वार्षिक रिपोर्ट
Annual Report
2009-10

भारतीय मसाला फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)
कालिकट - 673012 , **केरल, भारत**

Indian Institute of Spices Research
(Indian Council of Agricultural Research)
Calicut - 673012, Kerala, India

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2009 - 10

IISR Annual Report
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भारतीय मसाला फसल
अनुंसधान संस्थान
कालिकट

Indian Institute of
Spices Research
Calicut

भारतीय कृषि
अनुसंधान परिषद
नई दिल्ली

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Contents

प्रस्तावना

वार्षिक रिपोर्ट में वर्ष 2009 - 10 की उपलब्धियों का विवरण प्रस्तुत हैं। संस्थान ने सभी अधिदेश फसलों के जननद्रव्यों को बढाया तथा इलायची अनुसंधान केन्द्र, अप्पंगला और केन्द्रीय रोपण फसल अनुसंधान संस्थान, किडु में वन्य पाइपर स्पीसीसों का संरक्षण करने के लिए एक वैकल्पिक जननद्रव्य ब्लॉक को स्थापित किया। काली मिर्च के कल्टिवर्सों में पोलीमोर्फिसम का सफलतापूर्वक पता लगाने के लिए पाइपर स्पीसीस के लिए माइक्रोसैटेलाइट्स को विकसित किया। औषधीय पौधे जैसे वेटिवर और आलपीनिया की खेती काली मिर्च उत्पादन में अन्त: फसल के रूप में लाभदायक है। पौधशालाओं में काली मिर्च की विकसित प्रजातियों में पी सी आर विधि द्वारा विषाणु रहित रोपण सामग्रियों को चिन्हित करके उनको बहुगुणित किया जा रहा है। इलायची के दो आशाजनक अक्सेशनों (आई सी 547146 और आई सी 349630) को उनकी अधिक उपज तथा प्रति पौधा अधिक कैप्स्यूल के आधार पर भविष्य में मूल्यांकन के लिए अल्प सूचीबध किया।

कुरकुमा की 13 प्रजातियों की संकर उपजातियों में माइक्रोसैटलाइट मार्केर्स का अध्ययन किया गया। पाल जीन के आंशिक सीक्वन्स को निर्धारित किया। मृदा परीक्षण के आधार पर लक्षित पोषक तत्वों का प्रयोग करने पर अदरक की उपज बढी तथा जैविक खेती के लिए महिमा प्रजाति अधिक उपयुक्त है। अदरक राइज़ोस्फियर से कीटनाशक सूत्रकृमियों को पृथकीकरण किया। काली मिर्च, अदरक, हल्दी तथा दालचीनी के रसों में ओक्सीकरण रोधी क्षमता का अध्ययन किया गया तथा भण्डारण के उपरान्त उनकी क्षमता में कोई अन्तर नहीं दिखाई दिया। भण्डारण के पश्चात् करी पत्तियों के सुगन्धित तेलों के कीमो प्रोफाइलिंग में 'I-फिलान्ड्रेन की कमी के अतिरिक्त कोई प्रमुख अन्तर नहीं था। मसालों की औषधीयता पर इन सिलिको छानबीन के आधार पर फाइटोकेमिकल्स का अध्ययन किया गया।

काली मिर्च की वैज्ञानिक खेती के निर्धारित सापेक्षिक स्तर के अधिग्रहण का मूल्यांकन करने पर यह ज्ञात हुआ कि किसानों द्वारा अपनाई गई तकनीकियों की अपेक्षा अधिक लाभ एवं मूल्य प्राप्त हुआ। हमारे वैज्ञानिकों द्वारा करनाटक के कोडगु जिले में लगभग 16,000 हेक्टर में काली मिर्च की खेती में संस्थान द्वारा विकसित तकनीकियों का सफलतापूर्वक प्रदर्शन किया। कृषि विज्ञान केन्द्र एवं एटिक ने किसानों की आवश्यकताओं को समझकर 4000 से अधिक किसानों को प्रशिक्षण प्रदान किया। संस्थान द्वारा विकसित तकनीकियों को प्रदर्शित करने के लिए तकनीकी सप्ताह एवं मीडिया मीट आयोजित किया।

मेरा परम कर्तव्य है कि, मैं डा. एस. अय्यप्पन, महानिदेशक भारतीय कृषि अनुसंधान परिषद द्वारा दिये गये प्रोत्साहन एवं सहायता के लिये उनका धन्यवाद दूँ। परन्तु डा. एच. पी. सिंह, उप महानिदेशक (बागवानी) के अत्यधिक प्रोत्साहन एवं मार्गदर्शन के बिना हम यह अर्जित नहीं कर सकते थे। हम डा. उमेश श्रीवास्तवा सहायक महानिदेशक (बागवानी) को उनके द्वारा दी गयी सभी सहायताओं के प्रति अपनी कृतज्ञता प्रस्तुत करते है। मैं शोध सलाहकार समिति के अध्यक्ष एवं सदस्यों को शोध कार्यों को पुनर्गठित करने तथा उनके द्वारा दिये गये दिशा निर्देशों के लिये अपना आभार व्यक्त करता हूँ। हमारे कार्यक्रमों को अच्छी तरह चलाने के लिए संस्थान के वैज्ञानिकों एवं अन्य कर्मचारियों की सराहना करता हूँ। मैं वार्षिक रिपोर्ट का संकलन समय पर करने के लिये संपादकों की सराहना करता हूँ।

(वी. ए. पार्थसारथी)
निदेशक

कालिकट
दिनांक: 16.06.2010

PREFACE

The Annual report for the year 2009-10 presents the details of our achievements. The institute enriched its germplasm on all the mandate crops with an alternate germplasm block for conserving the wild *Piper* species established at CRC, Appangala and CPCRI, Kidu. Microsattelites developed for *Piper* species was successfully used to detect polymorphism in black pepper cultivars. PCR technique is being used to identify virus-free nucleus materials of all released varieties of black pepper for further multiplication in nurseries. Two promising cardamom accessions (IC547146 and IC349630) with high yield and more capsules per plant were shortlisted for further evaluation.

Cross species amplification studies of microsatellite markers were carried out in 13 *Curcuma* species. Partial sequence of *pal* gene was determined. Targeted application of nutrients based on soil test results increased yield in ginger and var. Mahima was more suitable for organic cultivation. Potential entamopathogenic nematodes were isolated from rhizosphere soils of ginger. Antioxidant potentials of black pepper, ginger, turmeric and cinnamon extracts were studied and no change in the activity potential was noticed on storage. Chemo-profiling of curry leaves essential oil showed no major changes except a decrease in l-phellandrene over storage. *In silico* screening on drugability of spices based phytochemicals was studied.

Impact assessment studies to assess the level of adoption of scientific cultivation practices in black pepper revealed an increased benefit: cost ratio realization with technology adoption by farmers. Our scientists have been able to successfully demonstrate technologies in black pepper in about 16,000 ha in Kodagu District of Karnataka. The KVK and ATIC conducted programmes to the farmers' need and trained more than 4000 beneficiaries. Technology week and Media meet were also conducted for showcasing the technologies developed by the institution.

I consider it a privilege to place on record the encouragement and support given by Dr. S. Ayyappan, 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. We are also grateful to Dr. Umesh Srivastava, ADG (Hort. II) for all the support given to us. I am equally thankful to the Chairman and members of Research Advisory Committee for their suggestions to reorient our research programmes. I appreciate the efforts taken by the staff of this Institute for their support in running our programmes. I appreciate the editors for having compiled and brought out this compilation.

V.A. Parthasarathy
Director

Calicut
Date: 16.06.2010

सारांश

काली मिर्च

आनुवंशिक संसाधन

काली मिर्च अक्सेशनों को एकत्रित करने के लिए इदुक्की जिला के तोडुपुषा, कोट्टयम जिला के पूनजार और वलमुक्कु तथा एरणकुलम जिला के पेरूमपावूर, मलयाट्टूर तथा कुन्नत्तुनाडु तालूक का सर्वेक्षण किया। कुन्नत्तुनाडु तालूक के वेट्टिलप्पारा और आतिरपल्ली से 105 अक्सेशनों को एकत्रित करके उचित पौध संरक्षण उपायों का उपयोग करने के बाद प्रायोगिक क्षेत्र, पेरूवन्नामुषि में रोपण किया। दीमापुर, नागालैंड से एक पाइपर स्पीसीस एकत्रित की। काली मिर्च जननद्रव्य संग्रहालय के पौधशाला और खेत जीन बैंक (वन्य पाइपर-1286, कल्टिवर्स -1300, विदेशी स्पीसीस-9) में 2595 अक्सेशनों को संरक्षित किया जा रहा है। इसके अतिरिक्त केन्द्रीय रोपण फसल अनुसंधान संस्थान, किडु में पहले से स्थापित जननद्रव्य में 100 से अधिक अन्य अक्सेशनों को सम्मिलित किया। वन्य पाइपर स्पीसीसों को संरक्षित करने के लिए एक वैकल्पिक जननद्रव्य ब्लॉक इलायची अनुसंधान केन्द्र, अप्पंगला में स्थापित किया तथा वन्य अक्सेशनों को रोपण करके इसकी संख्या समय समय पर बढायी जा रही है। उत्तर पूर्व क्षेत्रों से एकत्रित किये गये पहचान रहित पाइपर स्पीसीसों की केन्द्रीय राष्ट्रीय वनस्पतिशाला (बी एस आई), कोलकत्ता की सहायता से पहचान की गयी।

मूल सामग्री (रूट स्टॉक) अध्ययन

छान बीन अध्ययन की सहायता से यह ज्ञात हुआ कि, काली मिर्च की वन्य उपजाति, *पाइपर ओरनाटुम* द्रुत एवं मन्द म्लानी के कारकों *फाइटोफ्थोरा कैप्सीसी, रैडोफोलस सिमिलस* तथा *मेलोयिडोगाइन इनकोग्निटा* के प्रतिरोधक है। श्रीकरा प्रजाति की कलम को उप जाति की तरह रूट स्टॉक के रूप में प्रचलन किया। लेकिन वृद्धि कमज़ोर परन्तु समुच्चय प्रबल है। अत: अन्य पाइपर उपजातियां काली मिर्च के साथ प्रतिकूल है। जिसको यथासंभव अन्त स्टॉक को पी. ओरनाटुम को रूट स्टॉक के रूप में उपयोग करके परीक्षण किया। *पी. बीटल, पी. लोंगम, पी. एरगिरोफाइलम, पी. छाबा, पी.एटेन्युआटम* और *पी. कोलुब्रिनम* की वृद्धि सन्तोषजनक थी। परन्तु *पी. गलेटियम* की वृद्धि नहीं हुई।

कोर ई एस टी का विकास और जीन प्रतिरोपण; क्लोनिंगद्ध

तीन जीनों के लिये होमोलोगी की खोज प्रारंभ की तथा प्राइमर्स का रूपांकन किया। खेत में उगाये गये काली मिर्च के पौधों के एमआरएनए से विस्तारण के लिये प्रयुक्त विशिष्ट जीनों में बीटैन एलडिहाइड डीहाइड्रोजीनेस, ग्लूटाथियोन एस-ट्रान्सफेरेस और सुपर ओक्साइड डिस्मूटेस शामिल है। ट्रान्स्क्रिप्ट आधारित क्लोनिंग से जीन नियन्त्रण करने का प्रयत्न किया जिसके फलस्वरूप लगभग 100 बीपी के आकार का विस्तारण हुआ।

काली मिर्च में अन्त: फसल

अल्प आयु के काली मिर्च के बाग में औषधीय पौधों के साथ अन्त: फसल करने पर अधिकतम कुल लाभ काली मिर्च + *वेटिवेरिया ज़िज़ानियोयिड्स* से 46,225 रूपए प्रति हेक्टर तत्पश्चात् काली मिर्च + *अलपीनिया कलकराटा* (44,600 रूपए) के साथ लाभ: मूल्य अनुपात क्रमश: 2. 3 तथा 2.2 अंकित किया गया। पौधों की उंचाई 129.7 से 154.7 से. मीटर तथा अधिकतम उंचाई *अयप्पना ट्रिप्ली* के साथ अन्त: फसल में अंकित किया तथा अन्त: फसल के कारण पौधों की उंचाई में कोई कमी नहीं दिखाई पडी।

फलन के संबन्ध में पोषण एवं पादप हारमोन का स्तर

वैकल्पिक वर्षों में फलन होने वाले पौधों में पोषण और पादप हारमोन स्तर की मात्रा निर्धारण से पता चला कि तना और पत्तियों का पोषण स्तर फलन काल में फलन रहित कालों की अपेक्षा कम होता है। फलन काल में फलन रहित कालों की अपेक्षा कारबोहाइड्रेट से साइटोकाइनिन का अनुपात अधिक था।

भंडारण का गुणवत्ता पर प्रभाव

हैमर मिल तथा मैनुअल ग्राइन्डिंग द्वारा तैयार किये गये काली मिर्च के पाउडर के भंडारण के पांच महीने बाद तेल एवं ओलिओरेसिन की मात्रा में कमी अंकित की गयी। भूमि पर पडे रहने वाले नमूनों में अथाह कमी देखी गयी।

प्रत्येक नमूनों की औषधीय मान का एल्कहोल ऐक्स्ट्रेक्ट, जल ऐक्स्ट्रेक्ट और पेट्रोलियम ईथर ऐक्स्ट्रेक्ट का प्रयोग करके ओक्सीकरण रोधी गुणों का विश्लेषण किया। पांच महीने तक भण्डारित पाउडर के नमूनों में ओक्सीकरण रोध

ी गुणों में कोई अन्तर नहीं दिखायी दिया। परन्तु जी सी एम एस काली मिर्च के तेल संघटकों जैसे; पिनीन, माइरीसिन, लाइमोनिन और लिनालूल की मात्रा में महत्वपूर्ण अन्तर अंकित किया गया।

फाइटोफथोरा खुर गलन एवं मन्द पतन (स्लो डिक्लाइन) रोग

रसायनों का मूल्यांकन

पी. कैप्सीसी के प्रति तीन रसायनों, कैप्टन हेक्साकोनज़ोल, बेनज़ोइक एसिड और सैलीसाइक्लिक एसिड का इन विट्रो और इन विवो परीक्षण किया गया। उन में, 100 पी पी एम कैप्टन हेक्साकोनज़ोल और बेनज़ोइक एसिड तथा 200 पी पी एम सैलीसाइक्लिक एसिड में माइसीलियल वृद्धि में 100% प्रतिरोधकता प्राप्त हुई। इन्हीं रसायनों के साथ इन विवो परीक्षण करने पर क्रमश: 46.2%, 46.2% और 16. 4% रोग प्रतिरोधकता अंकित की गयी।

चार नये रसायनों, सेक्टिन (फेनामिडोन 10%+ मैनकोज़ेब 50%), इक्ओशन प्रो (फैमोसाडोन 16.6%+ साइमोक्सानिल 22.1%) कुरज़ेट एम 8 साइमोक्सानिल 8%+मैनकोजेब 64) और एक्रोबेट 50 (डिमेथोमोरफ 50%) को पी. कैप्सीसी के प्रति इन विट्रो मूल्यांकन किया गया। परीक्षण किये चारों रसायनों में, एक्रोबाट 50 पीपीएम में 100% प्रतिरोधकता दिखाई दी। सेक्टिन और इक्ओशन प्रो में क्रमश: 400 पीपीएम और > 500 पीपीएम में माइसिलियम की 100% प्रतिरोधकता अंकित की। अत यह कवकनाशी इन विवो परीक्षण के अधीन है।

फाइटोफथोरा वियुक्तियों की मेटालैक्सिल संवेदनशीलता मैनकोज़ेब के साथ मेटालैक्सिल-मैनकोज़ेब की विभिन्न सान्द्रताओं का तुलनात्मक अध्ययन किया। 5 पी पी एम मेटालेक्सिल-मैनकोजेब फाइटोफथोरा वियुक्तियों की वृद्धि में, जबकि 200 पीपीएम मैनकोज़ेब वृद्धि में शत प्रतिशत प्रतिरोधक होते है।

आशाजनक प्रतिद्वंदियों का मूल्यांकन

काली मिर्च से वियुक्त लगभग अस्सी अन्त: पादपी कवक वियुक्तियों कों *पी. कैप्सीसी* के प्रति इन विट्रो मूल्यांकन किया। चार वियुक्तियों (ईएफपी 11, 73, 81, और 83) को *पी. कैप्सीसी* की माइसीलियल वृद्धि में 80% से अधिक प्रतिरोधकता के साथ आशाजनक रूप में मिले। । पेरूवन्नामुषि के खेत में *पी. कैप्सीसी, आर. सिमिलिस* और *एम. इनकोग्निटा* के प्रति अन्त: पादपी जीवाणुओं (बी पी-35, 25, 17 और टी सी-10) और राइज़ोबैक्टीरिया (आई आई एस आर 853 और आई आई एस आर 6) का मूल्यांकन किया गया। वृद्धि पैरामीटर्स का निरीक्षण करने पर यह ज्ञात हुआ कि टी सी-10+ मेटालैक्सिल-मैनकोज़ेब और आई आई एस आर-853 + मेटालैक्सिल-मैनकोज़ेब से उपचारित करने पर बिना किसी रोग समस्या के पौधे की कैनोपी तथा उंचाई में वृद्धि हुई।

पौधशाला में एकीकृत प्रबन्धन

स्वस्थ एवं रोग रहित रोपण सामग्रियों के उत्पादन के लिये चार विभिन्न मृदा विसंक्रमण विधियों के साथ एकीकृत पादप संरक्षण रसायनों तथा जैवनियन्त्रण कारकों पर एक परीक्षण पौधशाला में आयोजित किया। रोग आपतन (संचारण परिस्थितियों की चुनौतियों के अन्तर्गत) पर निरीक्षण करने पर यह ज्ञात हुआ कि सभी मृदा विसंक्रमण विधियां एवं एकीकृत रसायनों जैसे कोप्पर ओक्सीक्लोराइड (0. 2%)+फोरेट और पोटेशियम फोस्फोनेट (0.3%) + फोरेट का छिडकाव करने पर फाइटोफथोरा संक्रमण में कमी आयी।

प्रतिरोधकता

आई आई एस आर शक्ति (04-पी 24-1) की खुली परागकण संतति को खेत में रोपण करने के चार साल बाद भी *पी. कैप्सीसी* के विरूद्ध प्रतिरोधकता देखी गई है। स्व परागकण संतति *पाइपर कोलुब्रिनम,* जो फाइटोफथोरा की प्रतिरोधक स्पीसीस है, फाइटोफथोरा प्रतिरोधकता के लिए पृथक्कृत किया।

आर. सिमिलस के संचारण से नमूनों में सिनामिक एसिड-4 - हाइड्रोलेस (सी 4 एच) और कफेयिक एसिड -ओ-मीथाइलट्रन्सफेरेस (सीओएमटी) की गतिविधियां सुग्राह्य काली मिर्च प्रजाति श्रीकरा में तत्पश्चात् प्रतिरोधक प्रजाति (एच पी 39) में बडी। श्रीकरा की अपेक्षा एच पी 39 में लिगनिन की मात्रा कम होती है। परन्तु एच पी 39 में आर. सिमिलस संचारण के एक महीने बाद नियन्त्रित मान दुगुना होता है।

वाइरस रहित मातृबेलों की स्थापना

काली मिर्च की विकसित प्रजातियों में पीसीआर विधियों द्वारा विषाणु रहित रोपण सामग्रियों को चिन्हित करके उनको पौधशाला में कीट रहित परिस्थिति में बहुगुणित किया जा रहा है।

काली मिर्च का रूपान्तरण

प्रत्येक की दो रचना को एग्रोबेक्टीरियम ई एच ए 105 में पाइपर येल्लो मोटाइल वाइरस (पी वाई एम ओ वी) और कुकुम्बर मोसाइक वाइरस (सी एम वी) को रूपान्तरण के लिये उपयोग किया। एग्रोबैक्टीरियम से संक्रमित भ्रूणीय मास को 48 घंटे के भीतर वेसल एस एच माध्यम में संबन्धित करते हैं। भ्रूणीय मास का उप संबन्धित चयनित मीडियम में रूपान्तरण करके अत्यधिक केनामाइसिन सहित प्रगतिशील अवस्थाओं को उस मीडिया से अलग करते है। प्रचुर मात्रा में उत्पन्न हुये भ्रूणीय मास को बाद में पौधों के पूर्ण विकास हेतू अतिरिक्त विकास के लिए बैसल एस एच की ओर स्थानांतरित किया जाता है। पूर्ण विकसित पौधों को डब्ल्यू पी एम में एक एक करके स्थानांतरित किया गया। पूर्ण विकसित पौधों के पत्तों से कुल जीनोमिक डी एन ए को पृथक्करण करके पी सी आर द्वारा पुष्टि की गयी। विषाणु चुनौती के अन्तर्गत ग्रीन हाउस निवेश में पी सी आर सुनिश्चित पौधे ज्यादा मज़बूत थे।

पोल्लू बीटल के प्रति जननद्रव्यों का विविक्तीकरण

पोल्लू बीटल (*लंका रामकृष्णई*) के प्रति एक सौ पचासी काली मिर्च अक्सेशनों को विविक्तीकरण किया। कल्टिवरों में, अक्सेशन 78 और 4044 वर्तमान वर्ष में पोल्लू बीटल के आक्रमण से मुक्त रहे। सबसे अधिक बेरी की हानि (36.5%), अक्सेशन 1484 में, तत्पश्चात् अक्से. 1611 (34.3%) में हुयी। संकरजों में अक्से. 1055, 1069, 1769 और 1752 पोल्लु बीटल की हानि से मुक्त रहे। अक्से. 1339 में 100% बेरी की हानि अंकित की गयी तत्पश्चात् अक्से. 807 (73.5%) में है।

इलायची

आनुवांशिक संसाधन

केरल के शबरिमलैई क्षेत्रों से पांच अक्सेशनों को एकत्रित करने के पश्चात् जननद्रव्य संरक्षणशाला में कुल 447 (मलबार 278, मैसोर 78, वाषुका 63 और अन्य 28) हो गये। पचास अक्सेशनों की आकृति का लक्षण वर्णन किया गया। अक्सेशनें, आई सी 547146 और आई सी 349630 को अधिक उपज एवं कैप्स्यूल की संख्या के लिये चिन्हित किया गया।

संकरजों का मूल्यांकन

पीईटी -I (19 संयोजन) और पी ई टी -II (10 संयोजनें) के एफ1 संकर संततियों का प्रारंभिक मूल्यांकन परीक्षण किया गया तथा दो अधिक उपज वाले संकरों को फिर से मूल्यांकन के लिए सूचीबध किया। संकरज जीजी x एन के ई -19 खुर गलन एवं पर्ण दाग के प्रति खेत में सहिष्णु तथा 70 प्रतिशत से अधिक पौधों में 8 मि. मी. आकार का कैप्स्यूल था। बहुस्थानीय परीक्षण के लिये संक्षिप्त सूचीबध में, एन एच वाई 10, एम ए 18 और एस ए एम दूसरों की अपेक्षा श्रेष्ठ थे।

कट्टे प्रतिरोधक जीनों से संबन्धित आणविक मार्कर्स की पहचान

दो पेरेन्ट्स जैसे ग्रीन गोल्ड (कट्टै सुग्राह्य) और एन के ई 12 (कट्टै प्रतिरोधक) से डी एन ए निकाला तथा आई एस एस आर प्राइमर्स (834 ए, 841 ए, 854 ए, 866, 867, 812 और 815) के सात सेटों के साथ पेरेन्टल पोलीमोरफिसम का अध्ययन पी सी आर द्वारा कियान्वित किया। दो प्राइमर्स (866, 815) ने पोलीमोरफिसम दर्शाया। पेरेन्ट जी जी के लिये प्राइमर 866 सुग्राही तथा पेरेन्ट एन के ई 12 के लिये प्राइमर 815 ने प्रतिरोधकता दिखायी।

सूखा सहिष्णुता

तीन जीनोटाइप आर आर 1 (आई सी 349591), सी एल 893 (आई सी 349537) ग्रीन गोल्ड (आई सी 349550) आर्द्रता सहिष्णु है तथा सीसीएस-1 (आई सी 349589) एक सुग्राह्य जीनोटाइप है उसको संकर करके अधिक उपज, उच्च गुणवत्तावाली तथा आर्द्रता सहिष्णु प्रजाति के विकास के लिये किया। सी एल-893 और उसका संकर संयोजन में उत्तम वृद्धि तथा अधिक उपज को अंकित किया। प्रत्येक गुच्छों में 20-37 तक तलशाखाओं की संख्या केप्स्यूल की औसत संख्या तथा 29 तक स्ट्रेस में क्रमबध 12.9-32.2 (औसत 20.7) है। प्रत्येक गुच्छे में पुष्पों की संख्या 20.6-37.4 तक और उसका औसत 28.5 तथा स्ट्रेस में 11.4-20.8 (औसत 16) है।

सुगन्धित तेलों की रूपरेखा

सुगन्धित तेल की मात्रा के लिए इलायची जननद्रव्य के बीस अक्सेशनों का मूल्यांकन किया गया। कैप्स्यूल में तेल की मात्रा शुष्क वज़न पर आधारित 3.5-6.7% और जीजी स्वयं में अधिकतम, तत्पश्चात् जीजी-ओ पी (6.0%)। तेल

की जीसी एम एस विश्लेषण से ज्ञात हुआ कि इन अक्सेशनों में क्रमश: 26.2% और 27.7%, 1,8 सिनोल और 45.8% और 46.2% á-टरपिनिल एसिटेट होता है।

जननद्रव्य का विविक्तीकरण

पर्ण दाग और राइसोम गलन के प्रति प्रतिरोधकता जानने के लिए खेतों में छोटी इलायची के अठतीस प्रजनन पंक्तियां एवं 20 संग्रहों का विविक्तीकरण किया गया। इनमें छ: जीनोटाइप ने राइसोम गलन के प्रति अधिक प्रतिरोधकता प्रकट की। छ: जीनोटाइप जैसे, आई सी 547222, आई सी 547223, आई सी 349645, आई सी 349649, आई सी 547158 और आई सी 349637 पर्ण दाग एवं राइसोम गलन के प्रति मध्यम प्रतिरोधक थे।

