.J., Saji, K.V., Johnson George, K. and Mathew, P.A. (2008) Spatial influence on the important biochemical properties of *Piper nigrum* Linn. Leaves. *Natural Product Radiance* 7(5): 444- 447.

29. Utpala Parthasarathy, Jayarajan, K., Johny, A.K. and Parthasarathy, V.A. (2008) Identification of Suitable areas and effect of climate change on ginger-A GIS study. *Journal of Spices and Aromatic Crops* 17 (2): 61-68.

30. Utpala Parthasarathy, Parthasarathy, V.A. and Jayarajan, K. (2008) A temperature sensitivity analysis on plantation crops; A GIS approach. *Journal of Plantation Crops* 36 (3): 372-375.

31. Zachariah, T.J., Leela, N.K., Maya, K.M., Rema, J., Mathew, P.A., Vipin, T.M. and Krishnamoorthy, B. (2008) Chemical composition of leaf oils of *Myristica beddomeii* (King), *Myristica fragrans* (Houtt.) and *Myristica malabarica* (Lamk). *Journal of Spices and Aromatic Crops* 17(1): 10-15.

LIST OF PROJECTS

I. Institute projects

Mega Project I: 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) [KV Saji and Utpala Parthasarathy]
2. Gen. XXVIII (813): Conservation and characterization of Piper germplasm (2008-2014) [K V Saji and R Senthil Kumar]
3. Gen. XIX (813): Conservation, characterisation, evaluation and improvement of Zingiber and Curcuma Spp (2007-2012) [D Prasath and K V Saji]
4. Gen. IX (813): Conservation and characterization of cardamom germplasm (2007-2012) [R Senthil Kumar and C N Biju]
5. Gen. XXVI (813): Evolving high yielding and high quality nutmeg clones by selection (2007-2011) [B Krishnamoorthy and J Rema]
6. Gen. XXVII (813): Improvement of cassia by selection (2007-2010) [B Krishnamoorthy and R Senthil Kumar]
7. Gen. XVI (813): Maintenance, enhancement and characterization of genetic variability in vanilla (*Vanilla planifolia* Andrews) (2005-2010) [R Ramakrishnan Nair and P A Mathew]
8. Gen. XXIX (813): A comparative study of molecular and bio-chemical diversity of garcinia of Eastern Himalayas and Western Ghat ranges with GIS (2008-2011) [Utpala Parthasarathy and K Nirmal Babu]
9. Hort. III (813): Collection, characterization, evaluation and maintenance of paprika and paprika alike chilies (2004-2009) [D Prasath and K N Shiva]

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

Gen. XVII (813): Breeding black pepper for high yield, quality, biotic and abiotic stress. (2006-2011) [V A Parthasarathy, B Sasikumar, T John Zachariah, K Nirmal Babu, R Suseela Bhai, Johnson K George; Santhosh J Eapen, K V Saji, S Devasahayam, K S Krishnamurthy and T E Sheeja]

1. Gen. XVII (813): Breeding black pepper for high yield and caryophyllene (2007-2010) [K V Saji and T John Zachariah]
2. Gen. XVII (813): Breeding black pepper for *Phytophthora* resistance (2007-2011) [K Nirmal Babu, T E Sheeja and R Suseela Bhai]
3. Gen. XXI (813): Breeding black pepper for resistance to "pollu" beetle (2007-2010) [K V Saji and S Devasahayam]
4. Gen. XXII (813): Breeding black pepper for tolerance to drought (2007-2010) [T E Sheeja and K S Krishnamurthy]
5. Gen. XXIII (813): Breeding black pepper for developing resistance to *Radopholus similis* and its molecular genetic analysis (2007-2010) [Johnson K George and B Krishnamoorthy]
6. Gen. X (813): Breeding cardamom for high yield and disease resistance (2007-2012) [R Senthil Kumar and M N Venugopal]