विषाणु रोगों की पहचान

करनाटक (5 वियुक्ति) एवं केरल (1वियुक्ति) से छ: कट्टे वियुक्तियों को संचित करके कीट रहित ग्लास हाउस में स्थापित किया। इम्यूनोसोरबन्ट एस्से (ई एल आई एस ए) से संबन्धित एनज़ाइम पर आधारित इलायची मोसाइक विषाणु का पता लगाने की विधि को मानकीकृत किया और एन्टीसीरम का टाइटर 1:250 था। इलायची से आर एन ए निकालने के लिये प्राइमर्स का प्रयोग करके रिवर्स ट्रान्स्क्रिप्शन पोलीमीरेस चयन रियेक्शन (आर टी पी सी आर) द्वारा सी डी एम वी को चिन्हित करने की प्रक्रिया के रूपांकन किया तथा प्रोटीन आवृत परिरक्षित क्षेत्रों के लिए मानकीकृत किया। करनाटक तथा केरल के विभिन्न भौगोलिक स्थानों से लिये गये इलायची के 50 खेत नमूनों में परीक्षण करके आर टी पी सी आर विधि को विधिमान्य मनाया।

करनाटक से दो कोक्के कन्दु वियुक्तियों तथा सूर्यनेल्ली (केरल, इदुक्की जिला) से नीलगिरी नेक्रोसिस रोग वियुक्ति को संचित करके कीट मुक्त ग्लास हाउस में स्थापित किया। करनाटक और केरल के प्रमुख इलायची उगाने वाले क्षेत्रों में सर्वेक्षण से यह ज्ञात हुआ कि सिरसी (जिला-उत्तर कन्नाडा, करनाटक), उप्पुतरा कोन्नतडी और वेल्लत्तूवल ग्राम (जिला-इदुक्की, केरल) में बनाना ब्राक्ट मोसाइक वाइरस (बी बी आर एम वी) की संक्रमिकता अधिक थी। इलायची के पौधों में बी बी आर एम वी के प्रमुख लक्षणों में निरन्तर अथवा अनिरन्तर छडी के आकार की उमरी हुई नाली। निरन्तर हल्का हरा अथवा हल्के पीले रंग की उभरी हुयी धारी तथा आभासी तना तथा पेटियोल में अनिरन्तर चित्ती।

हल्दी

आनुवंशिक संसाधन

खेत जननद्रव्य संरक्षणालय में, 1173 अक्सेशनों को अनुरक्षित किया जा रहा है। हल्दी (7 प्रजातियों) की नई प्रजातियों के प्रजनको के बीजों को बहुगुणित किया।

ओ पी बीज संततियां

हल्दी के 256 बीज संततियों तथा 23 मातृ पौधों का मूल्यांकन करने पर उपज में अधिक विविधता देखी गयी। उनतीस संततियों में 20 गुना बहुगुणन दर दिखाई दी। पांच बीज संततियों की 68 दूसरी पीढी की बीज संततियों में से कई संततियों ने बहुत अधिक गुणन दर प्रकट की।

स्व असंगति का अध्ययन

राजेन्द्र सोनिया के पैसठ फूल और बी एस आर - 2 के 100 से अधिक फूलों का स्व परागित करने पर भी कोई फल उत्पन्न नहीं हुआ। परागों की उपजाउपन का अभिरंजन विश्लेषण करने पर राजेन्द्र सोनिया में 60.4 % और बी एस आर - 2 में 55% उपजता देखी गई। परागण के 4 घंटे बाद भी स्टिग्मा पर अपर्याप्त इन विवो अंकुरण होता है। अत: इनं प्रजातियों में स्व असंगति कार्य प्रणाली प्रकिया संदिग्ध है।

माइक्रोसैटेलाइट मार्केर्स और चरित्रांकन

माइक्रोसैटेलाइट मार्केर्स की संकर स्पीसीस के प्रवर्धन के लिये 13 कुरकुमा स्पीसीसों का अध्ययन आरंभ किया। दो समान कुरकुमा स्पीसीस जैसे *सी. जीडेरिया* और *सी. मलबारिका* में 40 माइक्रोसैटेलाइट लोकी के लिये एस एस आर प्रोफाइल्स में समानता दिखाई दी।

पुष्पों की उपज तथा शुष्क प्राप्ति पर प्रभाव

हल्दी के पुष्प तथा पुष्प रहित पौधों में उनकी उपजता एवं शुष्क उपज की तुलना की। पुष्पित पौधों से औसतन उपज 504 ग्राम/पौधों तथा क्रमबध में 298 से 956 ग्राम/पौधों का अन्तर अंकित किया तथा सी वी 41.9 % है, वही पुष्परहित पौधों की औसतन उपज 524 ग्राम/पौधे तथा 321 से 861 ग्राम/पौधे क्रमबध विविधता अंकित की तथा सी वी 31.1% था। उसी प्रकार पौधों की औसत

शुष्क उपज 15.9% तथा क्रमबध विविधता 10.0 से 19.2% तथा 21.1% का सी वी; वहीं पुष्परहित पौधे में 17.5% जिसमें 12.7 से 19.8% क्रमबध विविधता अंकित की गई तथा 17.2 % सी वी था। टी टेस्ट के आंकडों के आधार पर पुष्पित तथा पुष्प रहित पौधों की उपज तथा शुष्क उपज में कोई अन्तर नहीं था।

पाल जीन का क्लोनिंग

पाल जीन विशिष्ट प्राइमर्स का उपयोग करके पी सी आर अवस्थाओं के उपयोग करके सार्वजनिक कार्य क्षेत्रों में उपलब्ध अनुक्रमों के आधार पर रूपांकित किया।

प्रकन्द गलन के प्रति रासायनिकों का मूल्यांकन

प्रकन्द गलन रोग के प्रबन्धन के लिए कोप्पर ओक्सीक्लोराइड 0.25%, काजू यौगिक पदार्थ 0.3%, बोर्डियो मिश्रण 1%, मेटालेक्सिल + मैनकोज़ेब 0.125%, मैनकोज़ेब 0.3%, पोटेशियम फोस्फोनेट 0.3%, कारबेन्डाज़िम + मैनकोज़ेब 0.3%, कैप्टान + हेक्सोकोनाजोल 0.3% और कारबेन्डाज़िम 0.5% तथा जैव नियन्त्रण कारकों (सी एल टी 102 और सी एल टी 110) की क्षमताओं का मूल्यांकन करने के लिये सेट्टिपुत्तूर (कोयंबतोर जिला) में खेत परीक्षण करने पर यह ज्ञात हुआ कि मेटालेक्सिल-मैनकोज़ेब 0.125% सी एल टी 110 की अपेक्षकृत मेटालेक्सिल-मैनकोज़ेब 0. 125% या सी एल टी 110 से उपचार करने पर क्रमश: 69.7% तथा 69.1% रोगों की कमी अंकित की गयी। एकल उपचार करने पर 13.4% तथा संयुक्त उपचार करने पर 12%उपज प्राप्त हुई।

प्ररोह बेधक की बायोनोमिक्स एवं उसका प्रबन्धन

प्ररोह बेधक, कोनोगीथस पंक्टिफेरालिस के जीवन चक्र का पांच मध्यम प्रतिरोधक तथा पांच सुग्राही अक्सेशनों पर अध ययन किया गया। मध्यम प्रतिरोधक अक्सेशनों पर औसत वयस्क काल, प्यूपल अवधि तथा पांचवीं इन्स्टार लार्वे की आयु अवधि काल क्रमश: 2.9, 12.4 तथा 7.5 दिन तथा सुग्राही अक्सेशनों पर यह क्रमश: 2.8, 15.7 तथा 7.8 दिन थे। यद्यपि यह अन्तर संख्यिकी की दृष्टि से अर्थपूर्ण नहीं थे। परीक्षणों से यह ज्ञात हुआ कि विभिन्न कीटनाशियों, लैमडा साइहेलोथ्रिन 0.0125% प्ररोहों में आक्रमण करने वाले प्ररोह बेधक की प्रतिशतता में कमी लाने में अधिक प्रभावशाली है।

अदरक

आनुवांशिक संसाधनें

खेत जननद्रव्य संग्रहालय में अदरक के छ: सौ अक्सेशनों का अनुरक्षण किया जा रहा है। अदरक की विमोचित प्रजातियों (तीन प्रजातियों) के बीजों को बहुगुणित किया गया। अदरक में चावल के माइक्रोसैटेलाइट्स के संकर विशिष्ट का प्रवर्धन सफल रूप से किया गया। तीन प्राइमर्स के परीक्षण करने पर अधिक प्रवर्धन उत्पाद मिला।

अधिक तेल वाली जाति तथा विदेशी संग्रहों की उपज का मूल्यांकन

तेरह जीन प्रकारों में जैवरसायनिक के मापदण्डों का विश्लेषण करने पर तेल की मात्रा में 1.2 से 2.8 % की विविधता थी। अक्सेशन 162 में अधिकतम तत्पश्चात् अक्सेशन 95 में तेल मात्रा अंकित की गई, जबकि ओलिओरेसिन की मात्रा में 2.0 से 4.6% का तथा फाइबर की मात्रा में 1.87 से 5.13 प्रतिशत का अन्तर था। बारह विदेशी (नेपाल) प्रकारों में तेल की मात्राओं में 1.2 से 2. 4%, ओलिओरसिन में 3.3 से 4.8% तथा फाइबर की मात्राओं में 2.50 से 5.11% अन्तर था।

कम फाइबर वाले प्रकारों की उपज का मूल्यांकन

अदरक की आठ अक्सेशनों को उनके जैवरासायनिक मापदण्डों के लिये मूल्यांकन किया। इन अक्सेशनों में तेल की मात्राओं में 1.2 से 2.0% जबकि ओलिओरसिन में 1.8 से 3.6% अन्तर था। फाइबर की मात्राओं में 3.54 से 5. 15% की विविधता एवं सबसे न्यूनतम मात्रा अक्सेशन 239 में तत्पश्चात् अक्सेशन 91 (4.0%) में थी।

अधिक पराग युक्त पोलीप्लोयिडी संग्रह

गत वर्ष चिन्हित किये अदरक के संग्रह संख्या 195 में गुणसूत्रों की संख्या अधिक पराग उर्वरतायुक्त प्रकार को जड के अग्र भाग पर माइटोटिक मेटाफेस प्लेट से सत्यापित किया गया। माइटोटिक मेटाफेस प्लेट के विश्लेषण से ज्ञात हुआ कि यह पौधा एक टेट्राप्लोयिड है जो कि 2n=44 अधिकांश कोषों में है। कुछ कोषों में गुणसूत्रों की विविधता का अवलोकन किया गया।

लक्षित उपज के लिये पोषक तत्वों की आवश्यकतायें

अदरक में लक्षित उपज प्राप्त करने के लिये प्रारंभिक उर्वरता स्तर के आधार पर नाइट्रोजन, फोस्फोरस, पोटैशियम

25, 35 तथा 45 कि. ग्राम/6 मी.^{2} बेड की मात्राओं को अप्पंगला में रयो डि जनीरो में 3-5 भागों में डाला। निरीक्षण करने पर 21.7, 28.2 और 35.8 कि. ग्राम/6 मीटर^2 बेड उपज प्राप्त हई जो क्रमश: लक्षित 25, 35 और 45 कि. ग्राम से कम थी। अधिकतम उपज 35.8 कि.ग्राम/बेड लक्षित उपज 45 कि. ग्राम/बेड थी जबकि लक्षित स्तर के 25, 35 और 45 कि. ग्राम के स्थान पर विचलन मध्यमान में औसतन क्रमश: -13, -19 और -20 का अन्तर था।

मृदा की गुणवत्ता और उपज पर जैव प्रबन्धन

परम्परागत, एकीकृत तथा जैविक जैसी विभिन्न प्रबन्धन प्रणालियों के अन्तर्गत नाइट्रोजन तथा पोटैशियम की अधिक उपलब्धता एकीकृत तथा जैविक प्रणाली में थी। जैविक प्रणाली में कैल्शियम तथा मैग्नीशियम की उपलब्धता अधिक थी। रसायनिक उर्वरक माइक्रोबियल बयोमास-एन, यूरिस सक्रियता तथा मेटाबोलिक अनुपात सार्थक ढंग से बढा है। जबकि जैविक खाद में बायोमास-सी,-पी, मृदा श्वसन डिहाइड्रोजनेस, एसिड फोस्फाटेस, ß-ग्लूकोसाइडेस की गतिविधियां अधिक थी। इससे यह ज्ञात होता है कि उपचारों में सूक्ष्मजीव, जेविक-सी तथा पोषक के कारण सूक्ष्म पारिस्थितिक तन्त्र बदलने से यह मापदण्ड पोषक प्रबन्धन को प्रभावित करते हैं।

जैविक प्रणाली के अन्तर्गत औसतन उपज 8.1 कि. ग्राम/3मीटर ^{2} जो अन्य प्रबन्धन प्रणालियों (7.4-7.7 कि. ग्राम/बेड) के बहुत करीब थी। जैविक प्रबन्धन के अन्तर्गत महिमा प्रजातियों में अधिक उपज (9.5 कि. ग्राम/बेड) तथा रजता में पारम्परिक विधि में करीब करीब उपज थी। वरदा प्रजाति को एकीकृत विधि द्वारा (7.4 कि. ग्राम/बेड) तत्पश्चात् परम्परागत तथा जैविक प्रणाली द्वारा अधिकतम उपज अंकित की गयी।

प्रकन्द गलन के प्रति राइज़ोबैक्टीरियल विकृतियों का मूल्यांकन

आशाजनक राइज़ोबैक्टीरियल वियुक्तियों को *रालस्टोनिया सोलानसीरम* तथा *पाइथीयम अफानिडेरमाटम* के प्रति उनकी जैव नियन्त्रण क्षमताओं एवं वृद्धि का मूल्यांकन ग्रीन हाउस में किया गया। जी आर बी 35 और जी आर बी 36 वियुक्तियों *आर. सोलानसीरम* के प्रति अधिकतम रोग दमन क्षमता प्रकट की तत्पश्चात् जी आर बी 70 और जी आर बी 91 में है। जी आर बी 35 और जी आर बी 91 तत्पश्चात् जी आर बी 68 *पी. अफानिडेरमाटम* के प्रति अधिकतम रोग दमन क्षमता है। राइज़ोबैक्टीरिया को खेत में भी मूल्यांकन करने पर, जी आर बी 68 वियुक्ति तत्पश्चात् जी आर बी 35 और जी आर बी 70 में अच्छा अंकुरण तथा रोग दमन क्षमता थी।

राइज़ोबैक्टीरिया द्वारा प्रभावित मृदा जैवरसायनिक एवं जीवाणु सूचियों का मूल्यांकन एक पोट कल्चर परीक्षण में किया गया। जी आर बी 25, जी आर बी 36, जी आर बी 38 और जी आर बी 70 वियुक्तियों द्वारा एकल उपचारित करने पर सूक्ष्मजीवों की गतिविधियों में कोई महत्वपूर्ण प्रभाव नहीं दिखाई दिया, परन्तु 75% नाईट्रोजन + 100% फोस्फोरस + 100% कैल्शियम के संयोग के साथ उपचारित करने पर सूक्ष्मजीवी बयोमास सी का मान अधिक था। जी आर बी 36 और जी आर बी 38 वियुक्तियों को 75% नाईट्रोजन+100% फोस्फोरस + 100% कैल्शियम के साथ उपचार करने पर यूरिस, एसिड फोसफाटेस, एल्कलिन फोस्फाटेस और डीहाइड्रोजीनेस की गतिविधियां बढ गयी।

प्ररोह बेधक का बायोनोमिक्स एवं उसका प्रबन्धन

प्ररोह बेधक, *कोनोगीथस पंक्टिफेरालिस* के जीवन चक्र का पांच मध्यम खेत प्रतिरोधक तथा पांच सुग्राह्यक अक्सेशनों में अध्ययन किया गया। सुग्राह्यक प्रतिरोधक अक्सेशनों पर औसतन वयस्क की आयु काल, प्यूपल अवधि तथा पांचवीं इन्स्टार लार्वे की आयु अवधि क्रमश: 2.9, 12.3 तथा 6.4 दिन थी तथा सुग्राह्यक अक्सेशनों पर यह क्रमश: 3.0, 11. 3 तथा 6.8 दिन थीं। विभिन्न कीटनाशियों में लैमडा सिहालोथ्रिन 0.0125% प्ररोहों में आक्रमण करने वाले प्ररोह बेधक की प्रतिशतता में कमी लाने में बहुत प्रभावशाली था।

कीटनाशक सूत्रकृमि

जिला वयनाडु, कोट्टयम, इदुक्कि (केरल), कोडगु (करनाटक), गुआहटी (असम) तथा बारापानी (मेघालया) के विभिन्न स्थानों से बासठ मृदा नमूनों का एकत्रित करके *गेल्लेरिया मेल्लोनिल्ला* लार्वे का उपयोग करके कीटनाशी सूत्रकृमियों को पृथकीकरण किया। इन मृदा नमूनों से कुल छ: कीटनाशी सूत्रकृमियों को पृथक किया। कोषिक्कोड, वयनाडु और कोडगु जिलों के विभिन्न स्थानों से चार सौ चौबीस प्ररोह बेधक लार्वों का एकत्रित करके उनमें से आठ रहैबडाइटिस तथा एक कीटनाशी सूत्रकृमियों के रूप में चिन्हित किया गया।

जायफल

ओरथोट्रोपिक प्ररोहों में प्लेगियोट्रोपिक कलम का आरंभ

जायफल के ओरथोट्रोपिक और प्लेगियोट्रोपिक प्ररोहों की पत्तियों तथा कलियों में ओक्सिन एवं साइटोकाइनिन का अध्ययन करने पर यह निष्कर्ष निकाला कि प्लेगियोट्रोपिक प्ररोहों की एक्सीलेरी कलियों में ओक्सिन की मात्रा अधिक होती है, जबकि ओरथोट्रोपिक प्ररोहो टरमिनल कलिकाओं में ओक्सिन की मात्रा अधिक थी। कलियों की अपेक्षा ओरथोट्रोपिक और प्लेगियोट्रोपिक प्ररोहों की पत्तियों में साइटोकाइनिन अधिक था।

गुणवत्ता

जावित्री के बीस अक्सेशनों को तेल की मात्राओं के लिये विश्लेषण किया गया। अक्सेशन आई सी -548917 में तेल की अधिकतम मात्रा (33%) तत्पश्चात् आई सी- 548922 एवं आई सी-548932 (30%) में अंकित की गयी।

कैसिया

पेरूवन्नामुषि में श्रेष्ठ प्रकारों के प्रतिरूपण का मूल्यांकन करने पर डी1 (आई सी 370423) में अधिक उंचाई (320. 6 से. मीटर) तथा शुष्क छाल की उपज (92 ग्राम) अंकित की गयी। इलायची अनुसंधान केन्द्र, अप्पंगला में परीक्षण किये 15 कैसिया प्रकारों में सी 1 (आई सी 370415) की अधिक उंचाई (545 से. मीटर) अंकित की जबकि इन्हीं प्रकारों में शाखाओं की संख्या, घेरे, पत्तों की लंबाई और चौडाई में कोई महत्वपूर्ण अन्तर नहीं था। आई सी 370406 में अधिकतम फ्रेश (1290 ग्राम/वृक्ष) और शुष्क (405.3 ग्राम/वृक्ष), तत्पश्चात् आई सी 370425 एवं आई सी 370427 में अंकित की गयी। अधिकतम शुष्क प्रति लाभ (56.25%) अप्पंगला के प्रथम गुल्म में आई सी 370401 में अंकित की गयी। आई सी 370410, 370423 और 370425 में अधिकतम तेल की मात्रा (4%) अंकित की गयी। आई सी 370415 में 21.57% ओलिओरसिन अंकित किया गया।

दालचीनी

दालचीनी की छाल को नवंबर में निकाल कर उसमें से तेल एवं ओलिओरसिन निकालने के लिए हेमर मिल में चूर्ण बनाते हैं। हेमर मिल से बनाये चूर्ण के नमूनों को तीन परत वाले पोलियस्टर के आवरण में भूमि में भण्डारण करते है। इन्हीं नमूनों में मासिक अन्तराल में तेल, ओलिओरसिन एवं प्रतिरोधक क्षमता के लिये विश्लेषण किया। भण्डारण के कारण तेल की मात्रा में आंशिक कमी के सिवाय अन्य किसी प्रतिरोधक गतिविधियों में परिवर्तन नहीं था।

गार्सीनिया

विविधताओं का अन्वेषण

डी आई वी ए भूगोलिक सूचना प्रणाली के बायो किलय मोडल की सहायता से उत्तर पूर्व हिमालयी राज्यों में गार्सीनिया के अस्तित्व को पूर्वानुमानित किया। गार्सीनिया की चार जातियों जैसे, *जी. काइडिया* (कुजि टीकेरा), *जी. लेनसिफोलिया* (रूपोही तेकेरा), *जी. पेडुनकुलाटा* (बोर थीकेरा) और *जी. क्सान्तोकाइमस* (तेपर टेंगा) मेघालया और असम में स्थित थी।

प्राकृतिक खाद्य रंग एवं रंजक

जी. गुम्मि गुट्टा, जी. होमब्रोनियाना, जी. इंडिका और *जी. टिनक्टोरिया* के फल या छिलके को एकत्रित किया तथा रंग निकालने के लिये उपयोग किया। करोटिनोयिड्स यौगिको की मात्रा *जी. गुम्मि गट्टा* में 0.013 *जी. टिंक्टोरिया* से 0.065 मि.ग्राम/100 ग्राम तथा अन्तोसियानिन योगिकों की मात्रा *जी. होम्ब्रोनियाना* में 0.007 तथा *जी. इंडिका* में 0. 053 मि.ग्राम/100 ग्राम हैं। लाइकोपिने की मात्रा *जी. टिंक्टोरिया* में 3.72 और *जी. इंन्डिका* में 4.95 मि. ग्राम/100 ग्राम का अन्तर है।

वैनिला

वी. प्लानिफोलिया और *वी. तहिटेनसिस* (खुर गलन रोग के लिये प्रतिरोधक) के बीच पारस्परिक संकरण आयोजित किया । दोनों संकरणों में फलों की संख्या अधिक थी। *वी. तहिटेनसिस* की पचपन स्वपरागित संततियों तथा *वी. प्लानिफोलिया* x *वी. तहिटेनसिस* की साठ संततियों को इन विट्रो में स्थापित किया।

मसाले

ओक्सीकरण रोधी गतिविधियां

करी पत्तियों में, नवीनतम नमूनों के अपेक्षाकृत तीन महीने पुराने नमूनों में सुगन्धित तेल के डी पी पी एच भूगोलिक, सामार्जक गतिविधियां आधी रह जाती है जबकि अगले तीन महीने में 50% और कम हो जाती है। जल तथा इथनोल

सार इस काल के दौरान स्थिर रहते है। फ्रेश नमूनों की तुलना में छ: महीने बाद निकाले गये नमूनों में फोस्फोमोलिब्डियम विधि या एफ ई (III) से एफ ई (II) ओक्सीरोधी क्षमताओं को कम करते है तथा इनमें कोई सार्थक भिन्नता नहीं थी। करी पत्तियों के सुगन्धित तेल की कीमो प्रोफाइलिंग में सार निकालने के तीसरे महीने बाद आई फिलानड्रेन में 50% कमी के अतिरिक्त कोई अन्तर नहीं दिखाई दिया।

आउट रीच कार्यक्रम

फाइटोफ्थूरा

फाइटोफ्थोरा की 241 वियुक्तियों को पुनरूत्थान करके संग्रहालय में अनुरक्षण किया तथा केरल के विभिन्न भागों तथा करनाटक के कूरग जिले से 43 नये फाइटोफ्थोरा वियुक्तियों को एकत्रित करके संग्रहालय में जमा किया तथा इन की कुल संख्या 284 हो गयी है। पृथक पर्ण संचारण विधि द्वारा फाइटोफथोरा की सौ वियुक्तियों का अनिष्टकरण का इन विट्रो परीक्षण किया तथा इन वियुक्तियों को तीन समूहों में रखा जैसे अधिक उग्रता, उग्रता और कम उग्रता।

126 काली मिर्च से फाइटोफथोरा वियुक्तियों के जीनोमिक डी एन ए को वियुक्त किया तथा एक प्राइमर जोडी GTCTGCGC TGTCGG AACT (113F)/ TRATGATGCGGTTCA TCTCG(114 R) के साथ एस एस आर प्रोफाइलिंग किया गया। आर. सिमिलिस के आई टी एस क्षेत्र का विश्वव्यापी प्राइमर्स के साथ प्रवर्धन किया। *पी. कापसीसी* और *आर. सिमिलिस* को चिन्हित करने तथा उनकी संख्या बताने के लिये जाति विशेषज्ञ मार्केस को रूपांकित तथा नियोजित किया।

एन सी बी आई के डीबीईएसटी से उपलब्ध फाइटोफथोरा कैप्सीसी के ईएसटीयों (56, 457) को डाउनलोड किया, साफ किया और 5966 कोंटिग्स का प्रयोग करके सीएपी3 कार्यक्रम में स्थापित किया। इन्हीं कोंटिग्स के प्रयोजन मूलक व्याख्या से प्रकट होता है कि प्रदर्शित ईएसटीयों के 84.73% जीन बैंक में मौजूद आवृत्तियों के साथ समानता रखते है। लगभग 3.57% (213) ईएसटीयां अज्ञात कार्यों के परिकल्पित प्रोटीन के लिए नियत किया जबकि 699 (11.7%) को "नो हिट"थे। *पी. कैप्सीसी* के ईएसटी आवृत्तियों में लगभग 223 माइक्रोसैटेलाइट का पता लगाया और उनके लिए प्राइमर्स का रूपांकन किया गया। *पी. कैप्सीसी* जीनोमिक डीएनए से एक 250 बीपी खण्ड को प्रवर्धित किया।

फाइटोवेब

मौजूदा फाइदिश को परिवर्तन करके फाइटोवेब, भारत में बागवानी फसलों के फाइटोफथोरा रोग पर एक विस्तृत पोर्टल विकसित किया। फाइटोलिब, फाइटोफथोरा पर शोध प्रकाशनों के इलेक्ट्रोनिक डेटाबेस को भी विकसित किया गया तथा इस पोर्टल द्वारा प्रक्षेपित किया।

पर्ण दाग रोग

पर्ण दाग रोग के नमूनों को एकत्रित करने के लिये करनाटक, केरल तथा तमिलनाडु में सर्वेक्षण किया। इलायची, काली मिर्च, सुपारी, हल्दी, अदरक, मिर्च तथा लौंग के 150 नमूनों में से 100 कोलेटोट्राइकम स्पीसीस से संक्रमित थे। इन समूहों की कोलोनी तथा कोनिडियल आकृति विज्ञान के आधार पर पहचान की गयी। इन कल्चर को बाद में शुद्ध किया तथा आगे के अध्ययन' के लिये इनका अनुरक्षण किया तथा इन्हीं कलचर्सों का कोलोनी चरित्रांकन तथा कोनिडियल और अप्रेस्सोरियल आकृति विज्ञान के आधार पर भी चरित्रांकित किया गया।