7. Gen. XV (813): Investigations on the reasons and solutions for the absence of seed set in ginger (*Zingiber officinale* Rosc.) (2005-2010) [R Ramakrishnan Nair and D Prasath]
8. Biotech X (813): Development of core ESTs and cloning of genes from *Piper nigrum* and *P. colubrinum* (2008-2011) [Johnson K George and K S Krishnamurthy]
9. Biotech. IX (813): Development of transgenics for resistance to *Phytophthora* and drought in black pepper (2006-2011) [K Nirmal Babu and T E Sheeja]
10. Gen. XXV (813): Genetics of seedling progenies of turmeric (*Curcuma longa* L.) (2007-2011) [R Ramakrishnan Nair and K N Shiva]

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

1. SSC. III (813): Assessment of quality of soils under spices based cropping systems (2005-2009) [R Dinesh, V Srinivasan and S Hamza]
2. SSC. IV (813): Nutrient budgeting for improved varieties of spices (2005-2010) [V Srinivasan, R Dinesh, C K Thankamani, S J Ankegowda and S Hamza]
3. Agr. XXIV (813): Phenology of ginger and turmeric (2006-2009) [K Kandiannan and Utpala Parthasarathy]
4. Agr. XXVII (813): Enhancing the productivity in black pepper by intercropping (2006-2009) [C K Thankamani and K Kandiannan]
5. Agr. XXVIII (813): Input use efficiency in turmeric in relation to quality (2007-2010) [K Kandiannan and V Srinivasan]

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

1. Phy. VII (813): Physiological and biochemical basis of productivity in black pepper (2003-2008) [K S Krishnamurthy and B Chempakam]
2. Phy. VIII (813): Mechanism of drought tolerance in cardamom and black pepper (2005-2010) [S J Ankegowda and K S Krishnamurthy]
3. Phy. IX (813): Investigation on factors controlling spiking in black pepper (2008-2011) [K S Krishnamurthy and S J Ankegowda]
4. Biochem VI (813): Influence of biochemical factors on curcuminoid levels in turmeric (2008-2011) [B Chempakam and A Shamina]

Mega Project V: 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 (2004-2009) [E Jayashree]
2. PHT. IV (813): Evaluation for physical and biochemical quality of spices (2005-2009) [T John Zachariah, K.N. Shiva and N K Leela]
3. Biochem VII (813): Management of mycotoxins in black pepper, ginger, turmeric and nutmeg (2008-2011) [B Chempakam and R Suseela Bhai]

Mega Project VI: Propagation studies in spice crops [Project Leader: C K Thankamani]

1. Hort. V (813): Rootstock intervention to manage root infection of *Phytophthora* and nematodes in black pepper (2006-09) [P A Mathew]
2. Hort. VI (813): Induction of orthotropic shoots in plagiotropic grafts of nutmeg (2008-2011) [J Rema and P A Mathew]

Mega Project XIII: Investigations on nutraceutical and pharmacokinetic aspects of spices [Project Leader: A Shamina]

1. Biochem. III (813): Studies on the nutraceutical properties of bioactive compounds in a few spices (2007-2010) [A Shamina and N K Leela]
2. Biochem. IV (813): Exploration of spices for natural food colours and pigments (2007-2010) [K N Shiva and T J Zachariah]
3. Biochem. V (813): Cloning of pal gene from turmeric (*Curcuma longa* L.) (2008-2011) [A Shamina and T E Sheeja]
4. Org. Chem. III: Flavour profiling of Zingiberaceae spices (2008-2012) [N K Leela and S Hamza]

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

1. Path. XIX (813): Development of diagnostics for viruses infecting small cardamom (*Elettaria cardamomum* Maton) (2008 – 2012) [C N Biju and A Ishwara Bhat]

Mega Project VIII: Conventional and molecular approaches for developing pest, pathogen and nematode resistance in spice crops [Project Leader: R Suseela Bhai]

1. Crop Prot. 1.4 (813): Identification of black pepper genotypes with multiple resistance against *Phytophthora* and Nematodes (2006-2009) [R Suseela Bhai and Rashid Pervez]
2. Ent. XIII (813): Screening of germplasm accessions of spices and evaluation of antibiosis resistance to major insect pests (2006-2011) [T K Jacob and S Devasahayam]
3. Path. XX (813): Screening of Piper germplasm accessions against *Piper yellow mottle virus* (PYMoV) (2008-2012) [A Ishwara Bhat and T K Jacob]

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

1. Crop. Prot. 1.5 (813): Integrated management of *Phytophthora* foot rot and slow decline diseases of black pepper (2008-2011) [R Suseela Bhai, Santhosh J Eapen, A Kumar and Rashid Pervez]
2. Org. Chem. II (813): Characterization of bioactive compounds with pesticide properties (2002-2010) [N K Leela and Rashid Pervez]
3. Nema. IV (813): Role of phenyl propanoids in black pepper - burrowing nematode interactions (2008-2011) [Santhosh J Eapen and A Shamina]
4. Path. XVIII (813): Isolation and evaluation of antimicrobial compounds from bacterial endophytes against major pathogens of spice crops (2008-2011) [A Kumar and Santhosh J Eapen]
5. Ent. XII (813): Bioecology and integrated management of shoot borer *Conogethes punctiferalis* Guen. infesting turmeric (2005-2009) [S Devasahayam and T K Jacob]
6. Path. XVII (813): Characterization, epidemiology and management of *Colletotrichum* spp. infecting black pepper, cardamom and turmeric (2006 – 2009) [M N Venugopal and C N Biju]
7. Nema V (813): Survey and identification of efficient entomopathogenic nematodes (EPNs) against major insect pests of ginger and turmeric (2008-2012) [Rashid Pervez, Santhosh J Eapen and S Devasahayam]

Mega Project X: 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 and A K Johny]
2. Econ. IV (813): Assessing sustainability of cropping systems involving spices (2007-2010) [M S Madan, A K Johny and K Jayarajan]

Mega Project XI: Extension and training [Project Leader: P Rajeev]

1. Ext. IV(813) : Training of research and extension personnel (2005-2010) [P Rajeev]
2. Ext V(813): A Study on diffusion, adoption and impact of varieties released from IISR and scientific crop management practices (2006-09) [P Rajeev and M S Madan]

Mega Project XII: Developing customized software and expert-system on spices [Project Leader: S J Eapen]

1. Stat. I (813): Development of databases and software (2004-2010) [K Jayarajan]

II. Externally aided projects

i) Department of Biotechnology, New Delhi

1. DBT-CIB-3: Development of microsatellite markers and characterization of Curcuma spp. (2006-2009) [T E Sheeja]
2. DBT-CIB 4: Development of Microsattelite markers, Molecular characterization of small (*Elettaria cardamomum* Maton) & large cardamom, (*Amomum subulatum* Roxb.), identify core collections and developing data base of important genotypes (2006-2009) [K Nirmal Babu, R Senthil Kumar, T E Sheeja]
3. DBT-CP4: Accredited Test Laboratory (ATL) under the national certification system for tissue culture raised plants (NCS-TCP) (2008-2011) [A Ishwara Bhat and K N Babu]
4. DBT-CP 3: Genetic transformation of black pepper to confer resistance against viruses (2006-2009) [A Ishwara Bhat and R Suseela Bhai]
5. DBT-SS1: Distributed information sub-centre (2000-2012) [Santhosh J Eapen]

ii) Indian Council of Agricultural Research, New Delhi

1. ICAR-CP 4: Application of Microorganisms for Agriculture and Allied Sectors (AMAAS) : Nutrient management, PGPR and biocontrol (2006-2009) [M Anandaraj and R Dinesh]
2. ICAR-CPPHT-1: Network Project on Organic Farming (2007-2012) [V Srinivasan, C K Thankamani and A Kumar]
3. ICAR Mega Seed Project: Seed production in agricultural crops and fisheries (2006-2012) [K Kandiannan and P A Mathew]
4. Outreach Project on *Phytophthora, Fusarium & Ralstonia* Diseases of Horticultural and Field crops (2008-2012) [M Anandaraj, K Nirmal Babu, A Kumar, R Suseela Bhai, Santhosh J Eapen and Johnson K George]

iii) Ministry of Environment and Forests, New Delhi

1. MOEF. I (813): Biodiversity in Piper and Garcinia and identification of spots of species richness in Western Ghats (using GIS and molecular markers) (2006-2009) [P A Mathew, Utpala Parthasarathy, Johnson K George and K V Saji]

iv) National Horticultural Mission, New Delhi

1. NHM-CPPHT-1: Production of nucleus planting materials of improved varieties of spice crops (2005-2010) [C K Thankamani, S Hamza and S J Ankegowda]

v) National Agricultural Innovation Project, New Delhi

1. NAIP-SS-1: Multi-enterprise farming models to address the agrarian crisis of Wayanad district of Kerala" Under Component-3: (Sustainable Rural Livelihood Security) of NAIP (2008 - 2012) [K N Shiva]