जैवसूचनायें

इन सिलिको अनुसंधान

ईएसटी संयोजन तथा दो कीटनाशी सूत्रकृमियों, *स्टरनिमा फैलटियाई* (83), तथा *हेटेरोरेहाइब्डिटिस बैक्टीरियोफोरा* (53614), की व्याख्या की। *रैडोफोलास सिमिलिस* तथा अन्य सूत्रकृमियों की सिनटेनिक संबन्ध का अध्ययन माइटोकोन्ड्रियल जीनोम अनुक्रम द्वारा किया गया।

फाइटोकेमिकल्स की वास्तविक छानबीन डा. ड्यूक फाइटोकेमिकल तथा एथनोबोटानिकल डेटाबेस, साहित्य खोज, पी ए एस एस भविष्यकथन तथा ए डी एम ई/टोक्स छान बीन से 56 आशाजनक प्रभावी योगिकों को संभावित नेमटिसइडल क्षमता के साथ पहचान किया। अनुनेय डोकिंग अध्ययन से ज्ञात होता है कि यह छ: फाइटोकेमिकल्स-कुरकुमिन, ब्रूसिन-एन ओक्साइड, कोलुब्रिन, ब्रूसिन, वैनिलिन, जीनोस्टाइकनिन तथा स्ट्राइकनाइन को अच्छे बाइन्डिंग स्कोर (एमओएलडोक स्कोर) होते है तथा ब्रूगिया मलायि के हाइड्रोजेन बोन्ड परस्पर अनुकूल संबन्ध के साथ ग्लूटाथियोन एस. ट्रोन्सफेरेस (जी एस टी) देख ली। अत:

इन फाइटोकेमिकल्स को बी. मलायी द्वारा होने वाले फाइलारियासिस उपचार के लिए आशाजनक प्रभावी यौगिकों से उपचारित कर सकते हैं। इन विट्रो एस्से यह पुष्टि करता है कि फाइटोकेमिकल्स कानिन डिरोफिलारिया इम्मिटिस के प्रति उच्च प्रतिरोधक क्षमतावान है और जी एस टी लिनालूल, अल्फा पिनेने, स्ट्रिकनिन, एन वी ए, वानिकल्लन, पाइपरिन, आइसोयूजिनोल, कुरकुमिन, बीटा कारियोफिलिन, सिनामिक एसिड, काप्साइसिन, सिट्रोनेल्लोल तथ जेरानियोल अवरोही क्रम में होते हैं।

नये डेटाबेस

एक नया डेटा बेस, जीएसटी नेतृत्व बेस (www.spicebioinfo.res.in/gstleadbase) को विकसित करके परिचारक किया। इस डेटाबेस में रसायनिक वस्तुयें तथा संभावित नेमाटीसाइडल यौगिकों के अन्य विवरण शामिल है जो सूत्रकृमियों में ग्लूटाथियोन- एस- ट्रान्सफेरेस को बाधा पहुंचाते हैं।

सूचना प्रौद्योगिकी

- स्पाइस स्टेट, मसालों की खेती, उत्पादन तथा निर्यात से संबन्धित सांख्यिकी पर डेटाबेस को अधिक विशेषताओं के साथ पुन: प्रारंभ किया।
- एक नये लेखा भाग को विकसित करके मौजूदा ओफीस ओटेमेशन सोफटवेयर एरिसोफट में सम्मिलित किया।
- अदरक एवं हल्दी के पैकेज ओफ प्राक्टीसस पर एक प्रभावी सीडी को विकसित किया।
- भारतीय कृषि अनुसंधान परिषद के मार्ग निर्देशों के अनुसार जूमला, सी एम एस सोफटवेयर का प्रयोग करके आई आई एस आर वेबसाइट आधुनिकरण के लिये निर्माणाधीन है।

विस्तार

गत वर्ष 1111 किसानों (241 कालिकट जिले से, 157 राज्य के अन्य भागों तथा 713 अन्य राज्यों से) ने एटिक तथा 1275 किसानों ने प्रायोगिक क्षेत्र, पेरूवन्नामुषि का भ्रमण किया। लगभग 1050 छात्रों ने संस्थान का भ्रमण किया। संस्थान ने केरल स्टेट बागवानी मिशन द्वारा प्रायोजित एक कैंपस प्रशिक्षण कार्यक्रम राज्य विभाग के विस्तार कार्मिकों के लिये आयोजित किया। एम एस स्वामिनाथन रिसर्च फाउन्डेशन, वयनाडु द्वारा प्रायोजित काली मिर्च पर आफ कैंपस दो प्रशिक्षण कार्यक्रम वयनाडु जिले में आयोजित किये। संस्थान ने केरल सरकार के जनश्री मिशन के अन्तर्गत एक कार्षिक संगोष्ठी, राष्ट्रीय स्तर पर पांच तथा क्षेत्रीय स्तर पर चार प्रदर्शनियां/किसान मेलाओं में भाग लिया। वयनाडु जिला में ग्रामीण संसाधन स्रोत के साथ सात वीडियो सम्मेलन सत्र आयोजित किये जिनमें 389 किसानों ने भाग लिया।

एन ए आई पी परियोजना के अन्तर्गत मोबेलाइसिंग मास मीडिया सपोर्ट फोर शयरिंग एग्रो इनफेरमेशन के लिए एक मीडिया मीट 9 नवंबर 2009 को आयोजित किया। लगभग बीस मीडिया संगठनों के तीस से अधिक मीडिया कर्मिकों ने भाग लिये। बीस से अधिक सूचनायें विभिन्न मीडिया में प्रकाशित हुई। एक श्रव्य कार्यक्रम आकाशवाणी, कालिकट में तथा चैनलों में वार्तायें प्रदशित हुई।

प्रशिक्षण कार्यक्रम

कृषि विज्ञान केन्द्र ने गत वर्ष 73 प्रशिक्षण कार्यक्रम आयोजित किये जिनमें 3024 प्रशिक्षार्थी लाभान्वित हुये। रिपोर्टाधीन काल में लगभग 400 किसानों को परामर्श सेवायें, रोपण सामग्रियों को खरीदने तथा अन्य आवश्यकताओं के लिये कृषि विज्ञान केन्द्र में आये। इस अवधि में किसानों के लिये तीन अध्ययनार्थ दौरा आयोजित किये जिनमें 96 किसान लाभान्वित हुये। आठ महत्वपूर्ण प्रदर्शनियां तथा चार खेती गत परीक्षण प्रारंभ किये।

तकनीकी सप्ताह/किसान मेला

भारतीय मसाला फसल अनुसंधान संस्थान, कालिकट, कृषि विज्ञान केन्द्र तथा एन ए आई पी ने मिलकर 8-12 फरवरी 2010 को पेरूवन्नामुषि में संयुक्त रूप से पांच दिवसीय किसानों का समारोह 'कार्षिक सांकेतिक दर्शनम 2010' आयोजित किया। पांच पुरस्कृत किसानों को बधाई दी। छ: भारतीय कृषि अनुसंधान परिषद, केन्द्रीय सरकार और 14 निजी उद्यमियों तथा निवेश अभियन्ताओं ने अपने संस्थान द्वारा विकसित तकनीकियों को प्रदर्शित करने के लिए प्रदर्शनी स्टाल लगाये। लगभग 250 किसानों ने तकनीकी सत्र में भाग लिया तथा 1500 तकनीकी निवेश सेवायें प्रदान करने से लाभान्वित हुये। किसानों को प्रशिक्षण देने के लिये तकनीकी विशेषज्ञों को आमन्त्रित करके कृषि के विभिन्न पहलुओं जैसे जैविक खेती, पशु पालन, पुष्प

कृषि, कुक्कुरमुत्ता पालन, फार्म यन्त्र तथा मत्स्य पालन पर तकनीकी सत्रों को आयोजित किया।

तकनीकियों के प्रभाव का मूल्यांकन

करनाटक के कोडगु जिला के 1615 हेक्टर काली मिर्च बागों में सर्वेक्षण किया जहां आई आई एस आर की वैज्ञानिक खेती प्रणालियों के स्तर का मूल्यांकन करने के फलस्वरूप यह प्रकट हुआ कि निम्नलिखित तकनीकियों को अपनाने पर अनुकूल प्रभाव पडता है; पत्तों में बोर्डियो मिश्रण छिडकना -100%, मृदा में कवकनाशियें -80%, नेमटिसाइड्स का -60%, गरमी में तट पर सिंचाई -70%, रसायनिक उर्वरकों को डालना -.20%, जैव नियन्त्रण कारकों का उपयोग -20 % आदि।

सोद्देश्य नमूनों में औसतन उपज (63%) 3.24 कि. ग्राम/स्टैंडेर्ड थी। जबकि नियन्त्रित प्लाटों में परंपरागत विधियां अपनाकर 1.9 कि.ग्राम/स्टैंडेर्ड थी। सोद्देश्य नमूने में खेती के लिए अंकित लागत प्रति बेल 80 रूपए थी तथा आकलित लागत और लाभ का अनुपात तकनीकियों को अपनाने पर 3.025 था। केरल के परंपरागत काली मिर्च उत्पादकों में किये गये पिछले सर्वेक्षण में लागत और लाभ का अनुपात 2.4 अंकित किया गया।

मानव संसाधन विकास

प्रशिक्षण

- ई एस टी विश्लेषण में नवीन प्रस्ताव और उनकी व्याख्या पर एक जैवसूचनाओं का प्रशिक्षण कार्यक्रम 20-23 अक्तूबर 2009 को आयोजित किया जिसमें विभिन्न संस्थानों/विश्वविद्यालयों से 17 प्रशिक्षार्थी ने भाग लिया।
- एम एस सी छात्रों के लिये 6 मई से 5 जून 2009 को जैवरसायन, जैवप्रौद्योगिकी तथा जैवसूचनाओं पर एक महीने का ग्रीष्मकालीन प्रशिक्षण आयोजित किया।
- इक्कीस एम. एससी. छात्रों ने अपना प्रोजेक्ट कार्य विभिन्न विषयों में संपन्न किया। पांच छात्रों ने एम. एससी. के पश्चात् प्रशिक्षण, एक छात्र ने एम. फिल. का प्रोजेक्ट कार्य किया तथा एक को पी. एचडी. की उपाधि प्राप्त हुई।

EXECUTIVE SUMMARY

BLACK PEPPER

Genetic resources

Surveys were conducted to collect black pepper accessions (cultivars) in Thodupuzha of Idukki district, Poonjar and Vaiamukku of Kottayam district, Perumbavoor, Malaytoor and Kunnathunadu of Ernakulam district. Altogether 105 accessions were collected and planted at Experimental Farm, Peruvannamuzhi. A *Piper* species from Dimapur, Nagaland was also collected. In the black pepper germplasm conservatory, 2595 accessions are being conserved (Wild pepper- 1286, Cultivars- 1300, Exotic species- 9). The unidentified *Piper* species collected from North Eastern Region was identified with the help of Central National Herbarium (BSI), Kolkata. Herbarium specimens were prepared, mounted and preserved in the *phenomics* facility. Microsattelites developed for *Piper* species were successfully used to detect polymorphism in black pepper cultivars.

Root stock studies

Screening studies helped to identify *Piper ornatum*, a wild species related to black pepper, resistant to *Phytopthora capsici*, *Radopholus similis* and *Meloidogyne incognita* involved in quick and slow wilt of black pepper. Hence, grafting was attempted with variety Sreekara as scion and the above species as rootstock. Since the growth was poor, other *Piper* species compatible with black pepper was tested as possible interstock for further testing using *P. ornatum* as rootstock. *P. betle, P. longum, P. argyrophyllum, P. chaba, P. attenuatum* and *P. colubrinum* were found to grow satisfactorily and appeared compatible.

Development of core ESTs and cloning of genes

Homology searches for three genes were undertaken and primers were designed. The specific genes include Betaine aldehyde dehydrogenase, Glutathione *S*-transferase and Superoxide Dismutase for amplification from mRNA of field grown black pepper plants. Transcript based cloning attempts for WRKY regulatory gene resulted in the amplification of a fragment of size of approximately 100 bp.

Intercropping in juvenile garden

Intercropping medicinal plants in juvenile black pepper garden recorded a maximum net return of Rs. 46,225 per ha from black pepper + *Vetiveria zizanoids* followed by black pepper + *Alpinia calcarata* (Rs. 44,600) with a Benefit: Cost ratio of 2.3 and 2.2, respectively.

Nutrient and plant hormone levels in relation to bearing

Quantification of nutrient and plant hormone levels in the alternate bearers showed that the stem and leaf nutrients levels were low during the bearing year compared to non-bearing year. Carbohydrate to cytokinin ratio was more during the bearing year compared to non-bearing year.

Influence of storage on quality

Storage of black pepper powder prepared by hammer mill and manual grinding showed reduction in oil and oleoresin content after five months of storage. Profound reduction was observed in manually ground sample.

Medicinal value of pepper was analysed for examining the antioxidant property using alcohol extract, water extract and petroleum ether extract. Three tests *viz.*, DPPH radical scavenging assay, phosphomolybdenum assay and ferric reducing power were carried out for the antioxidant test. Five months storage of powdered sample did not show change in antioxidant property. Black pepper oil constituents were monitored using GC-MS for the five months storage period. Significant changes were observed for pinene, myrcene, limonene and linalool contents.

Phytophthora foot rot and slow decline diseases

Evaluation of chemicals

Three chemicals such as captan hexaconzole, benzoic acid and salicyclic acid were tested *in vitro* and *in vivo* against *P. capsici*. Among them, 100% inhibition of mycelial growth was obtained at 100 ppm captan hexaconzole and benzoic acid and at 200 ppm salicyclic acid. *In vivo* experiments with these chemicals indicated disease inhibition of 46.2%, 46.2% and 16.4%, respectively.

Among the four new chemicals such as Sectin (Fenamidone 10% + Mancozeb 50%), Equation Pro (Famoxadone 16.6% + Cymoxanil 22.1%), Curzate M8 (Cymoxanil 8% + Mancozeb 64%) and Acrobat 50 (Dimethomorph 50%) tested *in vitro* against *P. capsici*, Acrobat 50 showed 100% inhibition at 50 ppm concentration. Sectin and Equation Pro showed 100%

inhibition of mycelium at 400 ppm and >500 ppm, respectively.

Metalaxyl sensitivity of *Phytophthora* isolates was tested with different concentrations of Metalaxyl-mancozeb in comparison with Mancozeb. Metalaxyl-mancozeb could inhibit (100% inhibition) the growth of *Phytophthora* isolate at 5 ppm whereas Mancozeb could inhibit the growth of the same isolate only at 200 ppm.

Evaluation of promising antagonists

Among eighty endophytic fungal isolates isolated from black pepper and evaluated *in vitro* against *P. capcisi,* four isolates (EFP 11, 73, 81 and 83) were promising with >80% inhibitory effect on mycelial growth of *P. capsici*. Observations on growth parameters indicated that application of *Curtobacterium luteum* (TC-10) + Metalaxyl-mancozeb and *Pseudomonas fluorescens* (IISR- 853) + Metalaxyl-mancozeb were promising with increased height and canopy of the plant.

Integrated management in the nursery

An experiment was conducted in the nursery for the production of healthy disease free planting material with four different soil disinfection methods followed by integration of plant protection chemicals and biocontrol agents. All the disinfection methods and integration of chemical application such as copper oxychloride (0.2%) + phorate and potassium phosphonate (0.3%) + phorate were promising in reducing *Phytophthora* infection under challenge inoculated conditions when the moisture content of the potting mixture was maintained below 15%.

Resistance

The resistance of open pollinated progeny of IISR Shakthi 04-P24-1 to root infection by *P. capsici* was confirmed even after 4 years after planting in tbe field. Selfed progenies of *Piper colubrinum*, a species known to be resistant to *Phytophthora* infection, segregated for *Phytophthora* resistance.

The activities of cinnamic acid-4-hydrolase (C4H) and caffeic acid-O-methyltransferase (COMT) increased in the susceptible black pepper variety Sreekara than in the resistant hybrid (HP 39) and wounded samples on inoculation with *R. similis*. Lignin content was comparatively low in HP 39 compared to Sreekara. But in HP 39, it increased to double the control values in a month after inoculation with *R. similis*.

Establishment of virus-free mother vines

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

Two constructs each of *Piper yellow mottle virus* (PYMoV) and *Cucumber mosaic virus* (CMV) in *Agrobacterium tumefaciens* EHA 105 were used for transformation. The embryogenic mass was infected with *Agrobacterium* harbouring respective constructs and cultured on basal SH medium for 48 h. Tbe co-cultured embryogenic mass was transferred to selection medium and growing points were removed onto the same medium with a higher kanamycin concentration. The proliferated embryogenic mass was then transferred to basal SH for further development into fully developed plantlets. Fully developed plantlets were transferred individually to WPM. Total genomic DNA isolated from leaves of fully developed plants was used to confirm the presence of inserts through PCR. The PCR positive plants were hardened under green house for challenge inoculation with viruses.

Screening of black pepper germplasm against Pollu beetle

One hundred and eighty five accessions of black pepper were screened against pollu beetle (*Lanka ramakrishnai*). Among the cultivars, Acc. 78 and 4044 were free from pollu beelte attack. The highest berry damage (36.5%) was recorded on Acc. 1484 followed by Acc. 1611 (34.3%). Among hybrids, Accs. 1055, 1069, 1769 and 1752 remained free from pollu beetle damage. Acc. 1339 recorded 100% berry damage, followed by Acc. 807 (73.5%).

CARDAMOM

Genetic resources

Five accessions were collected from Sabarimala area of Kerala making the total germplasm repository to 447 (Malabar 278, Mysore 78, Vazhukka 63 and others 28). Morphological characterization has been recorded in 50 accessions. Accessions IC547146 and IC349630 were short listed for high yield with more number of capsules per plant.

Evaluation of hybrids

Evaluation of F_1 hybrid progenies of Preliminary Evaluation Trial-I (PET-I) (19 combinations) and PET-II (10 combinations) was carried out and two high yielding selections were short listed for further

evaluation. Hybrid GG × NKE–19 was promising with more than 70 per cent 8 mm capsules and showed field tolerance to rhizome rot and leaf blight. Among the entries evaluated in Multi Location Trial, NHY-10, MA-18 and SAM performed better compared to check.

Identification of molecular markers linked to Katte resistance genes

DNA was extracted from two parents namely, Green Gold (GG) (*katte* susceptible) and NKE 12 (*katte* resistant) and PCR was performed with seven sets of ISSR primers (834a, 841a, 854a, 866, 867, 812, and 815) to study parental polymorphism. Two primers (866, 815) have shown polymorphism, primer 866 for susceptible parent- Green Gold and primer 815 for resistant parent- NKE 12.

Drought tolerance

Three genotypes RR1 (IC349591), CL-893 (IC 349537), Green Gold (IC 349550) relatively tolerant to moisture stress and CCS -1 (IC 349589) a susceptible genotype were crossed to develop drought tolerant variety with good yield and quality characters. CL-893 and its cross combinations recorded better growth and yield parameters which were reduced under stress.

Essential oil profile

Twenty accessions of cardamom germplasm were evaluated for essential oil content. Oil content in capsules ranged from 3.5-6.7% on dry weight basis, with highest in GG-self followed by GG-OP (6.0%). GC-MS analysis of the oil indicated that these accessions contained 26.2% and 27.7% 1,8- cineole and, 45.8% and 46.2% α- terphenyl acetate, respectively.

Screening of germplasm

Thirty eight breeding lines and 20 collections of cardamom were screened under natural field conditions to identify resistant sources against leaf blight and rhizome rot. Six genotypes each of breeding lines and collections exhibited highly resistant reaction to rhizome rot. Six genotypes namely, IC–547222, IC–547223, IC–349645, IC–349649, IC–547158 and IC–349637, exhibited moderately resistant and highly resistant reactions against leaf blight and rhizome rot.

Development of diagnostics for viral diseases

Six *katte* isolates were collected from Karnataka (5 isolates) and Kerala (1 isolate) and established under insect proof glass house conditions. Enzyme Linked Immunosorbent Assay (ELISA) based detection of *Cardamom mosaic virus* (CdMV) was standardized and the titre of the antiserum was found to be 1:250. A procedure for total RNA isolation from cardamom and detection of CdMV through reverse transcription–polymerase chain reaction (RT-PCR) using primers designed for the conserved region of coat protein was standardized. The RT-PCR method was validated by testing more than 50 cardamom field samples representing different geographical locations of Karnataka and Kerala.

Two *kokke kandu* isolates from Karnataka and one Nilgiri Necrosis disease isolate from Suryanelli (Idukki District, Kerala) were collected and established under insect proof glass house conditions. Surveys conducted in major cardamom growing areas of Karnataka and Kerala, revealed the prevalence of *Banana bract mosaic virus* (BBrMV) infection. The symptoms induced by BBrMV in cardamom included discontinuous or continuous spindle shaped streaks along the veins, continuous light green or light yellow streaks along the midrib and discontinuous mottling along the pseudostem and petiole.

TURMERIC

Genetic resources

One thousand one hundred seventy three accessions are being maintained in the field germplasm conservatory. The breeder's seed of released varieties of turmeric (7 varieties) was multiplied.

OP seedling progenies

Pot culture evaluation of 256 seedling progenies and 23 mother plants of turmeric showed high variability with respect to yield. Twenty nine progenies showed multiplication rate above 20 times. Of the 68 second generation seedling progenies of five seedling progenies, many showed very high multiplication rate.

Self incompatibility studies

Sixty five flowers of Rajendra Sonia and more than 100 flowers of BSR-2 were manually self pollinated but no fruit set was observed. Pollen fertility analysis by staining showed 60.4% fertility in Rajendra Sonia and 55% in BSR-2. *In vivo* germination on stigma was found to be sparse after 4 h of pollination. Self incompatibility mechanism in these varieties is suspected.

Microsatellite markers and characterization

Cross species amplification studies of microsatellite markers were carried out in 13 *Curcuma* species. Two

synonymous *Curcuma* species *viz*., *C. zedoria* and *C. malabarica* showed identical SSR profiles for 40 microsatellite loci.

Flowering on yield and dry recovery

The flowering and non-flowering plants of turmeric were compared for yield and dry recovery. On an average, flowered plants recorded fresh yield of 504 g/plant with a range of 298 to 956 g/plant and CV of 41.9%, whereas, non-flowered plants yielded 524 g/ plant with a range of 321 to 861 g/plant and CV of 31.1%. The flowered and non-flowered plants did not differ in yield and dry recovery.

Cloning of pal gene

Partial sequence of *pal* gene was isolated with PCR conditions optimized using *pal* gene specific primers, designed based on sequences available in the public domain. A 522 bp product amplified by PCR was isolated, cloned and sequenced. BLAST analysis revealed that the sequence showed 94.3% identity with the *pal* gene from ginger.

Evaluation of chemicals against rhizome rot

The field experiment to evaluate the efficacy of copper oxychloride 0.25%, Cheshunt compound 0.3%, Bordeaux mixture 1%, metalaxyl + mancozeb 0.125%, mancozeb 0.3%, potassium phosphonate 0.3%, carbendazim + mancozeb 0.3%, captan + hexoconazole 0.3% and carbendazim 0.5% and biocontrol agents (CLT 102 and CLT 110) for the management of rhizome rot disease indicated that application of metalaxyl-mancozeb 0.125% + CLT110 was at par with individual application of either metalaxyl-mancozeb 0.125% or CLT 110 with a disease reduction of 69.1% compared to 69.7% in individual treatments. There was an increase in yield of 12% in the combined treatment when compared to 13.4% in individual treatments.

Bionomics of shoot borer and its management

The life cycles of shoot borer, *Conogethes punctiferalis* were studied on five moderately field resistant and five susceptible accessions. The average adult longevity, pupal period and fifth instar larval period were 2.9, 12.4 and 7.5 days, respectively on moderately resistant accessions and 2.8, 15.7 and 7.8 days, respectively, on susceptible accessions. However, the differences were not statistically significant. The trials indicated that among the various insecticides, lamda cyhalothrin 0.0125% was more promising in reducing the percentage of shoots infested by the shoot borer.

GINGER

Genetic resources

Six hundred accessions of ginger are being maintained at the field germplasm conservatory. The breeder's seed of released varieties of ginger were multiplied. Cross species amplification of rice microsatellites was successfully done in ginger. Three of the primers tested gave good amplification products

Yield evaluation of high oil type and exotic collections

Among 13 genotypes analysed for biochemical parameters, oil content varied from 1.2 to 2.8%, while the oleoresin content ranged from 2.0 to 4.6% and fibre from 1.87 to 5.13%. Of the 12 exotic (Nepal) lines, the oil content ranged from 1.2 to 2.4%, oleoresin from 3.3 to 4.8% and fibre from 2.50 to 5.11%.

Yield evaluation of low fiber lines

Eight ginger accessions were evaluated for their biochemical parameters, of which the oil content ranged from 1.2 to 2.0%, while the oleoresin from 1.8 to 3.6%. The fibre content varied from 3.54 to 5.15%.

Polyploidy in ginger collection with high pollen fertility

Chromosome number of ginger collection No.195 which was identified during last year as high pollen fertile line was verified from mitotic metaphase plates at the root tips. Analysis of mitotic metaphase plates showed that the plant is a tetraploid having 2n=44 in majority of the cells.

Nutrient requirement for targeted yield

Based on the initial fertility levels of N, P, K, the fertilizer doses for obtaining 25, 35 and 45 kg/6 m^2 bed yield targets in ginger were worked out and applied in 3-5 splits at Appangala on variety Rio-de-genero. The yield levels observed were 21.7, 28.2 and 35.8 kg/ 6 m^2 bed for the targets 25, 35 and 45 kg, respectively. The highest yield of 35.8 kg/bed was obtained for the target 45 kg/ bed and the deviation from the target was -15 to -40%. A mean deviation of -13, -19 and -20% at 25, 35 and 45 kg target levels, respectively was observed. The farmers practice has recorded a yield of 35.6 kg/ bed.

Organic management on soil quality and yield

Under different management systems like conventional, integrated and organic the soil nutrient availability of N and K were higher in integrated system on par with

that of organic system. The Ca and Mg availability was higher under organic system. The foliar concentration of P and Zn was observed to be highest in fully organic management followed by integrated and conventional systems.

The mean yield recorded was 8.1 kg/ 3 m^2 under organic system which was on par to other management systems (7.4–7.7 kg/bed). Under organic management, var. Mahima yielded highest (9.5 kg/bed) and Rejatha yielded on par with conventional system. Highest yield in Varada was recorded in integrated (7.4 kg/bed) followed by conventional and organic systems.

Evaluation of rhizobacterial strains against rhizome rot

The promising rhizobacterial isolates were evaluated for their biocontrol potential against *Ralstonia solanacearum* and *Pythium aphanidermatum* and growth promotion in green house. The isolates GRB 35 and GRB 36 showed highest disease suppression followed by GRB 70 and GRB 91 against *R. solanacearum*. GRB 35 and GRB 91 followed by GRB 68 showed highest disease suppression against *P. aphanidermatum*.

Soil biochemical and microbial indices as influenced by rhizobacteria were evaluated in a pot culture experiment. The isolates GRB 25, GRB 36, GRB 38 and GRB 70 applied alone, did not significantly influence microbial activity. However, when applied in combination with 75% N + 100% P + 100% K, gave significantly higher microbial biomass C values. The activities of urease, acid phosphatase, alkaline phosphatase and dehydrogenase were highest in treatments involving the isolates GRB 36 and GRB 38 applied in combination with 75% N + 100% P + 100% K.

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Entomopathogenic nematodes

Sixty two rhizosphere soil samples were collected from different locations of Wayanad, Kottayam, Idukki (Kerala), Kodagu (Karnataka), Guwahati (Assam) and Barapani (Meghalaya) and baited using *Galleria mellonella* larvae. Out of 62 soil samples baited, 6 strains of entomopathogenic nematodes were recorded. Four hundred and twenty four shoot borer larvae were collected from various sites in Kozhikode, Wayanad and Kodagu Districts among which eight were associated with rhabditids nematodes and one with EPN.

NUTMEG

Induction of orthotropic shoots in plagiotropic grafts

The auxins and cytokinins in the leaves and buds of orthotropic and plagiotropic shoots of nutmeg were studied and it was observed that the auxin content was highest in the axillary buds of the plagiotropic shoots, whereas the terminal buds contained more auxins in orthotropic shoots. Cytokinin was high in the leaves of both orthotropic and plagiotropic shoots when compared to the buds.

Quality

Twenty accessions of mace were analysed for oil content. The oil content ranged from 12-33%, with highest oil yield in IC-548917 (33%) followed by IC-548922 and IC-548932 (30% each).

CASSIA

In the clonal evaluation of elite lines at Peruvannamuzhi, D1 (IC 370423) recorded significantly higher height (320.6 cm) and dry bark yield (92 g). Among the 15 cassia lines tested at CRC Appangala, C1 (IC 370415) recorded significantly higher height (545 cm), while no siginificant difference was observed among the lines for number of branches, girth, leaf length and breadth. IC370406 recorded the maximum fresh (1290 g/tree) and dry weight (405.3 g/tree) followed by IC370425 and IC370427. But the highest dry recovery of 56.25% was recorded in IC370401 at Appangala condition on first coppicing. IC 370410, 370423 and 370425 recorded maximum oil yield of 4%. IC370415 recorded 21.57 % oleoresin.

CINNAMON

Cinnamon bark was extracted in the month of November and powdered in bammer mill for oil and

oleoresin. Hammer mill ground sample was stored in three layered polyester cover. Samples were drawn at monthly intervals and analysed for oil, oleoresin and antioxidant activity. Except for slight reduction in oil content, no profound change was noted for antioxidant activity due to storage.

GARCINIA

Diversity exploration

With the help of BIOCLIM models (Altitude and Rainfall) of DIVA GIS, the existence of Garcinia in the North Eastern Himalayan states was predicted. Four species of Garcinia *viz., G. kydia* (Kuji Thekera), *G. lancifolia* (Rupohi Thekera), *G. pedunculata* (Bor Thekera) and *G. xanthochymus* (Tepor Tenga) were located in Meghalaya and Assam.

Natural food colors and pigments

The fruits or rinds of *G. gummi-gutta, G. hombroniana, G. indica, G. tinctoria* and nutmeg (*Myristica fragrans*) were collected and used for color extraction. The total carotenoids content varied from 0.013 (*G. gummi-gutta*) to 0.065 mg/100g (*G. tinctoria*) and anthocyanin content from 0.007 (*G. hombroniana*) to 0.053 mg/100g (*G. indica*). The lycopene content ranged from 3.72 (*G. tinctoria*) to 4.95 mg/100g (*G. indica*), among the garcinia species.

VANILLA

Reciprocal crosses were conducted between *V. planifolia* and *V. tahitensis* (species reported as resistant to root rot disease). High percent of fruit set was observed in both the crosses. Fifty five cultures of selfed progenies of *V. tahitensis* and 60 cultures of *V. planifolia* X *V. tahitensis* were established *in vitro*.

SPICES

Antioxidant activity

In curry leaves, the DPPH radical scavenging activity of essential oil was reduced by half by the 3rd month of extraction compared to the fresh samples and by another 50% by the next quarter. The water and ethanol extracts were relatively stable in this property over this period. No significant change in total antioxidant capacity, as measured by the phosphomolybdenum method, or Fe(III) to Fe(II) reducing activity was observed in any of the extracts in six months after extraction compared to the fresh samples. Chemo-profiling of curry leaves essential oil showed no major changes except a 50% decrease in l-phellandrene by the 3rd month after extraction

OUTREACH PROGRAMMES

PhytoFuRa

Phytophthora isolates (241 isolates) maintained in the repository have been revived and was enriched with 43 new *Phytophthora* isolates collected from different parts of Kerala and Kodagu district of Karnataka. The virulence of 100 *Phytophthora* isolates was tested *in vitro*.

Genomic DNA was isolated from 126 black pepper *Phytophthora* isolates and SSR profiling was done. ITS region of *R. similis* was amplified with universal primers. Genomic DNA isolation from 75 Panniyur-1 x Subhakara progenies was carried out and ISSR profiling is in progress to develop a linkage map.

PhytoWeb, a comprehensive portal on *Phytophthora* diseases of horticultural crops in India was developed by modifying the existing PhyDisH. PhytoLib, an electronic database of research publications on *Phytophthora* has also been developed and launched.

Leaf spot diseases

Surveys were carried out in Karnataka, Kerala and Tamil Nadu for assesing leaf spot diseases. Out of 150 samples including cardamom, black pepper, arecanut, turmeric, ginger, chilli and clove, 100 were infected with *Colletotrichum* spp. The cultures were identified and characterized based on colony and conidial morphology.

BIOINFORMATICS

In silico research

EST assembly and annotation of two entomopathogenic nematodes, *Steinernema feltiae* (83 nos.) and *Heterorhabditis bacteriophora* (53614 nos.) was also attempted. Syntenic relationship between *Radopholus similis* and other nematodes was studied using mitochondrial genome sequences.

A virtual screening of phytochemicals from Dr. Duke's phytochemical and Ethnobotanical database, literature search, PASS prediction and ADME/Tox screening has identified 56 promising lead compounds with potential nematicidal activity. Flexible docking studies revealed that phytochemicals - curcumin, brucine-n-oxide, colubrine, brucine, vanillin, genostrychnine and strychnine, had good binding score (MolDock score) and favorable hydrogen bond interaction with glutathione-S-transferase (GST) of *Brugia malayi*.

New Database

A new database, GST Lead Base (www.spicebioinfo.res.in/gstleadbase) was developed and hosted. The database includes chemical properties and other details of potential nematicidal compounds that inhibit glutathione-S-transferase in nematodes.

IT initiatives

- *SpiceStat*, the database on vital statistics of spice cultivation, production and export was relaunched with additional features.
- A new *accounts module* was developed and integrated in ARISoft, the existing office automation software.
- An *interactive CD* on ginger and turmeric package of practices was developed.
- As per the guidelines received from ICAR, the IISR website was modified by using Joomla, an open source CMS software, and it is under trial run.

EXTENSION

During the year, 1111 farmers (241 from within district, 157 from the state and 713 from outside the state) availed farm advisory services from ATIC and 1275 farmers visited the Experimental Farm, Peruvannamuzhi. More than 1000 students visited the institute on study tour. The institute conducted one on-campus training programe (5 days) for the State Department extension functionaries, sponsored by the Kerala State Horticulture Mission. Two off-campus training programmes on black pepper for farmers sponsored by M S Swamintahan Research Foundation, Wayanad were organized in Wayanad District. The institute also participated in one farmers' seminar under the Janasree mission of the Kerala Government, five exhibitions/farmers fairs at national level and four at regional level. Seven video conferencing sessions with village resource centers in Wayanad District were organized in which 389 farmers participated.

A Media Meet was also organized to mobilize mass media support for sharing Agro-Information, under NAIP project. Over 30 media persons from around 20 various media organizations attended. Over 20 news items appeared in various print media, one audio item in AIR-Calicut and news in channels.

Training programmes

The KVK has conducted 73 training programmes on various subjects during the period and trained 3024 beneficiaries. About 400 farmers visited for consultation, purchase of planting materials and other inputs from KVK. Three study tours were arranged for the farmers during the period, benefiting 96 farmers. Eight Front Line Demonstrations and four On-farm trials were undertaken.

Technology Week / Kisan mela - 'Karshika Sankethika Darshanam 2010'

A five day farmer's festival 'Karshika Sankethika Darshanam -2010' was jointly organised by the Indian Institute of Spices Research (IISR), Calicut, Krishi Vigyan Kendra (KVK) and NAIP, at Peruvannamuzhi during 8-12 February 2010. Five progressive award winning farmers were felicitated. Exhibition stalls were put up by six ICAR, Central government and 14 private entrepreneurs and input agencies for showcasing the technologies developed by the institutions. About 250 farmers participated in the technical sessions and about 1500 in the exhibition and benefited by the technological inputs/services provided. Technical sessions on different aspects of agriculture like organic farming, animal husbandry, floriculture, mushroom culture, farm machinery and pisciculture were arranged by inviting technical experts to train and interact with the farmers.

Impact assessment of technologies

Survey of 1615 ha of black pepper plantations in Kodagu District (Karnataka) where IISR had technology intervention programmes to assess the level of adoption of scientific cultivation practices revealed the following level of adoption of technology inputs in the purposive samples: foliar spray of Bordeaux mixture - 100%, soil drenching of fungicides - 80%, application of nematicides - 60%, basin irrigation in summer - 70%, application of chemical fertilizers - 20% and application of bioagents - 20%.

The average yield (with an average of 63% yielding vines) in the purposive sample was 3.24 kg/standard compared to 1.9 kg/standard in the control plots where conventional practices where followed. The recorded cost of cultivation in the purposive sample was Rs 80 per vine and the estimated cost: benefit ratio at the given level of adoption of technologies was 3.025. In

conventional black pepper growing tracts of Kerala, a previous survey recorded a cost benefit ratio of 2.4.

HUMAN RESOURCE MANAGEMENT

- A bioinformatics training programme on 'Recent advances in EST analysis and their annotation' was organized during 20-23 Oct., 2009 in which 17 trainees from various institutes/universities participated.
- One month summer training on Biochemistry, Biotechnology and Bioinformatics was conducted for M.Sc. students during 6th May – 5th June 2009.
- Twenty-one M.Sc. students carried out project work in various disciplines. Five students have undergone Post M.Sc. training and one for M. Phil project work and five students were awarded Ph.D.

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

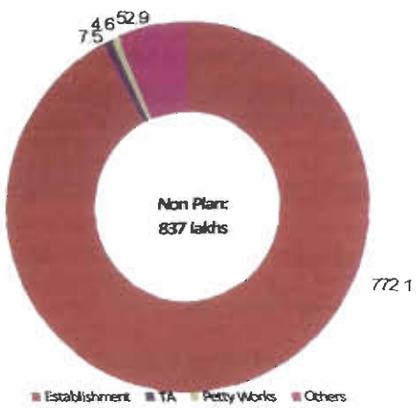
- To extend services and technologies to conserve genetic resources of spices as well as soil, water and air of spices agroecosystems.
- To develop high yielding and high quality spice varieties and sustainable production and protection systems using traditional and non-traditional techniques and novel 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 sure that research is targeted to the needs of the farming community.
- To serve as a national centre for storage, retrieval and dissemination of technological information on spices.

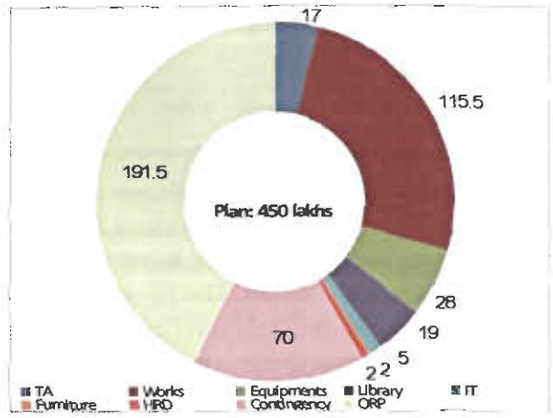
The spice crops on which research is being conducted at the institute include black pepper (*Piper nigrum*), cardamom (*Elettaria cardamomum*); ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), cinnamon (*Cinnamomum verum*), cassia (*C. cassia*), clove (*Syzygium aromaticum*), nutmeg (*Myristica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

Organization

The Director is the administrative head of the institute. The Institute Management Committee, Research Advisory Committee and 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 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. 1287 lakhs during the year, which included Rs. 450.0 lakhs under Plan and Rs. 837.0 lakhs under Non Plan.





Resource generation: Institute earned a total of Rs. 19.99 lakhs through sale of planting materials, biocontrol agents, training, publications and consultancy services.

Staff: The institute has a sanctioned strength of 43 scientific, 18 administrative, 36 technical and 61 supporting staff, of which 36, 14, 33 and 50 of scientific, administrative, technical and supporting staff, respectively are in position. The KVK has a sanctioned strength of 2 administrative, 11 technical and 2 supporting staff.

New facilities

Seed storage unit

Seed Storage Unit for storing turmeric and ginger seed rhizomes was established at IISR Experimental Farm, Peruvannamuzhi.

Post harvest technology Lab

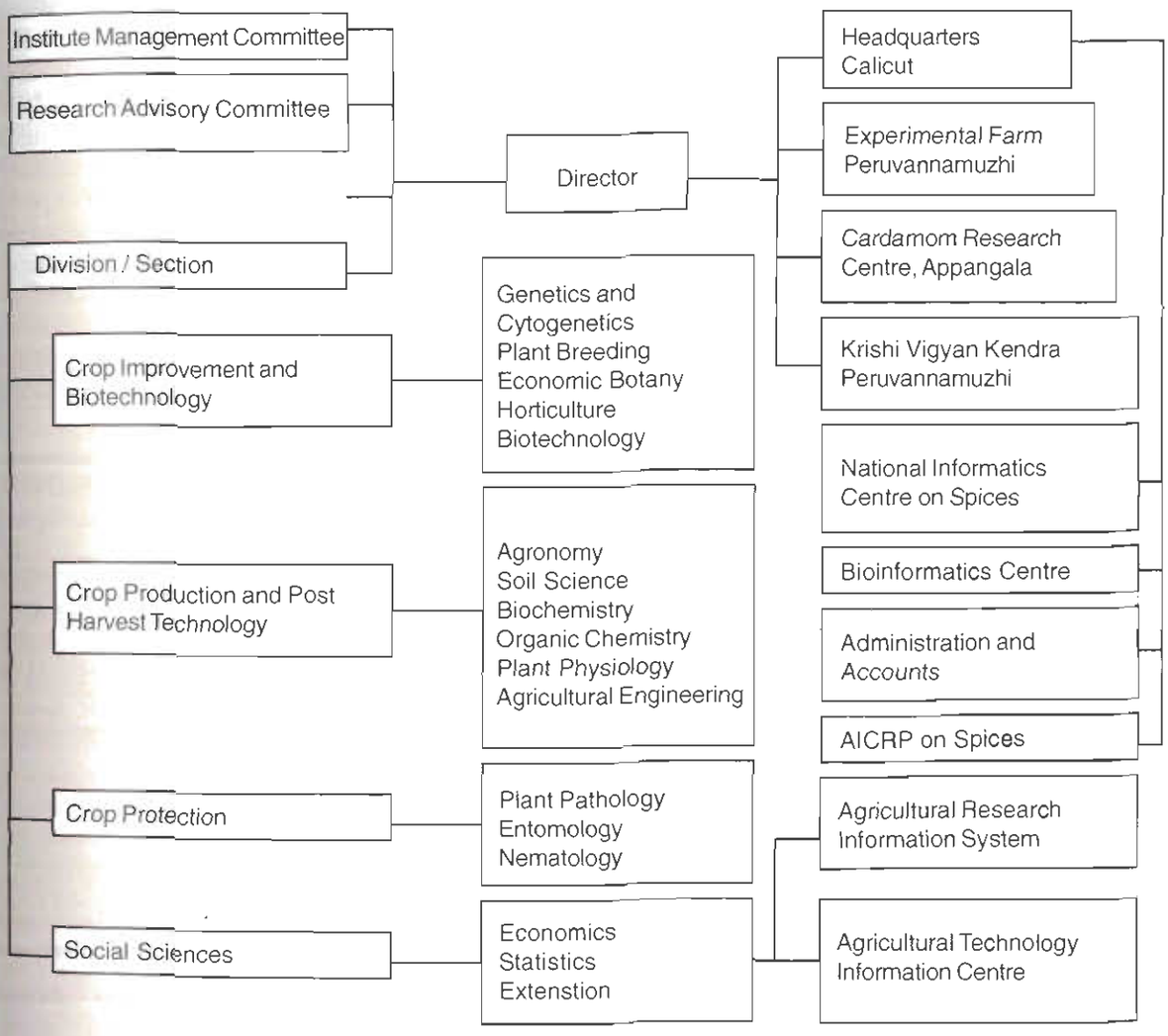
Post Harvest Technology lab was established at IISR Experimental Farm, Peruvannamuzhi with equipments like driers, graders and cleaners for processing spices.

Staff Position of the Institute

Category	Sanctioned	Position			Total	Vacant
		Calicut	Peruvannamuzhi	Appangala		
Scientist	43	29	2	5	36	7
Technical	36	16	14	3	33	3
Administration	18	12	-	2	14	4
Supporting	61	21	11	18	50	11
Total	158	78	27	28	133	25

Staff position of KVK

Category	Sanctioned	Position			Total	Vacant
		Calicut	Peruvannamuzhi	Appangala		
Technical	11	1	10	-	11	-
Administration	2	1	1	-	2	-
Supporting	2	-	2	-	2	-
Total	15	2	13	-	15	-



Organization of Indian Institute of Spices Research

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. Two accessions, INGR 8099- *Piper thomsonii* (IC-398863) - for its unique character for sex change and INGR 8100- *Piper nigrum* (IC- 563950) – A novel spike variant with proliferating spikes, were registered witb NBPGR for their unique characters.

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. Portion of 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. Irrigating pepper vines once in a fortnight from March to May months @ 50 litres/vine enhanced yields substantially. 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. Crops such as ginger, tapioca, coleus, amorphophallus and hybrid napier were found suitable for intercropping in black pepper gardens that are more than 15 years old. 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 and 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 PYMoV 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. Open pollinated progeny of IISR Shakthi (04- P24 -1) continued to show resistance to root infection by *P. capsici* with repeated inoculations. 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 effective against *Phytophthora capsici* and *R. similis* in black pepper have been isolated. Basal application of *T. harzianum* and aerial spray with 1% Bordeaux mixture was found effective in controlling anthracnose disease. 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 production were standardized.

Impact studies on adoption 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 aerial 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 level for application of soil fungicides, fertilisers and pesticides were very low at 21.14%, 7.7% and 7.6 % respectively.

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 significantly improved 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. Crosses 893 x RR1, GG x RR1, CCS1 x GG, GG x 893 and CCS1 x GG showed more drought tolerance as they took more time to fold leaves (leaf rolling) under open light than other crosses. High quality (more than 40% á- 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. Protocols for RNA isolation (RT-PCR) for detecting *Macluravirus* from the leaves obtained from *Katte* affected cardamom plants have been standardized.

Ginger: Germplasm repository at IISR is the largest with several exotic collections and high quality accessions. Seven hundred accessions of ginger are being maintained in field germplasm conservatory. 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 Acc. No. 195 showed mean pollen fertility of 67.73% by glycero-carmine staining and 60.31% by *in vitro* germination and is suitable for future studies on induction of seed set. 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 has been established. Post harvest technologies for processing and technologies for preparation of value added products such as salted ginger were standardized. 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. 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 publication, training programmes and demonstrations. Large scale multiplication and distribution of elite planting material were 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, diseases and drought. 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. 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. Seven high curcumin and high yielding varieties, Suvarna, Sudarsana, Suguna, Prabha, 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. The natural enemies of shoot borer (*Conogethes punctiferalis*) infesting turmeric were documented. 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. Processing with or without boiling or different drying methods did not lead to variation in oil, oleoresin and curcumin contents. 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. The cassia elite line A1 (IC No. 370400) has been registered with NBPGR for high cinnamaldehyde content in bark oil (81.5%) and leaf oil (80.5%). Two high quality cinnamon varieties, Navashree and Nithyashree and a nutmeg variety, 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. 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 á-phellandrene, â-phellandrene, camphor, t-*caryophyllene* and *germacrene*-D respectively. 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. 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. Another virus associated with necrosis and mosaic on vanilla was identified as a strain of *Bean common mosaic virus* (BCMV) based on coat protein gene sequence comparison and phylogenetic studies.

Paprika: The germplasm collected from various places of cultivation were 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. The lines ICBD-10, Kt-pl-19 and EC-18 were found promising with high colour value and low pungency. PCR based technique was developed to detect adulterants in commercial chilli powder.

BLACK PEPPER

Conservation and characterization of germplasm

The germplasm assembled at the conservatory are conserved in the nursery and field genebank with 2595 accessions (Wild pepper- 1286, Cultivars- 1300, Exotic species- 9). In addition, 100 more accessions were planted at CPCRI, Kidu during this year. One hundred and fifty accessions of germplasm planted at CRC, Appangala were characterized for morphological characters. Surveys were conducted in Thodupuzha (Arakulam, Vannapuram, Karikunnu, Mundan mudi, Pattayakudi) area of Idukki district, Poonjar and Valamukku of Kottayam district, Perumbavoor, Malaytoor and Kunnathunadu Taluks of Ernakulam district. The major areas surveyed were farmer's field and tribal hamlets and 105 accessions were collected. The accessions are planted at the germplasm conservatory at Peruvannamuzhi. One *Piper* species from Dimapur, Nagaland was also collected. Herbarium specimens of 75 black pepper accessions were prepared and mounted and preserved in the herbarium facility.

Breeding for high yield and caryophyllene

Four hundred and fifty seedlings raised from different cross combinations were maintained periodically in the germplasm nursery. Sufficient numbers of each combination were multiplied for further planting. Leaf oil constituents *viz.*, β- Caryophyllene, Germacrene-D, Elimol and Nerolidol were analyzed from the identified lines such as Malabar Excel, HP-785, HP-1117, Sreekara, Subhakara, Panchami, Pournami, Panniyur-1, IISR Thevam and IISR Girimunda. β- Caryophyllene was highest in HP-846.

Breeding for resistance to '*pollu*' beetle

Six hundred and fifty hybrid progeny combinations are being maintained and multiplied vegetatively for planting them in the field for further evaluation. Fifteen hybrid progenies from each of the combinations, Subhakara x Acc. 1114, Subhakara x Acc. 841, Subhakara x Acc. 1084, Subhakara x Acc. 816 were planted in the field. Observations showed that all the plants were free of *pollu* infestation on the leaves.

Breeding for *Phytophthora* resistance

One hundred and forty lines from Panniyur-1 x Subhakara mapping population were maintained in the field and in the nursery (Fig 1.1). Data on floral and other morphological characters showed segregation among progenies.

Fig. 1.1. Maintenance of mapping population in field

Fifty new crosses were made and 75 progenies were developed between Subhakara x IISR Shakthi for increasing the mapping population size for tagging *Phytophthora* resistance.

Screening of SSR primers against black pepper

A set of nine microsatellite markers reported by Menezes *et al.*, (2009) were screened against black pepper genotypes. Of these, four were found to be polymorphic among genotypes tested (Fig. 1.2).

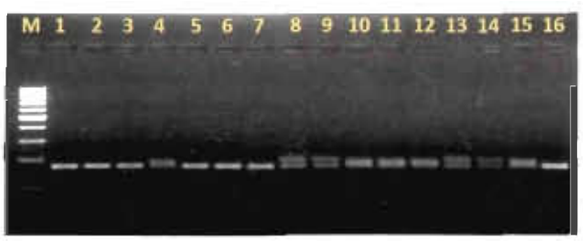


Fig. 1.2. SSR profiling of released varieties of black pepper

Lanes 1-16: Panniyur 1, Panniyur 2, Panniyur 3, Panniyur4, Panniyur 5, Panniyur 6, Panniyur 7, IISR Subhakara, IISR Sreekara, IISR Panchami, IISR Pournami, PLD 02, IISR Sakthi, IISR Thevam, IISR Girimunda, IISR Malabar Excel, Lane M: 100bp ladder

Screening of lines from germplasm and hybrids for resistance to *Phytophthora*

Among 50 lines selected for association mapping from germplasm, ten were screened using leaf, stem and root inoculation techniques. Cultivar 1324 was the best, showing resistance reaction (Fig. 1.3) for both stem and leaf screening (Table 1.1).

Development of transgenics for resistance to *Phytophthora* and drought

About 80 transgenics were regenerated with osmotin and 12 putative transgenic plants (with osmotin) were hardened. The putative trasgenics with osmotin were multiplied for screening. The transgenics which showed resistance reaction in last year's screening were kept for multiplication.

Cloning of genes

Homology searches for three genes were undertaken and primers were designed. The specific genes include Betaine aldehyde dehydrogenase, Glutathione

Fig. 1.3 Reaction of black pepper lines to *Phytophthora* by leaf screening (a) HP 365 (b) Coll. 1324

Table 1.1 Reaction of black pepper cultivars and hybrids for *Phytophthora*

Acc.No.	Name	Leaf	Stem	
		LL (mm)	LL (mm)	DP (mm)
984	Kalluvally	5.2	3	1.2
1050	-	13.4	13.3	2.5
1109	Vellanamban	10.4	9	3.1
1324	Aimpiriyan	No Lesion	4	1.4
HP 117	Narayakodi X Neelamundi	12	10.7	3.0
HP 127	Neelamundi X Karimunda	13.6	10.6	2.33
HP 344	Narayakodi X Karimunda	13.2	11.11	2.6
HP 365	Perumkodi X Karimunda	12.8	18.15	2.35
HP 427	Panniyur 1X Balankotta	13.8	10.3	3.18
HP 441	Perambramunda X Panniyur1	12.5	8.43	2.92

LL=Lesion length; DP=Depth of penetration

S-transferase and Superoxide Dismutase. The primers are being tested for amplifying specific sequences from black pepper mRNA population. Primers were designed from the WRKY domain, a 60 amino acid region that is highly conserved amongst the family members. Amplification from black pepper and *Piper colubrinum* RNA using these primers resulted in the PCR product of different lengths (110 bp, 125bp, 500 bp and 850 bp). The products are being cloned for sequencing.