PERSONNEL

Headquarters

Scientific

Name	Designation
Dr. V.A. Parthasarathy	Director
Dr. M. Anandaraj	Project Coordinator (Spices)
Dr. B. Chempakam	Head, Division of Crop Production & PHT
Dr. S. Devasahayam	Head, Division of Crop Protection
Mr. B. Krishnamoorthy	Principal Scientist (Plant Breeding)
Dr. K. Nirmal Babu	Principal Scientist (Plant Breeding)
Dr. M.S. Madan	Principal Scientist (Agri. Economics)
Dr. T. John Zachariah	Principal Scientist (Biochemistry)
Dr. B. Sasikumar	Principal Scientist (Plant Breeding) -on deputation
Dr. T.K. Jacob	Principal Scientist (Entomology)
Dr. J. Rema	Principal Scientist (Horticulture)
Dr. C.K. Thankamani	Sr. Scientist (Agronomy)
Dr. R. Ramakrishnan Nair	Sr. Scientist (Gen. & Cytogenetics)
Dr. R. Suseela Bhai	Sr. Scientist (Plant Pathology)
Dr. K. Kandiannan	Sr. Scientist (Agronomy)
Dr. P. Rajeev	Sr. Scientist (Agril. Extension)
Dr. K.S. Krishnamurthy	Sr. Scientist (Plant Physiology)
Dr. Santhosh J. Eapen	Sr. Scientist (Nematology)
Dr. N.K. Leela	Sr. Scientist (Org. Chemistry)
Dr. A. Kumar	Sr. Scientist (Plant Pathology)
Dr. V. Srinivasan	Sr. Scientist (Soil Science)
Dr. A. Shamina	Sr. Scientist (Bio chemistry)
Dr. K.V. Saji	Sr. Scientist (Economic Botany)
Dr. K.N. Shiva	Sr. Scientist (Horticulture)
Dr. T.E. Sheeja	Sr. Scientist (Biotechnology)
Dr. Rashid Pervez	Sr. Scientist (Nematology)
Dr. D. Prasath	Scientist (Sr. Scale) (Horticulture)
Dr. K. Abirami	Scientist (Horticulture)

Technical Officers

Dr. Johny A. Kallupurackal	Technical Officer (T9)
Dr. Hamza Srambikkal	Technical Officer (Lab) (T7-8)
Mr. P. Azgar Sheriff	Technical Officer (Lib.) (T7-8) - upto July 2008
Dr. Utpala Parthasarathy	Technical Officer (T7-8)
Mr. M.M. Augusthy	Technical Officer (T6)

Mr. K. Jayarajan	Technical Officer (Stat.) (T5)
Mr. M. Vijayaraghavan	Technical Officer (T5) (Workshop)
Mr. K.T. Muhammed	Technical Officer (T5) (Farm)
Mr. V. Sivaraman	Technical Officer (T5) (Farm)
Dr. C.K. Sushama Devi	Technical Officer (T5) (Lib.)
Ms. N. Prasannakumari	Technical Officer (T5) (Hindi Translator)
Mr. A. Sudhakaran	Technical Officer (T5) (Artist-cum-Photographer)

Administration

Mr. V.L. Jacob	Asst. Fin. & Accts. Officer
Mr. C.P. Padmanabhan	Asst. Admn. Officer (- i/c w.e.f. March 2009)
Ms. P.V. Sali	Private Secretary
Mr. K.G. Jegadeesan	Asst. Fin. & Accts. Officer
Mr. A.P. Sankaran	Asst. Admn. Officer (upto February 2009)