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

The wild species *Piper magnificum*, *P. hamiltoni P. peepuloides*, *P. hymenophyllum* were screened against *Phytophthora capsici*, *Radopholus similis* and *Meloidogyne incognita*. Prelimary results indicated that *P. hamiltoni* is resistant to *Phytophthora capscici*.

Screening of grafts of Sreekara variety of black pepper using IISR-Shakthi and C-1090 as rootstocks (tolerant to *Phytophthora capsici*) indicated that root rot can be controlled to below 10% with the use of phorate alone to control nematodes. Growth studies showed that the growth of Sreekara is not influenced by grafting on IISR Shakthi and C-1090. Since growth of pepper grafted on *P. ornatum*, a species resistant to major pathogens is very slow, other species were tried as interstock. Out of seven species tested, *P. colubrinum*, *P. argyrophyllum*, *P. attenuatum*, *P. chaba*, *P. longum*, and *P. betle* are compatible with *P. ornatum* but *P. galeatum* is not compatible. Black pepper variety Sreekara formed good union and expressed good growth on *P. hamiltoni*.

Nutrition and Cropping system

Nutrient requirement for targeted production

Dry yields of 5, 7.5 & 10 kg 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 recorded yield levels were 5.9, 5.4 and 6.6 kg/vine in the targets of 5, 7.5 and 10 kg/vine, with a deviation of +17.8, -28.3 and -33.5 respectively. Through targeted equation, nutrient requirement for 5 kg/ vine yield could be predicted with a positive deviation of +17%. The recorded yield at higher targets was negative due to the lean crop during this year after a good crop in last year.

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 that the organic carbon content in finer fractions of soil particles was significantly high under organic management system as compared to conventional system. It also increased significantly with the decreasing particle size, highest with 0.25 mm followed by 0.75 and 1.25 mm.

Similarly, available N, P, Ca and Mg were found to be significantly high in finer soil fractions of organic and integrated systems compared to conventional system. Moreover their availability increased significantly with increased fineness at both the depths (0-15 cm & 16-30 cm) studied.

Studies on allelopathy in tree species-black pepper interactions

The alcohol extracts of tree species like ailanthus, garuga, gliricidia, and erythrina were analysed for allelochemicals using TLC. The solvent used was ethyl acetate: petroleum ether (1:1) with MeOH- H_2SO_4 and $CHCl_3$-MeOH (90:10 and 95:5) as the spray reagents. No spots could be detected. In the pot study on the allelopathic effect of tree standards on growth of black pepper, the leaf and stem extracts of these standards were applied at varying rates (0, 12.5%, 25%, 50%, and 100%) to three-month old rooted black pepper cuttings (IISR Thevam). The extracts were applied at monthly intervals. Data on growth parameters (no of leaves and plant height) were recorded at 120 DAP. The results revealed that increasing concentration of extracts did not significantly influence plant height. Among the tree species, gliricidia extract consistently registered greater plant height (range 56.5-69.0 cm), followed by garuga (45.3-67.3 cm), ailanthus (44.0-61.0 cm) and erythrina (41.0-61.0 cm) extracts. The number of leaves did not vary markedly between tree species and extract concentration. However, at all concentrations, relatively greater number of leaves was registered by gliricidia (range 7-11).

Impact of irrigation on spike setting and yield

Vines which received irrigation (@ 50 litres/vine) from March II fortnight (FN) to May II fortnight at fortnightly intervals recorded significantly higher number of spikes, increased spike length, uniform spiking and higher berry yield than those which did not receive irrigation during this period.

Treatment	Old spikes (July)	New spikes (September)	Total	Spike length (cm)	Dry yield (kg/vine)
Irrigated (March II FN to May II FN)	31.2	3.0	34.2[b]	12.0[b]	7.5[b]
Rainfed	2.7	17.5	20.2[a]	9.5[a]	2.8[a]

(Values in a column followed by different alphabets indicate significant difference between the treatments)

Hormones and nutrients in relation to alternate bearing

Leaf carbohydrate, IAA and cytokinin levels have been quantified in alternate bearers. Carbohydrate to cytokinin ratio was more during the bearing year compared to non-bearing year. The alternate bearers had lower level of stem nutrients while there was not much difference in leaf nutrient content during the bearing year compared to non-bearing year.

To investigate if spiking can be regulated by providing nutrients during spike initiation period, three rounds of sprays (April II week, May I week and May IV week) of 19:19:19 NPK complex fertilizer (0.5, 1.0, 1.5 and 2.0 % nutrient solution) were given. Among the nutrient sprays, 2.0 % spray recorded the maximum berry yield (5.8 kg dry yield/vine) followed by 1.5 % spray (4.9 kg/vine). Control (water spray) recorded the least (3.8 kg/vine) indicating that yield levels can be enhanced during the poor bearing year through nutrient sprays during spike initiation period.

Post harvest technology

Black pepper powder and chemical quality

Black pepper powdered using hammer mill to fine mesh and stored in laminated polyester packs for five months were drawn at monthly intervals and analysed for chemical quality (oil, oleoresin, piperine and oil constituents) and medicinal property (antioxidant property). Antioxidant property of water, alcohol and petroleum ether extract were analysed for DPPH scavenging assay, phospho molybdenum assay and ferric reducing power. Maximum activity was observed for alcohol extract and all the three methods gave consistent activity. Five months of storage of powdered sample did not give any change in medicinal activity. Gradual reduction of oil, oleoresin and piperine was observed during the storage period. Low boiling oil constituents such as pinene, sabinene, myrcene and terpinolene showed reduction during the course of storage.

Storage of black pepper

Black pepper stored in 90% nitrogen and 10 % carbon dioxide in three layered laminated polyethylene packing and analysed for oil, oleoresin and piperine. The data was statistically analysed and compared with that of fresh samples of Panniyur- 1. The results indicated that storage for 480 days, retained the chemical quality equivalent to that of fresh sample, except for a mild reduction in moisture content.

Management of *Phytophthora* foot rot

Evaluation of new chemicals

Three chemicals namely, captan hexaconzole, benzoic acid and salicyclic acid were tested *in vitro* and *in vivo* against *P. capsici*. Among them, 100% inhibition of mycelial growth was obtained at 100 ppm captan hexaconzole and benzoic acid and at 200 ppm salicyclic acid. *In vivo* experiments with these chemicals indicated disease inhibition of 46.2%, 46.2% and 16.4%, respectively.

Four new chemicals namely, Dimethomorph 50% (Acrobat 50), Fenamidone 10% + Mancozeb 50% (Sectin), Famoxadone 16.6% + Cymoxanil 22.1% (Equation Pro), Cymoxanil 8% + Mancozeb 64% (Curzate M8) reported effective against *Phytophthora* spp. were evaluated *in vitro* against *P. capsici*. Among the four chemicals tested, Dimethomorph 50% showed 100% inhibition at 50 ppm concentration. Fenamidone 10% + Mancozeb 50% required 400 ppm and Famoxadone 16.6% + Cymoxanil 22.1% required 500 ppm for 100% inhibition of mycelium (Table 1.2).

In silico screening of nematicidal compounds from *Strychnos nux-vomica*

The biological activity of 62 compounds from *Strychnos nux-vomica* collected from literature and web resources was predicted using SAR (structure–activity relationships) method based on a training set containing 35000 known biologically active compounds with 565 types of biological activity. However, none of the compounds was known to have nematicidal or

Table 1.2. Evaluation of chemicals against *Phytophthora capsici*

Chemical	Conc. (ppm)	*In vitro* inhibition (%) of pathogen	% disease incidence (*In vivo*)	% disease reduction
Capatan hexoconazole	100	100	35.0	46.2
Benzoic acid	100	100	35.0	46.2
Salicylic acid	200	100	55.0	15.4
Fenamidone 10% + Mancozeb 50% (Sectin)	400	100	0.0	0.0
Famoxadone 16.6% + Cymoxanil 22.1% (Equation Pro)	500	100	0.0	0.0
Cymoxanil 8% + Mancozeb 64% (Curzate M8)	>2000	100	0.0	0.0
Dimethomorph 50% (Acrobat 50)	10	100	0.0	0.0
Control	-	-	65.0	-

antihelmintic activity, but Strychnine, Pseudostrychnine, N-oxystrychnine, Geissoschizine, Brucine-N-oxide and Secologanin were known to have antibacterial, antiviral and antifungal activity. Therefore synthetic strychnine, its hydrochloride and brucine sulpbate were procured and tested against *M. incognita* at 1000, 1500 and 2000 ppm concentrations. Strychnine hydrochloride showed 97% nematicidal activity at 2000 ppm whereas, strychnine showed 75% activity and Brucine sulpbate 74% activity over control at 2000 ppm.

Evaluation of biocontrol agents

The efficacy of endophytic bacteria (BP-35, 25, 17 and TC-10) and rhizobacteria (IISR-853 and IISR-6) against *P. capsici, R. similis* and *M. incognita* was evaluated in the field. Observations on growth parameters indicated that application of TC-10 + Metalaxyl-mancozeb and IISR- 853 + Metalaxyl-mancozeb were promising with increased height and canopy of the plant. No disease incidence was noticed during the period.

Evaluation of resistant lines and biocontrol agents

A field trial was in progress with three promising disease/nematode resistant lines (HP 39, IISR Shakthi, C 1090) and biocontrol agents (*Trichoderma harzianum, Pseudomonas fluorescens* (IISR 6 and IISR 853) and *Pochonia chlamydosporia*). The establishment and growth of plants was higher in C 1090 + IISR 6 followed by IISR Shakthi + *T. harzianum* and HP 39 + IISR 853. No disease incidence was observed during the year.

Integrated management of P. capsici, R. similis and M. incognita in nurseries

An experiment was conducted in the nursery with solarized potting mixture, with 12 treatments including chemicals and biocontrol agents. Observations on disease incidence indicated that all the disinfection methods and integrated and chemical methods were equally effective in checking disease incidence. Besides, soil moisture content was maintained below 15% by irrigating the plants once in two days. Among the integration of plant protection chemicals, copper oxychloride 0.2% + phorate was comparatively better in reducing the infection (54% disease reduction over control) under challenge inoculated conditions followed by potassium phosphonate 0.3% + phorate (44.95%). No difference in disease incidence was noticed between NPK treated and non-treated plants.

Role of phenyl propanoids in black pepper - burrowing nematode interactions

Estimation of COMT and C4H activities

Caffeic acid–O-methyltransferase (COMT) and cinnamic acid-4-hydrolase (C4H) of the roots of the susceptible Sreekara and resistant HP-39 were estimated at 48 h, seven days and one month after inoculation. C4H activity increased in HP39 on inoculation with *R. similis* and reached almost three times by seven days after inoculation compared to control. The changes in C4H activity were only marginal in wounded samples. The activity declined by one month after inoculation in both cases. However, in the susceptible Sreekara there were no discernible

changes in the enzyme activity. COMT activity increased within 48 h after *R. similis* inoculation in both Sreekara and in HP-39, compared to the activity in control plants and decreased thereafter.

Estimation of phenyl propanoids

Lignin content of the roots was comparatively low in resistant HP-39 than the susceptible Sreekara. However, it decreased significantly in Sreekara within 48 hours of inoculation, but increased to control values in a week. In HP-39, which had only 1/3rd the lignin content of the susceptible variety, the decrease in lignin content continued up to the 1st week after inoculation and increased to double the control values in a month.

Viral disease

Indexing and maintenance of virus-free mother vines

PCR based method was used for indexing black pepper plants of popular varieties against *Piper yellow mottle virus* (PYMoV). The identified virus-free material was then maintained and multiplied under insect-proof conditions.

Transformation of black pepper with virus constructs

Two constructs each of *Piper yellow mottle virus* (PYMoV) and *Cucumber mosaic virus* (CMV) in *Agrobacterium tumefaciens* EHA 105 were used for transformation. The embryogenic mass was infected with *Agrobacterium* harbouring respective constructs and cultured on basal SH medium for 48 h. The co-cultured embryogenic mass was transferred to selection medium and growing points were removed onto the same medium with a higher kanamycin concentration. The proliferated embryogenic mass was then transferred to basal SH for further development into fully developed plantlets. Fully developed plantlets were transferred individually to WPM. Total genomic DNA isolated from leaves of fully developed plants was used to confirm the presence of inserts through PCR. The PCR positive plants were hardened under green house for challenge inoculation with viruses (Fig 1.4).

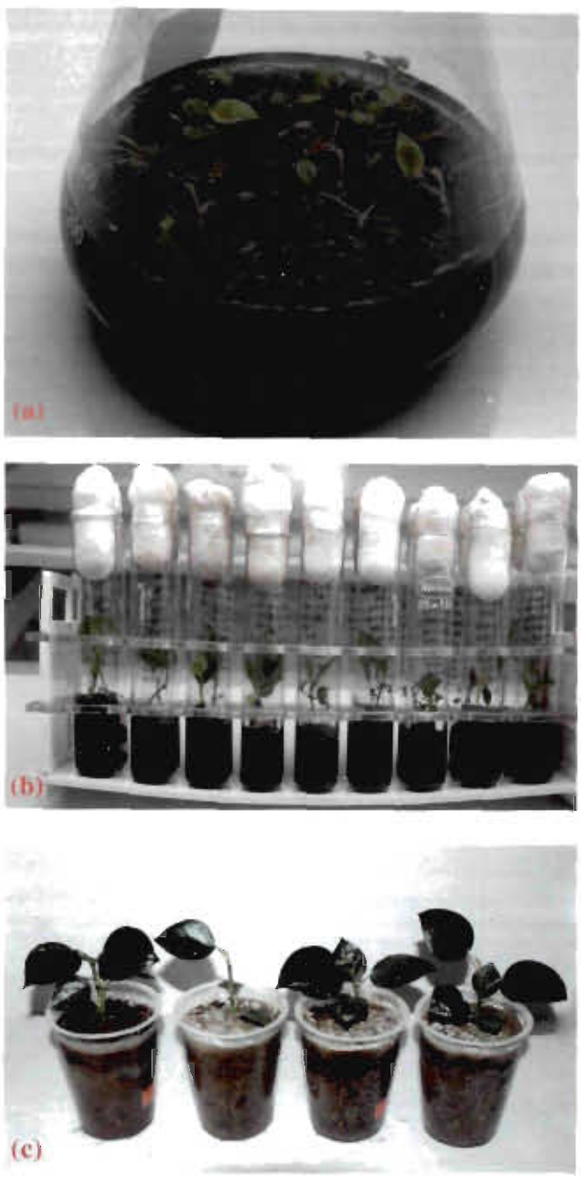


Fig. 1.4 Transformation of black pepper with viral constructs (a) Plantlets of 2-3 leaves in liquid medium (b) Well developed putative transformants in WPM medium and (c) Putative transgenic plants hardened in the green house

Screening of transgenic plants for the presence of transgene

Total genomic DNA isolated from 100 mg leaves of hardened plants were used for PCR and dot blot hybridization. All PCR positive plants were used for dot blot hybridization. About 1µg of DNA was dotted in to nitrocellulose membrane and fixed by heating at 80°C for 2 h. A 940 bp DNA fragment corresponding to the kanamycin gene was labeled with digoxigenin and used as a probe for hybridization according to the manufacturer's instructions (Roche Molecular Biochemicals, Mannheim, Germany). The hybridized membrane was washed, subjected to chemilluminescent development using CSPD substrate,

and then exposed to X-ray film. Plasmid pBI121 (250 ng) was used as a positive control while genomic DNA from a non-transformed plant served as a negative control. Of the 99 plants tested from different constructs, 78 showed positive reaction in dot blot.

Screening of Piper spp against PYMoV

Four hundred sixty accessions of *Piper* spp including wild *Piper* species, cultivated and wild species of *P. nigrum* were screened for PYMoV under glass house conditions through mealybug, *Ferrisia virgata*. After 60 days of inoculation, the plants were scored both visually (based on symptoms) and through PCR test using PYMoV specific primers. The results showed that all the 460 accessions tested were susceptible to PYMoV.

Pollu beetle

Identification of resistant sources

One hundred and eighty five accessions of black pepper available in the germplasm conservatory were screened against pollu beetle in the field. Among the cultivars, Accs. 78 and 4044 remained free from pollu beetle attack during the year. The highest berry damage (36.5 %) was recorded on Acc. 1484 followed by Acc. 1611 (34.3%). Among the hybrids, Accs. 1055, 1069, 1769 and 1752 remained free from pollu beetle damage. Acc 1339 recorded 100 % berry damage, followed by Acc 807 (73.5%).

Characterization of germplasm

From the present *ex-situ* gene bank collection of 447 accessions/ hybrids and disease resistant selections, 50 accessions have been characterized for morphological and yield characters based on IPGRI descriptor. Variability was found to be the maximum *(Table 2.1) for capsule wet weight (91.22 %)* followed by number of capsules (80.80 %) and minimum for capsule characters (capsule length 0.15% and capsule width 0.09%). Two promising accessions (IC349630 and IC547146) were identified with desirable yield contributing characters. During this year five accessions were collected from Vandiperiyar block of Sabarimala area.

Characterization for biotic and abiotic stress

During the year fifty eight cardamom accessions were screened for leaf blight and rhizome rot resistance under field conditions using 1-6 and 1-5 disease rating scales, respectively, and the percent disease index (PDI) was calculated. The accessions were further grouped into different categories based on their reaction to the disease.

Breeding for high yield and disease resistance

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. Large number of hybrids *between high yielding and disease resistant selection* have been evaluated to exploit the heterosis for yield and disease resistance. The PET I was laid out with *16 hybrids, the highest three year mean yield was* recorded in the hybrid combinations RR1 x CCS1 and CCS1x RR1 with 868 and 765 kg/ha respectively.

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) in PET II. The crosses were effected in four combinations (both direct and reciprocal). Among them ASH and GG x NKE 19 recorded significantly higher mean yield of 1119 and 833 kg/ha, respectively (Table 2.2).

Table 2.1. Variability of morphological and yield characters recorded in cardamom germplasm.

Characters	Range	Mean	S.D	C.V	Promising genotype
Plant height (cm)	128-323	198	0.42	20.99	IC 547218
Total tillers	5.80-42.20	19.35	6.69	34.56	IC 547142
Bearing tillers	4.25-23	11.29	4.08	36.10	IC 547142
Leaf length (cm)	40-63.40	49.72	5.18	10.42	IC 547222
Leaf width (cm)	5.60-12.10	8.05	1.19	14.78	IC 547165
No. of panicles	1.50- 30.60	11.72	6.10	52.03	IC 547146
Panicle length (cm)	24.5 – 56.2	36.28	6.95	19.17	IC 547144
Inter node 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/capsule	9.4-24.2	15.83	3.31	20.89	IC 547147
No. of capsules/plant	23-819.46	212.47	171.68	80.80	IC 547146
Capsules wet weight (g)	5-754.25	188.90	172.32	91.22	IC 349630 & IC 547146

Table 2.2. Performance of cardamom hybrids for yield

Entries	Dry yield (kg ha^{-1})			
	2007	2008	2009	Mean
GG x NKE12	934.76	174.51	213.16	440.81
GG x NKE 19	1635.35	479.83	384.99	833.39
NKE12 x GG	1746.75	157.29	320.81	741.62
NKE19 x GG	1212.23	355.54	235.67	601.15
GG Seedling	1413.03	295.04	236.97	648.35
GG Suckers	1206.93	94.44	124.91	475.43
NKE12	75.00	43.50	46.00	54.83
NKE19	1120.04	43.56	101.08	421.56
CCS1	1723.38	190.85	326.19	746.81
ASH	1930.90	825.21	601.78	1119.30
Mean	1299.83	265.98	259.16	608.32
CV%	41.23	29.95	52.99	
CD (p=0.05)	168.89	7.57	235.24	

Morphological characterization of selected germplasm accessions

Cardamom genotypes, 100 numbers depicting maximum diversity (including eight released varieties, 10 farmer's varieties and seven related genera) were selected for morphological characterization and preparing a descriptor with about 46 taxonomically and agronomically important characters based on IPGRI cardamom descriptor and DUS guidelines (PPV & FRA 2009). Available morphological and floral characters were recorded as per the proforma devised in the selected lines.

Molecular characterization

DNA was isolated from 109 accessions using the protocol standardized at IISR for molecular profiling. ISSR profiling of cardamom genotypes and related genera is in progress (Fig 2.1).

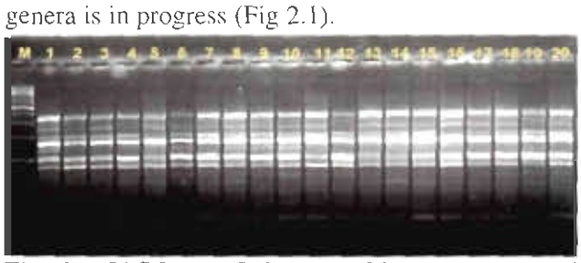


Fig. 2.1. ISSR profiling of 20 genotypes of cardamom using ISSR primer, UBC 807

Give lane information - Lane 1-20: PV1, CCS, RR 1, NKE 12, ICRI 2, ASH 1, ASH, AMB 2, CP 10, MB 3, GG, Sampaji, Palakuzhi local, Vander cardamom, Kalarickal White, Pink stem, Narrow leaf, VA1, MY1, MA 29; Lane M: 1 kb ladder (Fermentas)

Microsatellite development

EST database searches of cardamom did not reveal SSRs. But EST data base searches for sequence information containing micro satellites from ginger, a closely related species revealed over 900 SSR containing regions. Twelve rice SSRs were tested in small cardamom for cross generic amplification and three of them gave amplification in cardamom (Fig 2.2).

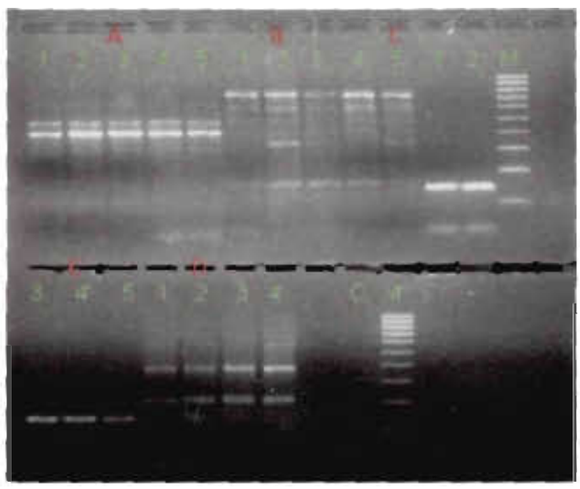


Fig 2.2. Profiling of five genotypes of cardamom using four rice SSR primers

Lane 1-5: RR1, GG, ICRI 3, Mudigere 1, PV 1; Lane C: Negative control, Lane M: 100 bp Ladder (Fermentas). Primers: A - RM 01; B - RM 72; C – RM 117; D – RM 131.

Identification of molecular markers linked to *Katte* resistance genes

DNA was extracted from two parents namely Green Gold (*katte* susceptible) and NKE 12 (*katte* resistant) and PCR was performed with seven sets of ISSR primers (834a, 841a, 854a, 866, 867, 812 and 815) to study parental polymorphism. Two primers (866, 815) have shown polymorphism, primer 866 for susceptible parent-GG and primer 815 for resistant parent-NKE12.

Drought tolerance in cardamom

Three genotypes RR1 (IC 349591), CL-893 (IC 349537), Green Gold (IC 349550) which is relatively tolerant to moisture stress and CCS -1 (IC 349589) a susceptible genotype were crossed to develop drought tolerant variety with high yield and quality characters. CL- 893 and its cross combinations recorded better growth and yield parameters which were reduced

under stress. Plant height ranged from 204-296 cm with a mean of 262 cm in control and in stress it ranged from 201-280 cm with a mean of 257 cm. Number of panicles per clump ranged from 20.6-37.4 with a mean of 28.5 and in stress it ranged from 11.4-20.8 with a mean of 16. Dry capsule yield (kg/ha) ranged from 220.6 to 521.7 with a mean of 402.9 kg/ha in control and in stress it ranged from 38.6 to 267.7 with a mean of 164.1 kg/ha. Cross CCS1 x 893 recorded maximum yield (521.7 kg/ha) in irrigated condition followed by CCS1 OP (519.7 kg/ha). In stress conditions, GG x CCS1 recorded maximum yield (267.7 kg/ha) followed by 893 self (210.7 kg/ha). GG x 893 recorded 183.9 kg/ha and 893 x GG yielded 187 kg/ha with bold green capsules (Fig 2.3).

Enzyme assays in selected drought tolerant and susceptible genotypes

Superoxide dismutase (SOD) as well as glutathione reductase (GR) activities differed significantly among cardamom accessions both under control and stress conditions. But the accessions showed similar activity between control and stress treatments indicating that these enzymes may not be useful as markers for stress tolerance. Ascorbate peroxidase activity was inconsistent and accession to accession variation in activity was high.

Flavour profiling of essential oil

Twenty accessions of cardamom germplasm were evaluated for essential oil content. Oil content in capsules ranged from 3.5-6.7% on dry weight basis, with highest in GG-self followed by GG-OP (6.0%). GC-MS analysis of the oil indicated that these accessions contained 26.2% and 27.7% 1,8- cineole and 45.8% and 46.2% á- terpinyl acetate, respectively.

Leaf spot

Screening of germplasm

Thirty eight breeding lines and twenty collections of cardamom were screened under natural field conditions to identify resistant sources against leaf blight and rhizome rot. Six genotypes each of breeding lines and collections exhibited highly resistant reaction to rhizome rot. Six genotypes *viz*., IC-547222, IC-547223, IC-349645, IC-349649, IC-547158 and IC-349637, exhibited moderately resistant and highly resistant reactions against leaf blight and rhizome rot, respectively.