IISR Experimental Farm, Peruvanamuzhi

Scientific

Mr. P.A. Mathew	Principal Scientist (Horticulture)
Dr. Johnson K. George	Sr. Scientist (Gen. & Cytogenetics)
Dr. R. Dinesh	Sr. Scientist (Soil Science)
Dr. A. Ishwara Bhat	Sr. Scientist (Plant Pathology)
Ms. E. Jayashree	Scientist (Sr. Scale) (AS&PE) (on study leave)

Technical Officers

Mr. V.K. Aboobacker Koya	Farm Supdt. (T9)
Mr. N.A. Madhavan	Technical Officer (T5) (Farm)
Mr. K. Kumaran	Technical Officer (T5) (Farm)

Krishi Vigyan Kendra

Technical Officers

Mr. P.S. Manoj	(T7) (Hort.) (on study leave)
Dr. S. Shanmugavel	(T7-8) (Veterinary Science)
Mr. K.M. Prakash	(T7-8) (Agronomy)

IISR Cardamom Research Centre, Appangala

Scientific

1. Dr. M.N. Venugopal	Principal Scientist (Plant Pathology)
2. Dr. S.J. Ankegowda	Sr. Scientist (Plant Physiology)
3. Dr. R. Senthil Kumar	Sr. Scientist (Horticulture)
4. Dr. C.N. Biju	Scientist (Plant Pathology)

Administration

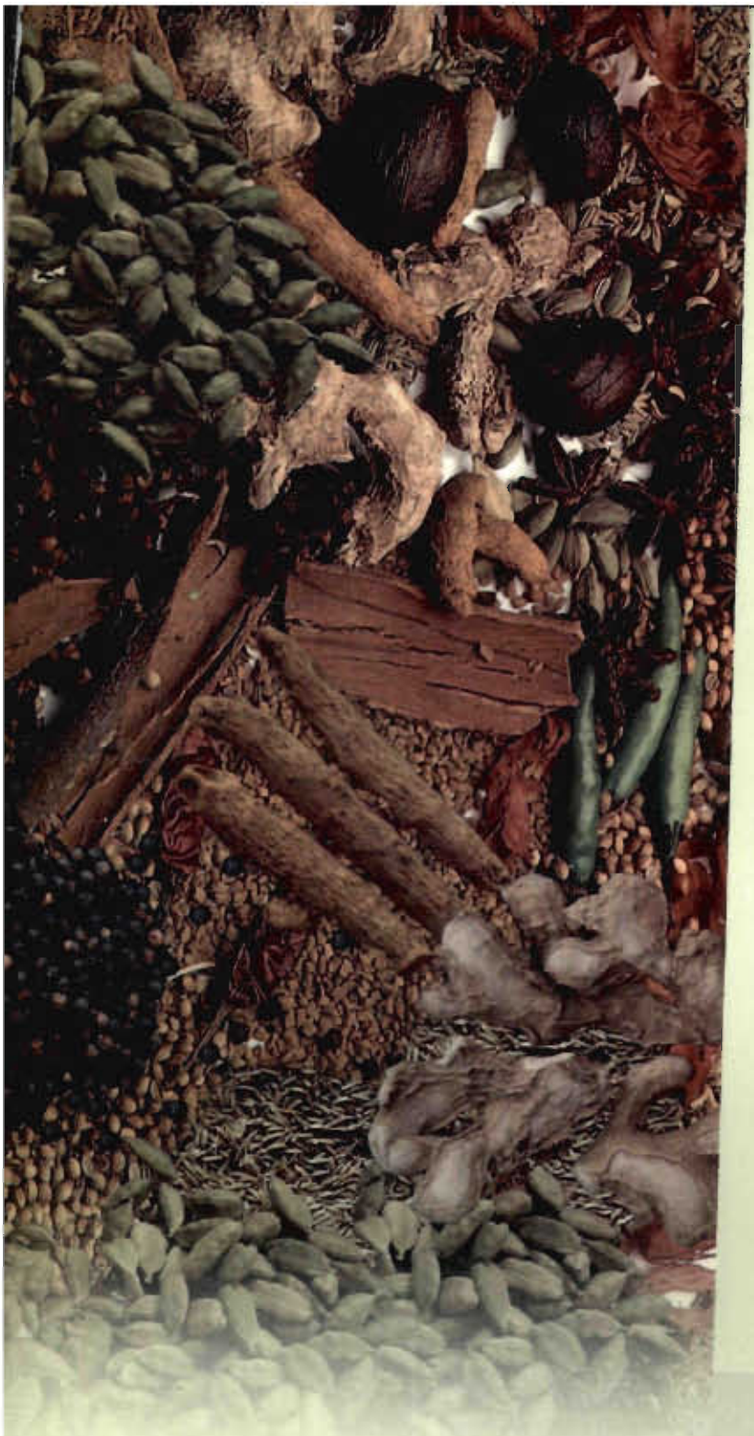
1. Mr. V. Vijayan	Asst. Admn. Officer (w.e.f. August 2008)