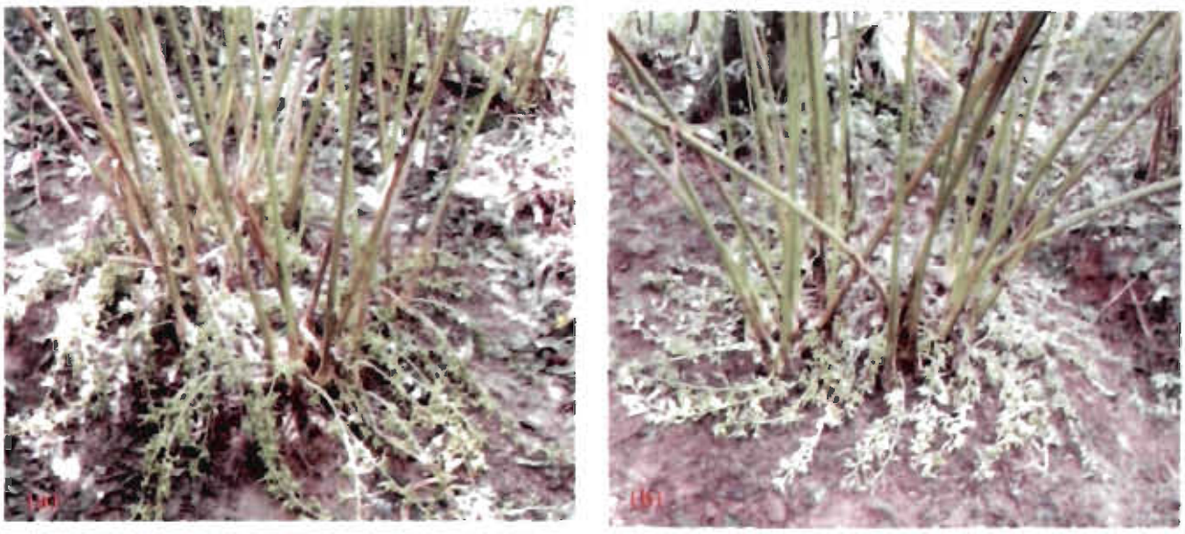


Fig 2.3. Hybrid combinations with yield and quality traits
(a) GG x 893 (high yield with green capsule); (b) 893 x GG (high yield with compact setting)

Viral diseases

Development of diagnostics

Six *katte* isolates were collected from Karnataka (5 isolates) and Kerala (1 isolate) and established under insect proof glass house conditions. Enzyme Linked Immunosorbent Assay (ELISA) based detection of *Cardamom mosaic virus* (CdMV) was standardized and the titre of the antiserum was found to be 1:250. A procedure for total RNA isolation from cardamom and

detection of CdMV through reverse transcription–polymerase chain reaction (RT-PCR) using primers designed for the conserved region of coat protein was standardized (Fig 2.4). The RT-PCR method was validated by testing more than 50 cardamom field samples representing different geographical locations of Karnataka and Kerala.

Two *kokke kandu* isolates from Karnataka and one Nilgiri Necrosis disease isolate from Suryanelli (Idukki District, Kerala) were collected and established under insect proof glass house conditions. Surveys conducted in major cardamom growing areas of Karnataka and Kerala, revealed the prevalence of *Banana bract mosaic virus* (BBrMV) infection in Sirsi (Uttara Kannada District, Karnataka), Upputhara, Konnathady and Vellathooval villages (Idukki District, Kerala). The symptoms induced by BBrMV in cardamom included discontinuous or continuous spindle shaped streaks along the veins, continuous light green or light yellow streaks along the midrib and discontinuous mottling along the pseudostem and petiole (Fig. 2.5). An RT-PCR method using virus specific primers designed for the coat protein gene was developed for the detection of BBrMV infecting cardamom.

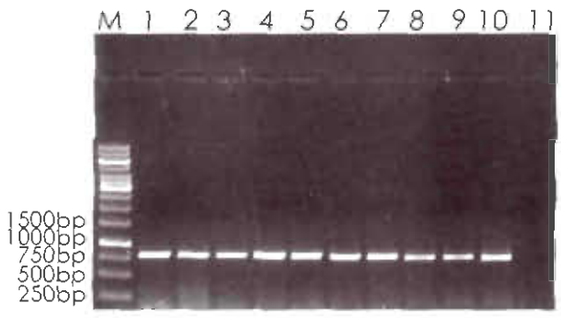


Fig. 2.4. Detection of CdMV by RT-PCR.

Lane M: DNA molecular size markers; Lane 1-9: cardamom samples from different regions; Lane 10: Positive control (known infected plant); Lane 11: Negative control (known healthy plant)

Fig. 2.5. Symptoms of *Banana bract mosaic virus* (BBrMV) infection in cardamom

GINGER

Conservation, characterization, evaluation and improvement

About 680 accessions of ginger are being maintained in the field germplasm conservatory. Herbarium specimens of 50 ginger accessions were prepared and mounted and preserved in the herbarium facility. In ginger, 500 kg of IISR-Varada, 250 kg of IISR-Mahima and 125 kg of IISR-Rejatha were produced as breeders' seed. Fifty accessions were characterized based on quality parameters in which the oil content varied from 1.2 to 2.0%, oleoresin from 1.6 to 3.4% and fibre content from 2.7 to 7.6% with minimum variation of 9.08% in moisture, followed by oil content (15.02%).

In a trial laid out with 13 high oil ginger accessions along with a check (IISR Varada), oil content varied from 1.2 to 2.8%, the maximum being in Acc.162, followed by Acc.95, while the oleoresin content ranged from 2.0 to 4.6% and fibre from 1.87 to 5.13%. Of the 12 exotic (Nepal) lines evaluated for quality parameters, the oil content ranged from 1.2 to 2.4%, oleoresin from 3.3 to 4.8% and fibre from 2.50 to 5.11, the lowest in Acc.239, followed by Acc. 91 (4.0%).

Multiplication of high pollen fertility line and pollination studies

The Acc. 195 was multiplied and morphological characters were recorded. *In vivo* and *in vitro* pollination studies were performed using Accs. 3, 4, 7, 12, 25 and 77. No seed set was obtained so far. Ovule development was observed in case of *in vitro* pollination using flowers of Acc. 7.

Maintenance of M3 and M4 generations of irradiated plants

One hundred and seventy seven M3 generation plants and 123, M4 generation plants derived from irradiated buds of different ginger cultivars were maintained. Morphological observations and yield were recorded. Variation depending upon the radiation dose and varieties was observed. Pollen fertility analysis was completed in 11, M3 generation plants one, M4 generation plant and 10 cultivars. Pollen fertility was low (< 25%) in all of them.

Cytological studies

Analysis of mitotic metaphase plates of high pollen fertile line, Acc. No. 195 showed that the plant is a tetraploid having 2n=44 in majority of cells. Cytological analysis of 15 plants of M4 generation derived from irradiated buds showed normal chromosome number, 2n=22.

Optimum P/Zn ratio requirement

In earlier studies the optimum leaf P/Zn level for ginger was worked out as 90 through response functions. To validate this, soil Zn and P levels were analyzed at the time of planting and leaf/ soil samples were taken for analysis at 60 DAP. The soil P/Zn ratio was in the range of 8.8 to 15.3 and that of leaf was 168 to 228. To adjust the ratio into the optimum range, soil application of Zn as well as foliar application were given and the soil and leaf samples were analysed on 120 DAP and yield data was recorded. The soil Zn ratio has lowered to 3.4 (varying from 1.2 to 4.9) and the leaf P/Zn ratio was brought down to 73 (varying from 49 to 86) by the supplementation. The P/Zn ratio of the control was 110. The rhizome yield in Zn supplement treatment was 7.76 kg/ bed as compared to 5.7 kg/bed in control with an increase of about 35 % over the control.

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 8.1 kg/ 3 m^2 under organic system which was on par to other management systems (7.4–7.7 kg/bed). Under organic management var. Mahima has yielded higher (9.5 kg/ bed) and Rejatha has yielded on par with conventional

system. Highest yield in Varada was recorded in integrated (7.4 kg/bed) on par with conventional and organic systems. Soil microbial parameters *viz.*, phosphodiestrase and dehydrogenase were higher under organic system. FYM (15t), neem cake (2t) and vermicompost (4t) application supplemented with Panchagavya and BD (501) sprays recorded significantly highest yield (11.16 kg/bed) on par with FYM + NC + VC application (9.7 kg/bed).

Quality

Variability in germplasm

Among the 13 high oil types Acc.162 had high oil of 2.8%, 4.6% oleoresin and 4.2% fibre. Accs. 95, 50,197 and 99 also retained high oil property. Among the identified low fibre types Accs. 91, 239 retained low fibre and high quality. Among the Nepal collections, Acc. 591 with 2.4% oil, 4.8% oleoresin and 3.5% fibre possessed high quality. Among the 35 germplasm samples Acc. 605 had 2% oil and 3.4% oleoresin.

Essential oil profile

Thirty one accessions of ginger were evaluated for essential oil content and it ranged from 0.7% - 2.3% with the highest yield in Acc. 566 followed by Acc. 730 (2%). GC – MS analysis of essential oil of ten accessions indicated compositional variations among the accessions and the chief components namely, ar-curcumene, zingiberene, farnesene and β-sesquiphellandrene ranged from 6-15%, 13-26%, 5-11% and 8-16%, respectively. Acc. 29 (26%) and 21 (23%) were superior in zingiberene content.

Effect of micronutrients on flavour

Preliminary studies indicated that application of Zn had no significant effect on essential oil content in ginger and turmeric. The application of Zn in soil resulted in higher levels of citral-a, citral-b and zingiberene in ginger.

Studies on non-volatiles

Ten accessions were analysed for gingerol composition. Total gingerol content in these accessions varied from 1.28-5.83% whereas 6-gingerol, 8-gingerol and 10-gingerol were in the range 0.6-5.3%, 0.11-0.41% and 0.06-0.26%, respectively.

Shoot borer

Life cycle

The life cycles of shoot borer were studied on six field resistant and susceptible accessions of ginger. The average adult longevity, pupal period and fifth instar larval period were 2.9, 12.4 and 7.5 days, respectively on resistant accessions and 2.8, 15.7 and 7.8 days, respectively on susceptible accessions. However, the differences in days taken to complete each stage were not statistically significant.

Isolation of EPNs

Sixty two soil samples were collected from ginger rhizosphere from different locations of Kozhikode, Wayanad, Kottayam, Idukki (Kerala) and Kodagu (Karnataka) districts, Guwahati (Assam), Faizabad (Uttar Pradesh) and Barapani (Meghalaya) for detection of entomopathogenic nematodes (EPNs). EPNs were extracted by insect-baiting and white trap method. Out of 62 soil samples baited out, only two strains of EPNs were obtained. Among the two strains of EPNs, one strain each was found from Peruvannamuzhi, and Faizabad.

Four hundred twenty four shoot borer larvae were collected from pseudostem of ginger from Kozhikode, Wayanad and Kodagu districts. Out of these, 112 larvae were found dead. Among these dead larvae, 11 were associated with mermithids, eight with rhabditids and only one was EPN.

Rhizome rot

Evaluation of rhizobacteria

The promising rhizobacterial strains were evaluated for their biocontrol and growth promotion potential on ginger in the green house. The strains GRB 35 (*Bacillus* sp.) and GRB 36 (*Klebsiella* sp.) showed highest disease suppression followed by GRB 70 (Unidentified) and GRB 91(Unidentified) against *Ralstonia solanacearum*. The isolates GRB 35 and GRB 91 followed by GRB 68 (*Seratia* sp) showed highest disease suppression against *Pythium* sp. GRB 70 followed by GRB 35 and GRB 68 were more promising for obtaining higher germination (Table 3.1).

The levels of microbial substrates (dissolved organic C and N; DOC and DON, respectively) were significantly greater in treatments involving PGPR strains (GRB 25, GRB 36, GRB 38 and GRB 70) applied in combination with chemical fertilizers. The PGPR strains applied alone did not significantly influence soil microbial activity. However, when applied in combination with 75% N + 100% P + 100% K, the PGPR strains positively influenced microbial biomass-C, -N, -P, soil respiration and N mineralization. Also, the activities of urease, acid- and –alkaline phosphatase

and dehydrogenase were highest in treatments involving PGPR (GRB 36, GRB 38) applied in combination with 75% N + 100% P + 100% K. The metabolic quotient (qCO_2), which has been used as a bioindicator for environmental stress, was markedly lower in treatments involving PGPRs.

The selected rhizobacteria were also evaluated in field on ginger and the rhizobacterial isolate, GRB 68 showed good germination percentage, disease suppression and higher yield followed by GRB 35 and GRB70.

Table 3.1 Evaluation of rhizobacteria against bacterial wilt and rhizome rot in ginger in the greenhouse

Treatment	Germination (%)	Bacterial wilt (%)	Rhizome rot (%)
Burkholderia sp. GRB 25	81.3 (64.6*)	96.3 (78.9)	96.3 (78.9)
Bacillus sp. GRB 35	96.3 (78.9)	35.2 (36.4)	48.1 (43.9)
Klebsiella sp. GRB 36	69.9 (56.7)	44.4 (41.8)	66.7 (54.7)
Unidentified GRB 38	96.3 (78.9)	88.9 (70.5)	61.1 (51.4)
Unidentified GRB 57	88.9 (70.5)	81.5 (64.5)	92.6 (74.2)
Seratia sp. GRB 58	88.9 (70.5)	88.9 (70.5)	92.6 (74.2)
Seratia sp. GRB 68	96.3 (78.9)	66.6(54.7)	57.4 (49.3)
Unidentified GRB 70	100 (90.0)	48.1 (43.9)	70.4 (57.0)
Unidentified GRB 71	96.3 (78.9)	88.9 (70.5)	70.4 (57.0)
Unidentified GRB 91	85.2 (67.4)	53.7 (47.1)	44.4 (41.7)
Pseudomonas aeruginosa -IISR 51	88.9 (70.5)	81.5 (64.5)	62.9 (52.5)
Streptomycin sulphate 1g/L (seed treatment)	88.9 (70.5)	72.2 (58.2)	74.1 (59.4)
Metalaxyl- Mancozeb 1.25g/L (Seed treatment + Soil drench)	88.9(70.5)	88.9 (70.5)	51.8 (46.1)
Control	66.6 (54.7)	100 (90.0)	100 (90.0)
CD (p=0.05)	18.4	16.87	21.93

*Values in parenthesis are Arcsine transformed

TURMERIC

Conservation and characterization of germplasm

About 1173 accessions of turmeric are being maintained at field germplasm conservatory. Herbarium specimens of 50 turmeric accessions were prepared and mounted and preserved in the herbarium facility. In turmeric 1057 kg Prabha, 1571 kg Prathibha, 1250 kg IISR-Alleppey Supreme, 1000 kg IISR-Kedaram were produced as breeders' seed.

Maintenance and evaluation of seedling progenies

Two hundred and fifty six seedling progenies and 23 mother plants were recorded with morphological observations and yield. High variability with respect to yield was observed. Twenty nine progenies showed multiplication rate above 20 times. Sixty eight second generation seedling progenies of five seedling progenies were also maintained. Many of these second generation progenies showed very high multiplication rate.

Chromosome number analysis was also completed in 25 progenies. All of them showed deviation from normal number of 2n=63. Most frequently occurring number was 2n=84 (Table 4.1).

Percentage of curcumin, oil and oleoresin was analysed from 12 mother plants and 150 seedling progenies of last year harvest. Wide variation was observed between seedling progenies of different mother plants as well as among the progenies of the same mother plant (Table 4.2).

Development of microsatellite markers and characterization of Curcuma

Characterization of the 30 geographically distinct turmeric accessions using microsatellite markers indicated the existence of limited genetic diversity. Grouping of accessions within the cluster was independent of geographical area, except in a few cases. The identification of identical allelic fingerprints generated by geographically distinct accessions indicated the movement of turmeric within the length and breadth of the country and subsequent popularization and acquiring of a different vernacular name. From this study, it is evident that accessions collected on the basis of vernacular identities may not be genetically distinct (Fig. 4.1).

Pollination studies in cultivars

Sixty five flowers of Rajendra Sonia and more than 144 flowers of BSR-2 were manually self pollinated and observed for fruit setting. No fruit set was observed. Pollen fertility analysis by staining showed 60.4% fertility in Rajendra Sonia and 55% in BSR-2. *In vivo* germination on stigma was found to be sparse

Table 4.1 Chromosome number of 25 seedling progenies

Chromosome Number (2n)	Seedling Progeny Number
82	126/2, 138/29
84	126/10, 126/12, 126/13, 126/15, 138/8, 138/24, 138/35, 138/36, 138/39, 138/64, 138/66, 138/70, 138/76, 415/1, 415/4, 434/11, 434/13, 447/1, 449/3
86	126/16, 415/10
78	138/68
76	138/17

Table 4.2 Comparison of quality parameters among few mother plants and their progenies

Mother Plant No.	Number of progenies analyzed	Quality in mother plants			Range among seedling progenies		
		Oil (%)	Oleoresin (%)	Curcumin (%)	Oil (%)	Oleoresin (%)	Curcumin (%)
18	20	4.00	7.66	1.73	2.67-6.0	5.38-12.09	0.88-3.71
20	3	3.87	7.63	1.70	3.6-4.8	7.29-10.79	1.03-1.77
65	8	4.40	7.32	1.85	3.2-5.2	5.7-9.89	1.05-3.13
69	6	4.00	8.67	1.99	4.4-5.6	7.92-10.88	1.02-1.91
126	14	5.20	14.40	5.67	3.2-6.0	6.43-10.9	0.90-3.24
138	66	4.00	10.70	3.71	2.0-7.2	6.09-13.34	0.64-3.61
300	4	5.20	9.76	1.58	3.6-4.8	5.8-11.49	0.19-3.00
415	10	4.40	8.66	2.73	2.67-6.4	5.19-11.55	0.98-2.97

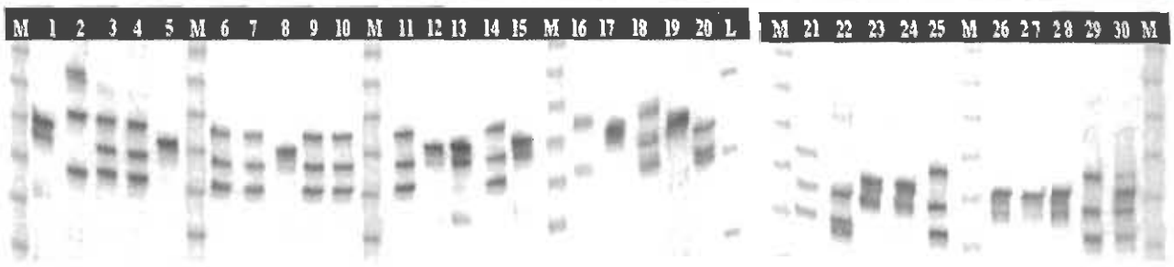


Fig. 4.1. The amplification pattern of SSR markers in 30 turmeric accessions.

Lane N - 10 bp DNA ladder, Lane M- 20 bp DNA ladder, Lane 1- 30- turmeric accessions collected from diverse geographical locations from India.

after 4 h of pollination. Operation of self incompatibility mechanism in these varieties is suspected.

Nutrient requirement for targeted production

Based on the initial soil availability of major nutrients, nutrient required for targeted yield production (NR), contribution of nutrient from soil (CS), contribution from FYM (CFym) and contribution from fertilizer (CF) were calculated for turmeric var. Prathiba and fertilizer doses to obtain yield targets was calculated and applied. The highest yield up to 22.0 kg/bed was obtained for the target levels 15 & 20 kg/bed. Through targeted equation, nutrient requirement for 15 & 20 kg/bed yield could be predicted with minimum deviation of -5.8 to +14.8%. At highest target level of 25 kg/bed there existed a deviation of -44% which might be due to the excess of fertilizer nutrients causing imbalance. The yield increase as compared to the normal recommendation was in the range of 42-75%.

Yield kg/bed	N	P_2O_5 (g/bed)	K_2O	Realized yield (kg/bed)	Deviation %
15	30	-	60	17.2	+ 14.8
20	60	-	130	18.8	- 5.8
25	90	15	210	13.8	- 44.6
Recommended	35	25	60	9.75	-

Micronutrient on quality

Application of one foliar spray of 0.25% Zn and soil application of 5 kg/ha Zn have recorded higher rhizome yield of 14.5 and 13.7 kg/ bed, respectively. They were on par with 10 kg Zn soil application and two foliar sprays. All the Zn application treatments recorded significantly superior yield than control. Oil, curcumin and oleoresin contents were significantly higher in two foliar sprays of Zn @ 0.25%. Application of B as two foliar sprays (0.2%) has increased the yield significantly up to 16.3 kg/bed on par with lime application alone

(14.7 kg/bed), indicating the benefits of correcting the soil pH in increasing the B availability. Boron showed no influence on oil and curcumin contents. But oleoresin content increased significantly with two foliar sprays @ 0.2% B application (11.5%).

Organic Farming

Turmeric was grown organically by applying FYM, vermicompost, ash and rock phosphate, Azospirillum and phosphobacteria and, *Trichoderma* and *Pseudomonas* sp. (IISR-6 & 853) as bio control agents for disease control. Organic system recorded significantly highest rhizome yield of 13.7 and 12.0 kg/bed in Alleppey Supreme and Prathiba, respectively as compared to conventional system, which recorded 10.5 and 9.7 kg/bed. The integrated system recorded on par yield levels of organic system. Soil enzyme activities under integrated system was significantly higher than conventional system but was on par with organic system. FYM + neem cake (NC) + vermicompost (VC) application yielded significantly highest rhizome yield (14.98 kg/bed) on par with FYM + NC + VC supplemented with Panchagavya (13.0 kg) and FYM (30t) application alone (12.7 kg).

Effect of flowering on yield and quality

Eleven varieties of turmeric *viz*., Rajendra Sonia, Suranjana TCP, Kedaram, BSR 2, Roma, Prathibha, Alleppey Supreme, Resmi, Duggirala red, Mega turmeric 1 and Narendra Haldi were evaluated for two years in the field. Out of these, Duggirala red and Mega turmeric 1 did not flower in both the years (2008-09 and 2009-10), Narendra Haldi flowered during second year (2009-10) only. The two year mean indicated that on an average flowered plants recorded fresh yield of 504 g/clump with a range 298 to 956 g and CV of 41.9%, whereas, non-flowered plants yielded 524g/clump with a range 321 to 861 g and CV of 31.1%. Similarly, mean dry recovery of flowered plants was 15.9% with a range of 10.0 to 19.2% and CV of 21.1%; whereas, non-flowered plants recorded 17.5% with a range of 12.7 to 19.8% and CV of 17.2%. The study indicated that flowered and non-flowered plants did not differ in yield and dry recovery (Table 4.3).

Cloning of *pal* gene

Partial sequence of *pal* gene was isolated with PCR conditions optimized using *pal* gene specific primers, designed based on sequences available in the public domain. A 522 bp product amplified by PCR was isolated, cloned and sequenced. BLAST analysis

Table 4.3. Comparisons of yield and curcumin content of flowered and non-flowered plants

Varieties	Fresh yield (g/clump)		Dry recovery (%)		Dry yield (g/clump)		Curcumin (%)		% plants flowered
	F*	NF**	F	NF	F	NF	F	NF	
Rajendra Sonia	956	861	10.0	12.7	95.9	109.0	4.44	4.36	2.00
Suranjana TCP	604	576	14.7	17.7	88.6	101.9	4.05	3.73	1.50
Kedaram	325	393	16.4	19.8	53.4	77.8	4.05	5.10	0.88
BSR 2	525	554	12.1	12.8	63.6	71.1	5.17	4.57	1.50
Roma	298	321	19.2	19.5	57.2	62.7	4.06	4.75	1.50
Prathibha	419	486	18.8	19.8	78.9	96.1	4.09	5.06	0.56
Alleppey Supreme	524	438	18.3	18.4	95.9	80.5	4.38	4.35	0.74
Resmi	383	561	17.6	19.2	67.4	108.0	4.54	4.64	1.88
Mean	504.1	523.8	15.9	17.5	75.7	88.8	4.23	4.57	1.32
SD	211.1	163.0	3.4	3.0	15.2	15.7	0.21	0.48	
CV (%)	41.9	31.1	21.1	17.2	20.0	17.7	5.06	10.43	
CD (p=0.05)	NS		NS		NS		NS		

*Flowered plants; ** Non-flowered plants

revealed that the sequence showed 94.3% identity with the *pal* gene from ginger.

Influence of biochemical factors on curcuminoid levels

Assay of downstream enzymes

Assay of Hydroxy cinnamate: CoA ligase (4CL; E.C.6.2.1.12) (using two substrates - *p*-coumaric acid and ferulic acid) in 4, 5 and 6 month old roots and rhizomes and curcuminoid synthase (CS) in 5 and 6 month old roots and rhizomes of high and low curcumin turmeric accessions was completed. The 4CL activity was negligible during the later phase of rhizome development. CS activity in the roots of high curcumin varieties – Prathibha, Suguna, Sudarsana and Alleppey Supreme (66%) – and the low curcumin accessions – 170, 279, 384 and 390 - increased significantly from 5th to 6th month after planting. In rhizomes, the CS activity in the high curcumin varieties was either on par or increased slightly; while in the low curcumin accessions, the CS activity decreased from the 5th to 6th month.

Secondary metabolites in turmeric accessions

Lower concentration of oleoresin and essential oil was seen in accessions with low levels of curcumin indicating a partial involvement of these metabolites in the synthesis of curcumin precursors. GC and GC MS analysis of the essential oils from representative samples of high and low EO types indicated higher levels of turmerone, ar-turmerone and zingiberene in the accessions with high essential oil content. These components have been conclusively proved for its varied medicinal and pharmacological properties.

Starch, the major reserve carbohydrate in turmeric rhizome, exhibited an inverse relationship with curcumin levels among the turmeric accessions screened. This shows that the primary metabolite is being utilized for the formation of the very early precursors of cucumin biosynthesis, thus supporting the phenyl propanoid pathway accepted for the pigment synthesis. HPLC analysis to find out the distribution of the three curcuminoids was also done during the study in a few turmeric accessions. Among the 11 high curcumin types analysed, all the accessions except Accn 608 had higher levels of curcumin I. Accessions 366, 608 and 702 had elevated levels of curcumin II, while Accs 227 and 883 possessed higher levels of curcumin III. Among the low curcumin accessions, Accs 5,38,48,83 and 355 were having high levels of curcumin I, which were also rich in curcumin II. Highest range of variation was seen in the case of curcumin III, which showed a range from 4.74 to 23.8%.

Post Harvest Technology

Storage studies

Turmeric variety Prathiba stored in 90% nitrogen and 10% carbon dioxide in three layered laminated polyethylene packing was analysed for oil, oleoresin and curcumin. Mild reduction in moisture content and oil was noted by 480 days and the study indicated that storage for 480 days retains the curcumin and oleoresin equivalent to freshly stored sample. The sample had a moisture content of 8.5%, 2.80% oil, 13.2% oleoresin and 5.2% curcumin.

Shoot borer

Life cycle

The life cycle of shoot borer was studied on five field resistant and susceptible accessions of turmeric. The average adult longevity, pupal period and fifth instar larval period were 2.9, 12.3 and 6.4 days, respectively on resistant accessions and 3.0, 11.3 and 6.8 days, respectively, on susceptible accessions. However, the differences in days taken to complete each stage were not statistically significant.

Evaluation of insecticides

Four insecticides namely, malathion 0.1%, carbosulfan 0.075%, imidacloprid 0.0125% and lamda cyhalothrin 0.0125% found promising in the greenhouse were evaluated against the shoot borer in the field. The insecticides were sprayed at three week intervals during July to November and the incidence of infested shoots was recorded at crop maturity during December. The trials indicated that among the various treatments lamda cyhalothrin 0.0125% was significantly more effective in reducing the percentage of shoots infested by the shoot borer.

Disease management

Evaluation of chemicals

The field trial at Settiputhur (Coimbatore District) to evaluate the efficacy of copper oxychloride 0.25%, Cheshunt compound 0.3%, Bordeaux Mixture 1%,

metalaxyl + mancozeb 0.125%, mancozeb 0.3%, potassium phosphonate 0.3%, carbendazim + mancozeb 0.3%, captan + hexoconazole 0.3% and carbendazim 0.5% for the management of rhizome rot disease indicated maximum disease reduction with metalaxyl-mancozeb (69.7%) followed by copper oxychloride (63.7%) when compared to control (Table 4.4).

Evaluation of biocontrol agents

The field trial at Settiputhur (Coimbatore District) to evaluate the efficacy of six short listed *Trichoderma* isolates (CLT-102, CLT-107, CLT-110, CLT-114, CLT-118, and CLT-121 and IISR-6) showed that CLT-107 and CLT-110 application recorded significantly lower incidence of the disease (7.71% and 7.75%, respectively) when compared to control (21.44%).

Integrated management

A field trial was conducted at Settiputhur (Coimbatore District), with 11 treatments including different combinations of promising chemicals (metalaxyl-mancozeb 0.125% and copper oxychloride 0.25%) and biocontrol agents (CLT 102 and CLT 110). The results showed that application of metalaxyl-mancozeb 0.125% + CLT 110 was at par with individual application of either metalaxyl-mancozeb 0.125% or CLT 110 with a disease reduction of 69.1% compared to 69.7% in individual treatments. There was an increase in yield of 12% in the combined treatment when compared to 13.4% in individual treatments.

Table 4.4. Evaluation of chemicals for the management of rhizome rot

Treatments	Disease incidence (%)			
	2007-08	2008-09	2009-10	Pooled
Copper oxychloride (0.25%)	16.48	17.49	9.17	9.04
Cheshunt compound (0.3%)	22.90	20.90	14.72	12.60
Bordeaux Mixture (1%)	26.06	23.60	16.81	15.78
Metalaxyl-Mancozeb (0.125%)	19.63	16.13	7.09	7.18
Mancozeb (0.3%)	26.30	25.24	13.01	15.63
Potassium phosphonate (0.3%)	26.63	24.69	18.19	16.22
Carbendazim- Mancozeb (0.3%)	26.54	25.58	19.58	17.52
Captan + Hexoconazole (0.3%)	24.14	25.34	17.22	16.85
Carbendazim (0.5%)	22.64	22.47	18.06	15.51
Control	30.49	28.96	23.33	22.00
CD (p=0.05)	3.05	4.17	3.93	4.39

VANILLA

Maintenance of germplasm, seedling progenies and interspecific hybrids

Ninety three germplasm collections were maintained at IISR Experimental Farm, Peruvannamuzhi. Fifty seedling progenies, 50 interspecific hybrids and 150 mutants were established *ex vitro*. A total of 544 *in vitro* cultures of selfed seedling progenies, interspecific hybrids involving different species and plants derived from irradiated fruits were also maintained.

Maintenance of evaluation trials and recording morphology

Field trials of germplasm collections and seedling progenies were maintained. Observation on fruit length was recorded from 15 germplasm accessions pollinated last year. Data on morphology and flowering were recorded from 29 accessions and variation in morphological characters was observed. Seventeen collections flowered during the period from January-March 2010. Number of inflorescence ranged from 1-15 in different collections.

In vitro establishment of interspecific hybrids between *V. Planifolia* and *V. Tahitensis*

Seventy cultures of *V. planifolia* x *V. tahitensis* and 111 cultures of selfed progenies of *V. tahitensis* were established (Fig. 5.1). Fruit setting was achieved in crosses between *V. tahitensis* x *V. planifolia* and germination cultures were initiated. As *V. tahitensis* is another cultivated species of vanilla having tolerance to root diseases these hybrids are important for resistance breeding.

Fig 5.1. Progenies from (a) *Vanilla tahitensis* (b) *V. planifolia* x *V. tahitensis* grown *in vitro*

Tree spices

Cassia

In the clonal evaluation of cassia elite lines at Peruvannamuzhi, IC-370423 recorded significantly higher height (320.6 cm) and IC-370415 highest dry bark yield (218 g).

Among the 15 cassia lines tested at CRC, Appangala, IC-370415 recorded significantly greater height (545cm), while no significant difference was observed among the lines for number of branches, girth, leaf length and breadth. IC-370406 recorded the maximum fresh weight (1290 g/tree) and dry weight (405.3 g/tree) followed by IC-370425 and IC-370427. But the highest dry recovery of 56.25% was recorded in IC-370401 at Appangala condition at 1st coppicing which was performed two years after main harvest. IC-370410, 370423 and 370425 recorded maximum oil yield of 4%. IC-370415 recorded 21.57 % oleoresin yield (Table 6.1).

Nutmeg

Herbarium specimens of 25 nutmeg accessions were prepared, mounted and preserved in the herbarium facility. In the trial on clonal evaluation of high yielding nutmeg lines, A9/185 was found to have significantly more height (597.1 cm), canopy (548.6 cm), girth (206.25cm) and number of primary branches (74.5).

Table 6.1. Clonal evaluation of cassia lines at Appangala (yield data-1st coppicing, quality)

Acc. No	IC No.	Fresh Wt (g/tree)	Dry Wt (g/tree)	Dry Recovery (%)	Oil (%)	Oleoresin (%)
A2	370401	355.0	200.0	56.25	3.3	13.20
A6	370404	651.0	213.0	32.68	2.6	12.96
A7	370405	96.9	54.5	56.20	2.6	19.20
A8	370406	1290.0	405.3	31.40	3.3	14.90
B2	370408	580.0	106.6	18.35	2.0	17.87
B4	370410	144.0	35.0	24.30	4.0	17.72
B8	370414	696.3	152.5	21.90	2.6	15.99
C1	370415	758.5	173.7	22.90	2.0	21.57
C4	370418	358.9	120.6	33.60	3.3	20.68
D1	370423	331.0	108.7	32.83	4.0	16.90
D2	370424	736.8	210.0	28.50	2.6	18.51
D3	370425	810.2	263.3	32.50	4.0	15.97
D5	370427	758.6	220.0	29.00	2.0	17.45
D6	370428	606.6	165.0	27.20	3.3	18.76
D7	370429	623.8	169.3	27.14	3.3	17.84
Mean		586.5	173.2	31.65	3.0	17.30
CV (%)		50.9	51.8	34.55	23.7	14.05
CD (p=0.05)		43.1	5.7			

In the trial on clonal evaluation of nutmeg lines having high myristicin and elemicin, A9/4(3) recorded significantly higher height (47.6 cm), canopy (28 cm) and girth (0.705cm), while A9/4(11) recorded significantly higher height (45.9 cm) and girth (0.705 cm).

In the trial on clonal evaluation of nutmeg lines having low myristicin and elemicin and high sabinene, A9/95 had a significantly higher girth (0.99 cm), while A9/102 had a significantly higher number of primary branches (2.69).

Induction of orthotropic shoots in plagiotropic grafts

Fifteen different treatment combinations, including pruning, bending, spraying of three different hormones namely, IAA, Kinetin and GA at different concentrations and combinations, were carried out in plagiotropic grafts of two nutmeg accessions, A4-22 and A-11-10. Though large number of branches was induced in the graft none of them were orthotropic. The grafts would be observed for one year.

Budding for production of orthotropic grafts

Budding was done with orthotropic and plagiotropic buds of nutmeg on *M. fragrans* rootstock. Patch budding with brown and green buds on *M. fragrans* rootstock and chip budding with green buds on *M. fragrans* and *M. malabarica* rootstocks with buds from orthotropic shoots. In 60% of the plants, initial union was observed after a period of 30 days from budding in chip budded plants. The percentage success was low on patch budding.

Manipulation in trees and orthotropic shoots to produce large number of orthotropic shoots for use as scions

Various treatments like de-topping of trees and de-topping of orthotropic grafts were carried out to produce large number of orthotropic shoots in nutmeg, which in turn could be used for grafting/budding purpose as there is a constraint in the availability of orthotropic shoot production in nutmeg. Large numbers of orthotropic shoots were produced. The height at which pruning to be done need to be standardized.

Factors responsible for orthotropic and plagiotropy in nutmeg

The auxins and cytokinins in the leaves and buds of orthotropic and plagiotropic shoots of nutmeg were studied and it was observed that the auxin content was highest in the axillary buds of the plagiotropic shoots whereas the terminal buds contained more auxins in orthotropic shoots. Cytokinin was high in the leaves of both orthotropic and plagiotropic shoots when compared to the buds. The protein, total carbohydrate, reducing sugars, starch, phenol and nitrate reductase in leaves and twigs were also determined in nutmeg.

Analysis of nutmeg germplasm samples

Mace samples of twenty accessions were analysed for oil content. The oil content ranged from 12 to 33%, with highest oil yield in IC-5489-17 (33%) followed by IC- 5489-22 and IC-5489-32 (30% each). GC- MS analysis indicated IC5489-45 had high safrole of 23% and IC- 5489-22 had high myristicin of 24.1%.

Garcinia

North Eastern States of India was surveyed according to the prediction of BIOCLIM model of DIVA GIS for garcinia species and six species were collected. Of which, three species, *Garcinia lanceaefolia* (Rupahi thekara), *G. pedunculata* (Bor thekara) and *G. oxyphylla* (Mahi thekara) are not reported in Western Ghats. Rupahi thekara and Bor thekara showed a HCA content of 4.5% and 2.8%, respectively and no HCA was found in Mahi thekara.

Fig 6.1 Garcinia species collected from North Eastern India; (a) *Garcinia lanceaefolia*; (b) *G. oxyphylla*; (c) *G. pedunculata*

STUDIES ON THE MYCOTOXINS AND NUTRACEUTICAL PROPERTIES OF BIOACTIVE COMPOUNDS IN SPICES

Identification of bacterial antagonists against Aspergillus sp.

Four endophytic and two rhizosphere bacteria were evaluated for their antagonistic property against *Aspergillus* species. Among these bacterial angonists, IISR 853, Bp 35, Bp 25, Bp 17, TC, species of *Pseudomonas* (IISR 6) was highly effective in preventing the growth of the fungus *in vitro*. Extracts from seven plant species were also evaluated for their antagonistic property. Plant extracts (leaves) from *Ixora sp*, Nutmeg, *Polyalthia longifolia, Tectonia grandis, Garcinia indica, Garcinia gummigutta and Acassia* sp. were tried. No detectable antagonism was seen with alcohol and aqueous extracts.

Identification of potential aflatoxin inhibitory isolates

Using six different mycological media, morphological characterization of 15 isolates from toxigenic and non toxigenic species of *Aspergillus* was done, among which six were identified as toxigenic and nine as nontoxigenic. Molecular characterization of toxigenic and non toxigenic strains from the existing cultures of *Aspergillus* sp. are in progress.

Nutraceuticals

The antioxidant property of water and ethanol extracts of *Garcinia indica, G. gummi-gutta*, tamarind and curry leaves, and essential oil of curry leaves were compared at different time periods – immediately after extraction (I quarter), after three (II quarter) and six months (III quarter) - 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; the total phenols of the extracts were also quantified. The chemoprofiling of the essential oils was done using GC-MS.

Garcinia indica

- The total phenol content of water and ethanol extracts were stable up to three months after extraction; after which it decreased to half in the water and ethanol extracts

G. gummi-gutta

- The total phenol content of water and ethanol extracts were stable for three months after extraction and decreased thereafter by 1/3rd the original value in the water extract, and by half in the ethanol extract
- The DPPH radical scavenging activity decreased in water extract, from 65% to 40% within three months after extraction

Tamarind

- The total phenol content of water and ethanol extracts were stable for three months after extraction; after which it decreased, by 1/3rd in water and ethanol extracts
- The DPPH radical scavenging ability of tamarind water extract decreased from 54% in fresh extract to 37% by the 3rd month after extraction and in the ethanol extract it decreased from 62% to 41% in the same period

Curry leaves

- No significant change in total phenols was recorded in essential oils, water and ethanol extracts, in the first three months after extraction. But by the sixth month, it reduced from 2.3 to 0.03 mg/ml essential oil and by half in the water and ethanol extracts.
- The DPPH radical scavenging activity of the essential oil decreased significantly by half the original value with every quarter of storage.
- The main component of curry leaf essential oil was β-caryophyllene; the minor components being α-pinene, α-humulene, α-guaiene and epiglobulol.
- All the above extracts were either on par with or superior to the synthetic phenols BHA and BHT, in their antioxidant potential, even on storage
- No significant difference was observed in the total antioxidant potential and the Fe(III) to Fe(II) reducing ability in the samples up to six months of storage.

PASSCom - GST lead DB: *In silico* and *in vitro* studies revealed that the spice phytochemicals curcumin, brucine-n-oxide, β-colubrine, brucine, vanillin, genostrychnine, linalool, α-pinene, strychnine, NVA, piperine, isoeugenol, β-caryophyllene, cinnamic acid, capsaicin, citronellol and geraniol showed promise as lead compounds that can bind with the greatest inhibitory potential, the detoxifying enzyme, glutathione-S-transferase (GST) of both human lymphatic filariasis causing nematode *Brugia malayi* and canine *Dirofilaria immitis* GST.

In silico screening of nematicidal compounds from *Strychnos nuxvomica*

Using *in silico* tools and SAR (structure–activity relationships) method biological activity of sixty two compounds isolated from *Strychnos nux-vomica* was predicted. None of them were reported to have nematicidal or antihelmintic activity. Among these, two chief compounds that possessed antibacterial, antiviral and antifungal activity, strychnine and brucine were subjected to bioassay against the second stage juveniles of *M. incognita* at 1000, 1500 and 2000 ppm concentrations (Table 7.1). *In vitro* bioassay showed that brucine possessed higher nematicidal activity compared to strychnine. But the efficacy of strychnine increased in the hydrochloride form where as in the case of brucine, the activity decreased in the sulphate form.

Exploration of spices for natural food colors and pigments

The fruits (rinds) of *G. gummi-gutta, G. hombroniana, G. indica, G. tinctoria* and nutmeg were subjected to biochemical analysis in order to know pigment contents. The total carotenoids content varied from 0.013 (*G. gummi-gutta*) to 0.065 mg/100g (*G. tinctoria*) and anthocyanin content from 0.007 (*G. hombroniana*) to 0.053 g/100g (*G. indica*). The lycopene content ranged from 3.72 (*G. tinctoria*) to 4.95 mg/100g (*G. indica*), among the Garcinia species with minimum variation of 20%. However, nutmeg-mace yielded 91.50 mg/100g of lycopene.

A total of 130 accessions of paprika and paprika like chillies including hybrids are being maintained and evaluated for color value. The color value varied from 230 to 510 ASTA units, the highest being with EC-35, followed by EC-65 with a mean value of 300 ASTA units and variation of 33%. However, oleoresin content ranged from 9.0 to 13.0% with a variation of 11.48%.

Table 7.1. Efficacy of compounds from *Strychnos nuxvomica* leaf against root-knot nematode

Concentration (ppm)	% Mortality of nematodes over control			
	T1 (Strychnine)	T2 (Strychnine hydrochloride)	T3 (Brucine)	T4 (Brucine sulphate)
1000	41 (39.7*)	66 (54.1)	67 (55.0)	32 (34.0)
1500	48 (42.7)	78 (62.5)	85 (67.6)	44 (41.2)
2000	58 (49.8)	97 (82.5)	87 (69.7)	74 (60.57)
Mean	48 (44.1)	80(66.4)	80 (66.1)	50 (45.2)

*Values in parenthesis are Arcsine transformed

OUTREACH PROGRAMMES

PHYTOFURA

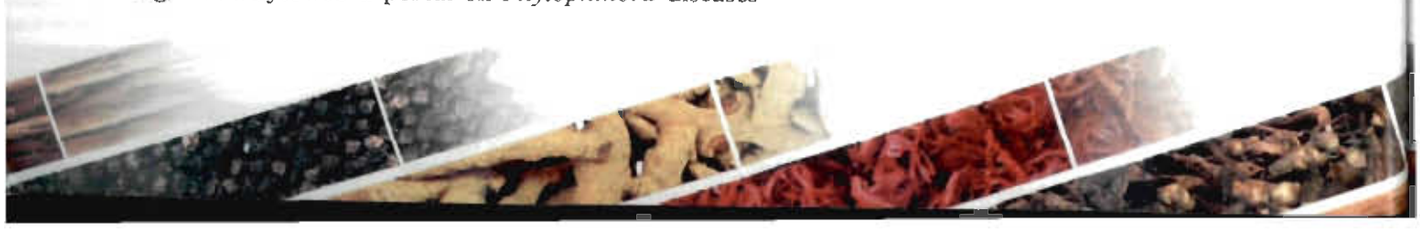
Phytophthora characterization

Phytophthora isolates (241 isolates) maintained in the repository have been revived and was enriched with 43 new *Phytophthora* isolates collected from different parts of Kerala and Coorg district of Karnataka, bringing the total to 284. The virulence of 100 *Phytophthora* isolates were tested *in vitro* by detached leaf inoculation method and were grouped the isolates into three *viz*., highly virulent, virulent and less virulent.

Genomic DNA was isolated from 126 black pepper *Phytophthora* isolates and SSR profiling was done with one primer pair GTCTGCGCTGTCGGAACT (113 F)/ TRATGATGCGGTTCATCTCG (114 R). ITS region of *R. similis* was amplified with universal primers. Species specific markers for detection and quantification of *P. capsici* and *R. similis* have been designed and employed. Putative *Phytophthora* isolates containing *elicitin* genes were identified through custom designed primers. Two SCAR markers developed for *Phytophthora* resistance were tested and validated in black pepper.

Genomic DNA isolation of 75 Panniyur I x Subhakara progenies was completed and ISSR profiling is in progress to develop a linkage map. ESTs (56,457 numbers) of *Phytophthora capsici* available from dbEST of NCBI were downloaded, cleaned and assembled into 5966 contigs using CAP 3 program.

Fig. 8.1. Phytoweb a portal on *Phytophthora* diseases



Functional annotation of these contigs revealed that 84.73% of the ESTs displayed significant similarity to known sequences in GenBank. About 3.57% (213 numbers) ESTs were assigned to hypothetical proteins of unknown function while 699 (11.7%) had "no hit". About 223 microsatellites were detected in EST sequences of *P. capsici* and primers were designed for them. Based on the EST annotation made using bioinformatics tools, *avirulence*-associated protein has been identified. Sequence information from reported Elicitin genes from NCBI database was aligned and three sets of primers were designed.

PhytoWeb, a comprehensive portal on *Phytophthora* diseases of horticultural crops in India was developed by modifying the existing PhyDisH. Phytolib, an electronic database of research publications on *Phytophthora* has also been developed and launched through this portal.

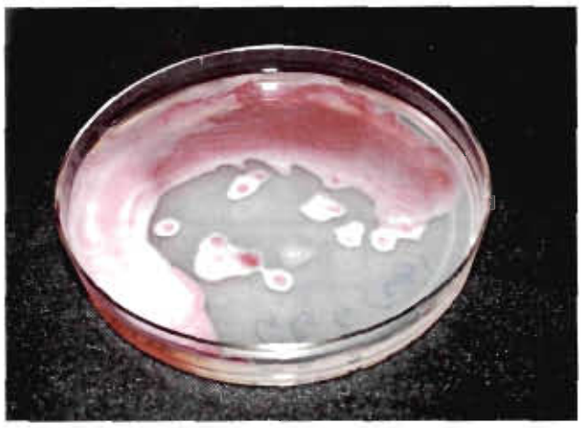


Fig. 8.2. Typical colonies of *Ralstonia solanacearum* Biovar 3 causing bacterial wilt of solanaceous vegetables and ginger

Ralstonia characterization

Ralstonia solanacearum causing bacterial wilt of ginger was isolated from major ginger growing regions of the country such as Kerala and Sikkim (Fig 8.2). *Ralstonia solanacearum* wilted ginger plants in 7-10 days upon soil inoculation. All isolates were found to be Biovar 3 of Hayward's biovar classification. Isolates could be identified by *Ralstonia solanacearum* specific primers in PCR. Primer sequences specific for 65 different virulence genes and housekeeping gene for DNA repair protein (RecN) was designed from full genome sequences of GMI1000 for genome wide analysis of *Ralstonia solanacearum*.

LEAF SPOT DISEASES

Collection of isolates

Surveys were carried out in Karnataka, Kerala and Tamil Nadu for collection of samples of leaf spot diseases. Out of 150 samples including cardamom, black pepper, arecanut, turmeric, ginger, chilli and clove, 100 were infected with *Colletotrichum* spp. The cultures were identified based on colony and conidial morphology. The identified cultures were subsequently pure cultured and maintained for further studies. The cultures were further characterized based on colony characteristics and conidial and appressorial morphology.

SUCKING PESTS IN HORTICULTURAL CROPS

Molecular systematics of cardamom thrips (Sciothrips cardamom)

Sixty eight samples of cardamom thrips were collected from 48 locations, covering five major cardamom growing districts in Kerala and Karnataka for studies on molecular diversity using mitochondrial cytochrome oxidase as marker, in collaboration with Indian Institute of Horticultural Research, Bangalore. The study indicated that there were no significant genetic differences in various populations of cardamom thrips.

EXTENSION AND IMPACT ASSESSMENT

Mobilising Mass Media Support for Sharing Agro – Information

A Media Meet was organized to mobilize mass media support for sharing Agro-Information, under NAIP project (Fig. 9.1). Over 30 media persons from around 20 media organizations attended. Over 20 news items appeared in various print media, one audio item in AIR-Calicut and news in channels.

Dissemination of Innovative Technologies through Media

- Over 56 news items have come in print. Two success stories printed in The Hindu and Theekathir (Tamil).
- A video film based on the success story on IISR intervention in black pepper gardens at Kodagu was made.
- Twelve Audio capsules on technologies, high yielding varieties and integrated management of pest and disases were prepared and broadcast through AIR Calicut.

Diffusion and impact surveys

The survey carried out in 48 farmers' field on adoption and impact of improved varieties of black pepper in four districts of Kerala yielded the following results:

- The mean area under black pepper as a mixed crop was 0.73 ha with an average number of 250 vines.
- The ratio of bearing to non bearing vines was 3:2.
- The extent of coverage of improved varieties was 65.36%.
- The mean yield for HYV was 1160 kg/ha as compared to 620 kg/ha for traditional varieties
- The estimated cost benefit ratio from the primary data on cost of cultivation, yield and average wholesale price of black pepper during 1998-2007 was 2.48.
- The major constraints as perceived by the farmers were disease incidence, high cost of cultivation especially labour, and non availability of quality planting material.
- The comparisons of yield data of adopter and non adopter categories indicated that three technologies namely, aerial spraying of Bordeaux mixture, irrigation during summer and application of biocontrol agents and growth promoters are major determinants of yield.

The survey to study impact of scientific technological interventions in 1615 ha of black pepper gardens covering 14 estates in Kodagu district where the institute had already launched intervention programmes yielded following results:

- The level of adoption of critical technology inputs was as follows: Foliar spray of Bordeaux mixture-96%, soil drenching of fungicides-80%, application of nematicides -60%, basin irrigation in summer-70%, application of chemical fertilizers- 20% and application of bioagents-20%.
- The mean yield with an average of 63% yielding vines was 3.24 kg/vine. The yield recorded in the control sample was 1.9 kg/vine.
- The mean cost of cultivation was Rs 80 per vine.
- The estimated cost benefit ratio was 3.025 (in conventional black pepper growing tracts of Kerala, the previous survey recorded a cost: benefit ratio of 2.4).

Secondary data pertaining to the number of black pepper cuttings distributed over the years from the institute as nuclear planting material was collected and compiled. Based on this, estimate on the probable extent of spread of these varieties based on the number of cuttings distributed for direct planting and the rate of diffusion or spread rate were worked out. (Table 9.1).

Fig. 9.1. Media meet organized to mobilize mass media support

Table 9.1. Estimated spread of released black pepper varieties

Variety	Year of release	No. of cuttings distributed	Estimated area covered @ 850 nos/ha (ha)*	Potential yield (dry) (kg/ha)	Expected yield @ 60% of potential	Estimated total production (tonnes)
Panniyur-1	1971	48457254	57009	1242	745	42483
Panniyur-2	1989	565616	665	2570	1542	1026
Panniyur-3	1989	565616	665	1953	1172	779
Panniyur-4	1989	565616	665	1277	766	509
Sreekara	1990	185240	218	2677	1606	345
Subhakara	1990	190145	224	2352	1411	315
Panniyur-5	1993	322783	380	1826	1096	416
Panniyur-6	1999	195412	223	2127	1276	293
Panniyur-7	1999	195414	230	1410	846	194
Panchami	2001	56863	67	2828	1697	113
Pournami	2001	83646	98	2333	1400	138
IISR Thevam	2005	5600	7	2148	1289	9023
IISR M. Excel	2005	2112	3	1440	864	2592
IISR Girimunda	2005	2671	3	2880	1728	5184
IISR Shakthi	2005	63	0	2253	1352	0
Average/ Total				2088	1253	63410

(The average stand combining mixed or pure cropping systems is assumed as 425 per ha and two vines/ standard)*

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 it's headquarter at Indian Institute of Spices Research, Calicut. AICRPS has at present 34 centers which include 19 regular, 8 co opting and 7 voluntary centres located in 21 states of India under 21 State/Central Agricultural Universities/Research Institutes. The XI Plan budget of AICRPS is Rs. 1400 lakhs with Rs 250.00 lakhs (ICAR share) during 2009-10. About 110 research programmes covering the mandate spice crops are being conducted at various centres. These programmes are carried out under the major disciplines of genetics and crop improvement, crop production and crop protection. The salient findings in the mandate crops are presented here.