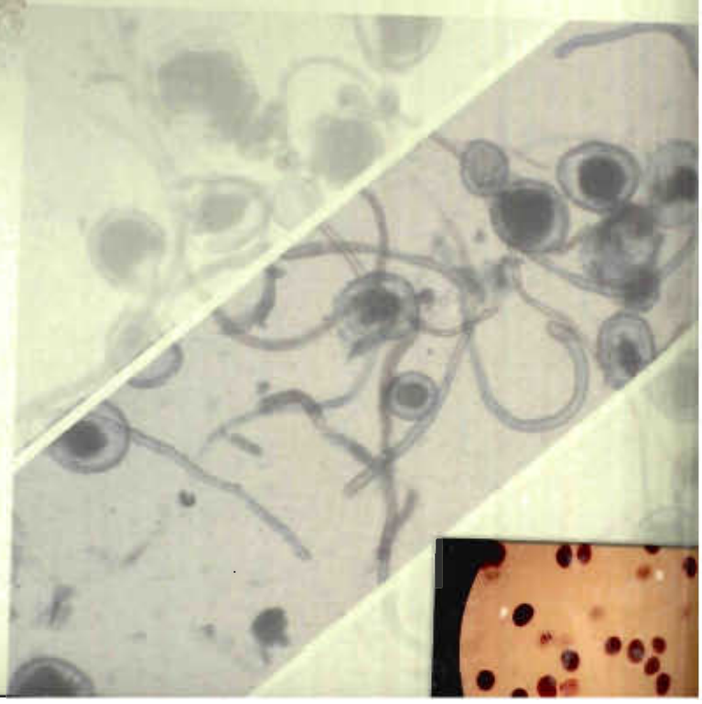
WEATHER DATA – 2008

IISR Experimental Farm, Peruvannamuzhi, Kerala				
Month	Temperature (°C)		Rainfall (mm)	Rainy days (no.)
	Maximum	Minimum		
January	31.7	18.3	0.0	-
February	34.1	21.0	11.8	1
March	33.3	21.4	232.4	10
April	33.7	23.0	13.9.0	12
May	32.7	23.3	212.2	12
June	28.8	23.0	891.4	28
July	28.7	22.9	769.2	27
August	28.9	22.8	533.6	21
September	30.7	22.6	414.8	14
October	31.7	22.4	481.6	14
November	33.1	21.4	53.4	3
December	33.1	20.5	38.4	3
Mean/ Total	31.7	21.9	3638.8	145

Cardamom Research Centre, Appangala, Madikeri, Karnataka				
Month	Temperature (°C)		Rainfall (mm)	Rainy days (no.)
	Maximum	Minimum		
January	29.3	10.0	0.0	-
February	29.4	12.0	9.8	2
March	29.7	13.4	229.0	8
April	31.0	16.9	14.6	2
May	29.0	16.7	6.2	1
June	25.4	16.0	558.6	26
July	25.2	15.9	506.6	22
August	23.7	17.5	530.2	20
September	26.1	16.9	166.2	10
October	28.2	17.6	171.8	9
November	28.6	14.9	0.0	-
December	28.5	14.4	0.0	-
Mean/ Total	27.8	15.2	2193.0	100

ANNUAL REPORT 2008 -09





iisr
Indian Institute of Spices Research
Post bag 1701, Marikunnu p. o.,
Calicut-673012, Kerala, India.
Phone: 0495-2731410, Fax: 0091-495-2731187,
E-mail: mail@spices.res.in, Web site: www.spices.res.in