Black pepper

Black pepper germplasm consisting of cultivated, exotic, wild and related species are maintained under different AICRPS centres. The characterization of germplasm resulted in identification of high yielding accessions. Among 22 accessions evaluated at Chintapalli, Panniyur-1 recorded highest fresh yield of 7.6 kg/vine followed by Neelamundi (6.84 kg/vine). Among the new germplasm accessions evaluated at Panniyur, Angamaly, Chalakudy, ICP 48 and Vattamunda were promising during the year 2009 with a spike yield more than 3 kg/vine. The number of spikes/vine were maximum for Angamaly (1300) followed by Chalakudy (854). In a CVT in black pepper at Panniyur maximum green berry yield/vine was recorded by Cul 1041 (2.5 kg/vine) followed by Cul 5489 (2 kg/vine) whereas at Sirsi dry berry yield was maximum in Panjyur-1 (963 g/ine) followed by HP-105 (747 g/vine) and HP-34 (383 g/vine). At Ambalavayal maximum setting percentage was shown by PRS 22, followed by Cul 5489, Coll.1041, Karimunda OP (98%). Among the intervarietal hybrids in black pepper, P6 x P5 was found to be promising with green berry yield of 5 kg/vine. In a fertilizer trial, black pepper vines treated with the integrated methods recorded significantly higher dry berry yield (1.20 kg/vine) compared to those with fully organics (1.01 kg/vine) and fully inorganic (0.94 kg/vine) methods at Sirsi, where as at Pechiparai, the highest yield of 3.78 kg/vine was recorded in the fully inorganic trial and it was on par with integrated which recorded an yield of 3.54 kg/vine. Application of Potassium phosphonate + *Trichoderma harzianum* and Bordeaux mixture + COC were equally efficient in reducing foot rot incidence by 70.47 and 56.85 per cent respectively, compared to farmers' practice.

Cardamom

Among the germplasm evaluated during 2009-10 at Pampadumpara, highest fresh and dry yield was recorded in CRSP-147 (5550 g/plant & 1055 g/plant respectively) followed by CRSP 145 (3035 g/plant & 575 g/plant). PV-2 registered the highest drying percentage (23.4%) among the accessions.

The open pollinated progeny $4C_8$ recorded maximum no. of capsules/plant (58.50) at Mudigere. In a CVT at Pampadumpara, highest dry yield was recorded in PS 27 (1016.58 g/plant) followed by MHC 26 (335.42g/plant). The damage caused by thrips ranged from 26 to 48%. Thrips attack was the lowest for CL 722 and highest for MCC 246. The damage due to *azhukal* disease was highest for MCC 246 and GG and lowest for MCC 309. The percentage loss due to capsule borer was least for MHC 26 and CL 722 and highest for MCC 73 and GG. At Mudigere, clone CL-722 was found superior for dry capsule yield (341.00 kg/ha) in the CVT trial.

Large cardamom

Five accessions *viz.*, SCC 213 (Golsey), SCC 214 (Golsey), SCC 215 (Golsey), SCC 216 (Ramla) and SCC 217 (Ramla) were collected from Middle Singhik, Sentam and Nung village of North Sikkim and planted at Sikkim. Characterizations of the collected germplasm were made as per descriptor.

Ginger

Among the promising accession evaluated at Dholi, RG-14 and RG-24 gave maximum yield (8.00 kg/7.2m^2) followed by RG-13 (7.30 kg/ 7.2m^2). Highest rhizome yield/plant was recorded in GCP-1 (672.33 g) followed by GCP-28 (502.00 g), GCP-48 (355.00 g) and GCP-9(350.67) at Pundibari. The accessions SG 962, SG

976, and 26/2004 were found superior for dry matter and essential oil content in comparison to check Himgiri at Solan. In an IET at Dholi, RG-3 was found to be a promising accession with a yield of 21.34 t/ha as compared to check variety Nadia (17.81 t/ha) and could be promoted to CVT. In a trial to study the influence of environment on genotypes of ginger it was observed that the variety Surabhi recorded highest yield (32.60 t/ha) of fresh rhizome followed by variety Nadia (21.13 t/ha) at Phasighat. In ginger application of fully organic fertilizers gave highest yield (12.90 t/ha) followed by integrated fertilizer (11.62 t/ha) at Dholi centre. Ginger planted in soil treated by biofumigation using cabbage gave highest yield and registered lowest incidence of soft rot at Dholi and Kumarganj.

Turmeric

Among the 180 accessions evaluated at Pundibari centre, TCP-88, TCP-36 and TCP-25 were found to be promising with respect to yield. At Jagtial, JTS-315 and JTS-14 were found to be promising. In a CVT of turmeric at Chintapalle PTS-39 recorded maximum yield of 36.37t/ha where as at Raigarh, Narendra Haldi-1 gave the highest yield of 21.49 t/ha. TCP-129 recorded the highest yield (21.24 t/ha) in an IET on turmeric at Pundibari. The performance of the varieties Rajendra Sonia at Dholi, Roma at Chintapalle, Suprabha at Kanke, Narendra Haldi at Pundibari, Duggirala, IISR Pratibha, Roma and RCT-1 in Mizoram were superior to other varieties. At Dholi application of integrated fertilizer of organic and inorganic resulted in maximum yield of 54.93 t/ha followed by fully organic (50.30 t/ha). The cost: benefit ratio of integrated fertilizer management gave the maximum return of Rs.4.46 per unit cost (1:4.46) followed by fully inorganic *i.e.*, Rs.3.80 per unit cost (1:3.80). Application of 100% of the recommended dose of fertilizer of turmeric through drip irrigation at fortnightly interval gave highest yield (39.34 kg/plot). Mechanical harvesting indicated that the time taken by the tractor mounted harvester is less when compared to power tiller mounted harvester. The percentage of damaged rhizome is also minimum (1.7%) and cost for operating the tractor mounted harvester was low in comparison with power tiller mounted harvester and manual harvesting.

Tree spices

Tree spices germplasm is maintained at Dapoli and Pechparai centre. Among the four selections of cassia evaluated in a CVT, D3 was found to be promising at Pechiparai.

Coriander

Among the 275 accessions evaluated at Coimbatore, the coriander grain yield ranged from 360 kg/ha to 1080 kg/ha. The highest mean yield was registered by the accession CS- 121 (1080 kg per ha). In a CVT, COR-31 at Dholi and Raigarh and COR-30 at Guntur were identified as promising. At Guntur, LCC-200 (594 kg ha^{-1}) and LCC-143 (547 kg ha^{-1}) recorded significantly higher yield than the best check Sadhana (484 kg ha^{-1}) and were found suitable for growing under drought conditions. At Jobner, genotype UD 510 was found suitable for growing under irrigated conditions while UD 277 and UD 324 were suitable for drought conditions. Irrigation at 30 and 60 DAS recorded highest yield (995 kg/ha) followed by irrigation at 30 and 45 DAS (883 kg/ha) at Guntur. The entry COR-34 recorded a high volatile oil yield (7.17 l/ha) followed by COR-31 (6.94 l/ha), COR-27 (6.75 l/ha), and RCr-435 (6.49 l/ha).

Cumin

Genotypes, UC -239, UC -274 and UC -225 were identified as suitable for growing under limited moisture conditions. The entry, CUM-13 recorded maximum seed yield of 667.71 kg/ha at Jobner. The entries GC-4 (4.45%) and CUM-11(4.2%) recorded very high volatile oil at Jobner.

Fennel

Among the fifty three collections evaluated at Dholi, twelve accessions, namely, RF-31, RF-21, RF-23, RF-5, RF-11, RF-15, RF-16, RF-33, RF-444-1, GF-2, RF-10 and RF-38 gave the maximum yield ranging from 1.05 kg to 0.70 kg/5.4m^2 as compared to high yielding variety Rajendra Saurabh (check). Among promising lines, RF-31 produced maximum yield (1.05kg/5.4m^2) followed by RF-21 *i.e.*, 1.00kg/5.4m^2. The entry FNL-40 gave maximum yield of 1216.67 kg/ha in a CVT trial at Raigarh. Two entries FNL-26 and FNL-25 were identified as promising and proposed for release from Jobner centre. The highest mean volatile oil content of 2.89% was recorded in FNL-26 followed by 2.78% in FNL-30 at Jobner.

Fenugreek

Among the one hundred seventy seven germplasm evaluated at Dholi, RM-190 gave a maximum yield of 0.92 kg/4.5 m^2 followed by RM-191 (0.91 kg/4.5 m^2). None of the entries screened against powdery mildew at Jagudan were found to be free from the incidence of powdery mildew and the incidence ranged between

24.50 to 84.75 %. Among the accessions screened, minimum incidence was noticed in JFG-212 (24.50%) followed by JFG-217 (28%). Among the thirteen genotypes evaluated at Coimbatore, the CVT line FGK- 28 recorded the highest grain yield of 348.33 kg/ha followed by FGK-34 & HM-57 of 335.00 kg/ha. At Raigarh and Jabalpur accessions FGK -27 and FGK 28 performed better than lines. At Jobner the entry UM-126 recorded maximum seed yield of 2163.43 kg/ha in an IET. In a large scale demonstration it was observed that, seed treatment and soil application with the rizobacteria FK -14 + FL-18, resulted in a very high yield of 1800 kg/ha followed by seed treatment with FL-18 alone (seed yield 1630 kg/ha).

BIOINFORMATICS CENTRE

Functional annotation of *Phytophthora capsici* ESTs

Functional annotation of *Phytophthora capsici* EST resources was carried out and putative transcripts were identified. EST assembly and annotation of two entomopathogenic nematodes, *Steinernema feltiae* (83 nos.) and *Heterorhabditis bacteriophora* (53614 nos.) was also attempted. Syntenic relationship between *Radopholus similis* and other nematodes was studied using mitochondrial genome sequences.

Virtual screening of phytochemicals

A virtual screening of phytochemicals from Dr. Duke's phytochemical and Ethnobotanical database, literature search, PASS prediction and ADME/Tox screening has identified 56 promising compounds with potential nematicidal activity. Flexible docking studies revealed that phytochemicals - curcumin, brucine-n-oxide, β-colubrine, brucine, vanillin, genostrychnine and strychnine, had good binding score (MolDock score) and favorable hydrogen bond interaction with glutathione-S-transferase (GST) of *Brugia malayi*. Thus, these phytochemicals can be taken as promising lead compounds to treat filariasis caused by *B. malayi*. *In vitro* assay confirmed that the phytochemicals with the greatest inhibitory potential against canine *Dirofilaria immitis* GST were linalool, α-pinene, strychnine, NVA, vanillin, piperine, isoeugenol, curcumin, β-caryophyllene, cinnamic acid, capsaicin, citronellol and geraniol, in descending order.

GST Lead Base, a new database

A new database, GST Lead Base (www.spicebioinfo.res.in/ gstleadbase), was developed and hosted (Fig. 11.1). The database includes chemical properties and other details of potential nematicidal compounds that inhibit glutathione-S-transferase in nematodes.

Bioinformatics training programmes

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

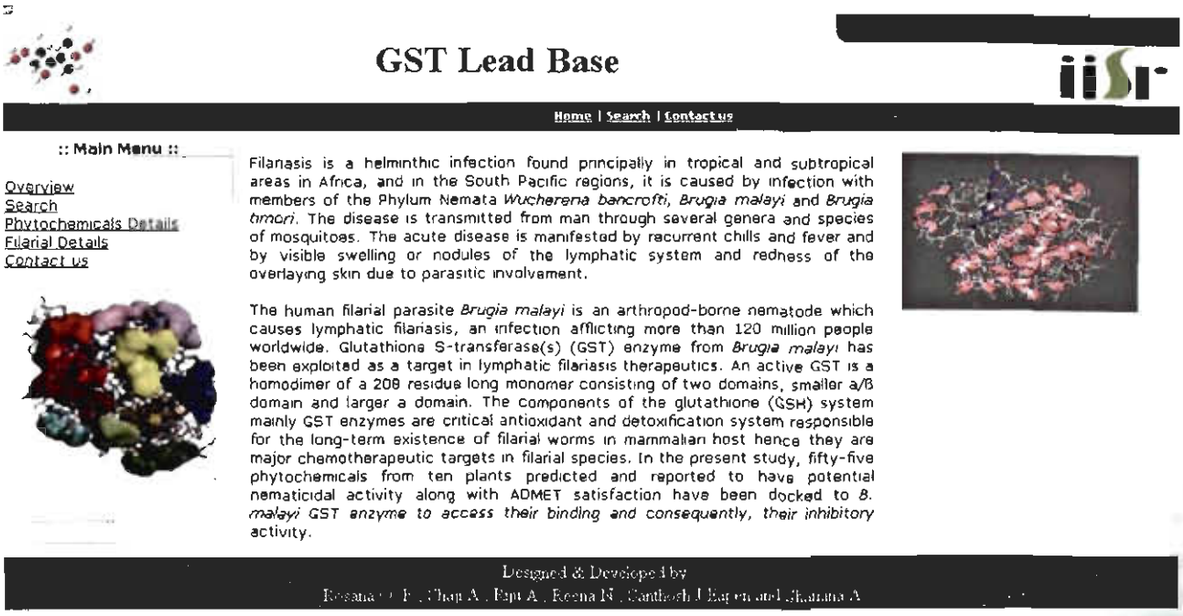


Fig. 11.1. GST Lead Base - data base on potential nematicidal compounds

- Training programme on 'Recent advances in EST analysis and their annotation' during 20-23 Oct. 2009. 17 trainees.

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

- Summer Training on Biochemistry, Biotechnology and Bioinformatics, 06 May to 05 June 2009 for nine trainees.
- The IISR Bioinformatics Centre and Regional Science Centre, Calicut jointly organized a Bioinformatics camp for higher secondary students during 20-25 April 2009.

During the period, two scientists (one each from NRC Citrus and NRC Banana) were given special training in Bioinformatics during 27 Jan – 2 Feb 2010. The traineeship was offered to two candidates while studentship was offered to four Bioinformatics students.

- PhytoFuRa, the web portal of the ICAR outreach project on *Phytophthora*, *Fusarium* and *Ralstonia* Diseases of Horticultural and Field Crops was created and hosted. The portal has a public domain consisting of databases and external links. All the participating centres can access the portal with a user name and password for online submission of reports and for accessing various custom made resources. Phytolib, a web based bibliography service, was made available in this portal. The portal facilitates speedy dissemination of information, exchange of ideas and online monitoring of research progress.

ARIS CELL

- *SpiceStat*, the database on vital statistics of spice cultivation, production and export was relaunched with additional features.
- A new *accounts module* was developed and integrated in ARISoft, the existing office automation software.
- An *interactive CD* on ginger and turmeric package of practices was developed (Fig. 12.1).
- As per the guidelines received from ICAR, the IISR website was modified by using *Joomla*, an open source CMS software, and it is under trial run.
- An expert system on black pepper pests and diseases was developed.

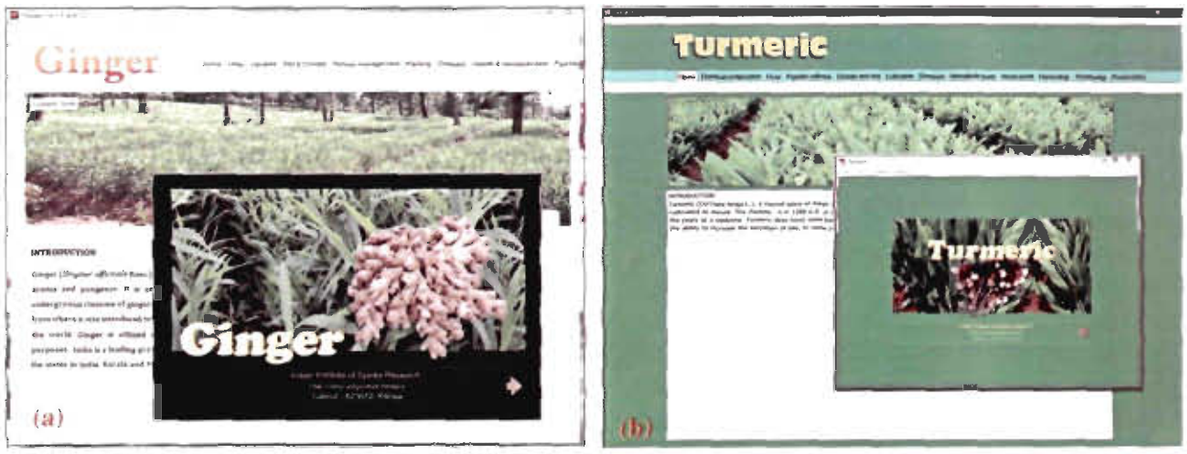


Fig. 12.1. Interactive CDs on package of practices: (a) Ginger (b) Turmeric

LIBRARY

IISR library significantly improved its technical resources by procuring new books, databases and journals. About 162 books have been procured during the period while 91 books, four technical reports, four theses and 14 project reports were received *on gratis*. To facilitate this, a book exhibition was organized during 1-2 March 2010. New computer systems (6 Nos.) were added. The library software, LIBSYS, was upgraded. Biometric access control system along with CC TV and camera were introduced in the library to ensure better security. An LCD TV facility was installed to help in multimedia presentations. The library continued to be a part of CeRA, the E- journal consortium of ICAR. The online bibliography database, CAB Abstracts, was procured directly from CABI. The Agri Tit Bits being published from library was made electronic since Aug. 2009 and seven issues were brought out (Fig. 13.1). The digital institutional repository, DSpice, was updated with more research publications of scientists. A new bibliography service, PhytoLib, was conceived, developed and launched. Similarly a tool to locate appropriate journals in each subject domain (Journal Finder) was also developed.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AGRI Titbits

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spices breakthrough general

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Fig. 13.1. Electronic version of Agri Tit Bits

AGRICULTURAL TECHNOLOGY INFORMATION CENTRE

Technology inputs and advisory services

The technology inputs distributed from the centre include planting material of improved varieties of spices, biocontrol agents, vermicompost, spice products and scientific publications including extension literature. During 2009-10 planting material worth Rs 59,479 was distributed from the centre. The proceeds from sale of publications amounted to Rs 18,492. *Trichoderma* and *Pseudomonas* formulations worth Rs.17,688 were distributed to farmers. The sale of bio agents also showed an increase of 49.6% over last year. The total income generated from the centre was Rs.98,510.

Out reach extension services

The partnership services offered by the institute include training, consultancy and contract research. The institute offers training programmes on demand from various agencies targeted for field extension functionaries of state departments, research workers of other ICAR institutes and state agricultural universities. During the year, 1111 farmers (241 from within district, 157 from the state and 713 from outside the state) availed farm advisory services from ATIC and 1275 farmers visited the Experimental Farm, Peruvannamuzhi. About 1050 students visited the institute on study tour. The total visits to ATIC by various stake holders registered an increase of 25% over 2008-09. The information seeking behavior of farmers showed the following trend: Direct visits – 1186; Phone calls – 281; Letters – 153; E mail – 119.

The Hindi version of the package of practices of black pepper, ginger and turmeric were printed for free distribution to farmers. Front line demonstration programmes on performance of improved varieties of black pepper released from IISR laid out in 18 farmers' plots in Anakkampoyil, Koorachund and Thalayad in Kozhikode district were continued and multi disciplinary team of scientists visited these plots as per a schedule to follow up and provide advisory services.

The institute conducted one on-campus training programe (five days) for the state department extension functionaries, sponsored by the Kerala State Horticulture Mission. Two off-campus training programme on black pepper for farmers sponsored by M S Swamintahan Research Foundation, Wayanad were organized in Wyanad District. The institute also participated in one farmers' seminar under the Janasree mission of the Kerala Government, five exhibitions/ farmers fairs at national level and four at regional level. Seven video conferencing sessions with village resource centers in Wayanad District were organized in which 389 farmers participated.

A training evaluation methodology of academic training programmes organized at the institute was developed, tested and used. The analyisis showed that the gain in knowledge by the trainees was statistically significant and the calculated training effectiveness index was above 0.83.

KRISHI VIGYAN KENDRA

Training programmes

The Kendra has conducted 116 training programmes on various subjects during the period under report. A total of 3837 persons have benefited out of the programmes. The details of the training programmes are furnished in tables 15.1a & b.

bio products, chicks and the activities of Plant & Animal Health Centre.

The Kendra operated a Plant and Animal Clinic offering various services to the farmers. An artificial insemination facility is also maintained at the centre to upgrade the genetic stock of livestock. The centre offered consultation, treatment and doorstep services charging nominal fee. The various activities taken up during the period are as follows:

1. Cases treated/ advisory services provided : 683
2. AI in cattle using exotic frozen semen– 276
3. AI in goats - 109
4. Animal Health Campaign/ Infertility camps organised– 5
5. Animals vaccinated against Foot and Mouth disease: 20756
6. Ksheerothsavam attended: Block level: 3

Table 15.1a. Training programmes conducted during 2009-10

Category	No. of courses	No. of participants			No. of SC/ST participants
		Male	Female	Total	
Practising farmers, Farm Women and Rural Youth	112	2280	1440	3720	611
Extension functionaries	4	102	15	117	13
Total	116	2382	1455	3837	624

Table 15.1b. Discipline-wise training programmes conducted

Discipline	No. of courses	No. of participants			No. of SC/ST participants
		Male	Female	Total	
Crop production	22	661	372	1033	41
Horticulture	12	184	51	235	8
Animal science	77	1441	968	2409	557
Soil Health & Fertility Management	2	18	46	64	5
Plant Protection	3	78	18	96	13
Total	116	2382	1455	3837	624

Revolving Fund Programme

The Kendra has a revolving fund programme to generate income for productive uses. 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, anthurium plants, minor fruit plants, miscellaneous ornamental plants etc. are produced under this programme. A total of 2891 farmers visited KVK during the period for consultation, purchase of planting materials and other inputs from KVK. During the period an amount of Rs. 4.56 lakh has been realised through sale of planting materials.

7. Cattle show and calf rally: 3
8. No. of layer chicks produced: 3386
9. Broiler chicken (vencob): 456 kgs.
10. Sale of pregnant heifer: 4 nos.

Other extension activities

Kisan mela and exhibitions

KVK is regularly participating in exhibitions within the district. In addition, the Kendra also participates in exhibitions outside the district in association with the host institute. During the period under report, KVK has participated in the following exhibitions.

Farmers' study tours

A team of 30 progressive farmers visited the Livestock Farm at Veterinary College, Pookkode as a part of post exposure farmers' study tour programme on 23.09.09.

Date/period	In connection with/ organised by	Venue
07.7.09	Kisan Gosthi- ATMA at Nalanda Auditorium, Calicut	Calicut
08.7.09	Kisan Gosthi- ADA Koilandy	Koilandy
16.7.09	Kisan Gosthi- ADA Perambra	Perambra
25.8.09 to 31.8.09	Exhibition -Farm and Home-Subiksha Trade Fairs	Perambra
06.10.09	Exhibition- IV National Conference of KVK	TNAU Coimbatore
18.1.10 to 26.1.10	Exhibition – Gandhiji Study Centre	Thodupuzha
11.3.10 to 14.3.10	Exhibition- National Conference on Quality Planting Materials- Health Management	New Delhi
23.02.10	Field day (Silage making and feeding of silage)	Kalpathur

Table 15.2. Seminars conducted by KVK during the period

Date	Topic	Organised by	Venue	No. of participants
16.7.09	Diseases of cattle and their control measures	KVK	Meppayyur	110
20.7.09	Preservation and feeding of fodder crops	KVK	Changaroth	59
17.8.09	Organic farming	Dept. of Agri.	Thiruvalloor	92
17.8.09	Organic farming	Dept. of Agri.	Changaroth	103
17.8.09	Diseases of cattle and their control measures	Dept. of Agri.	Perambra	75
17.8.09	Preservation and feeding of fodder crops	KVK	Perambra	97
06.10.09	Calf management and ecto and endoparasites control measures	KVK	Pillapperuvanna	86
24.10.09	Heifer management and postpartum care of cows	Animal Husbandry	Balussery	97
10.02.10	Backyard poultry rearing	KVK	KVK, Peruvannamuzhi	112
11.02.10	Oestrus synchronisation and artificial insemination in cattle	KVK	KVK, Peruvannamuzhi	75
12.02.10	Broiler goat rearing	KVK	KVK, Peruvannamuzhi	92

Farmer's Mela for showcasing Agricultural Technologies

A five day farmer's festival 'Karshika Sankethika Darshanam -2010' was jointly organised by the Indian Institute of Spices Research (IISR), Calicut, Krishi Vigyan Kendra (KVK) and NAIP, at Peruvannamuzhi during 8-12 February 2010. Five progressive award winning farmers were felicitated. Exhibition stalls were put up by six ICAR, Central government and 14 private entrepreneurs and input agencies for showcasing the technologies developed by the institutions. About 250 farmers participated in the technical sessions and about 1500 in the exhibition and benefited by the technological inputs/services provided. Technical sessions on different aspects of agriculture like organic farming, animal husbandry, floriculture, mushroom culture, farm machinery and pisciculture were arranged by inviting technical experts to train and interact with the farmers (Fig. 15.1).

Fig. 15.1. Farmer's Mela for showcasing Agriculutral Technologies

Table 15.3. Staff deputed for Training/ Workshop

Name of the person	Title of the programme	Period of training	Place of training
P. A. Mathew K.M. Prakash Dr. S. Shanmugavel	Convergence Meeting of KVKs, ATMA and Department	04.04.09	KVK, Kannur
P. A. Mathew	Workshop on Jack fruit-The under exploited fruit of Kerala – Challenge in supply chain management	28.05.09 to 29.05.09	KVK, Pathanamthitta
K.M. Prakash	Special training on water harvesting	27.07.09	ZPD, Bangalore
K.M. Prakash	Watershed Development – New Guidelines	3.08.09 to 11.08.09	CRIDA, Hyderabad
K.M. Prakash	Creative writing in Agriculture	5.10.09 to 9.10.09	Indian Institute of Mass Communication, New Delhi
P.S. Manoj K.M. Prakash	IV National Workshop of KVKs	06.11.09 to 08.11.09	TNAU, Coimbatore
K.M. Prakash	Sensitisation Workshop on coconut leaf beetle, *Brontispa longissima*	12.02.10	National Bureau of Agricultural Important Insects, Bangalore
K.M. Prakash	Climate change	23.03.10 to 25.03.10	Central Training Institute, KAU
Dr. S. Shanmugavel	National Seminar on Wealth from Livestock and Agriculture Waste	12-13 November, 2009	Veterinary College and Research Institute, Namakkal

Maintenance of Demonstration blocks/units

The KVK maintains model demonstration blocks/units in its farm for 'seeing and learning' by the farmers. The details of the units are shown below:

- 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
- Poultry demonstration unit
- *Dairy* demonstration unit
- Mango scion bank
- Goatary unit

Technologies transferred

Front Line Demonstrations

These programmes are carried out with the co-operation and complete participation of progressive farmers under the direct supervision of KVK scientists. A part of the expenditure of this demonstration is met by KVK. The results of various FLD programmes conducted by the Kendra during the period are detailed below:

- *Demonstration of HYVs of black pepper with high intrinsic qualities.*
- Popularization of pepper production through bush pepper production technology
- *Farmer participatory* bud rot management in coconut (ATMA sponsored)
- *In situ* green manuring in coconut garden using grain cowpea
- Feed management in goat for meat production
- Demonstration on milk production performance in dairy cattle by feeding with silage under scarcity conditions
- Popularization of hormone treatment for fertility management in cows
- Popularization of hormone treatment for fertility management in goats

OFT Programmes

These programmes are done by testing a released technology in real farm situation with the participation of farmers. The problems faced by the farmers 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* (Fig.15.2). The major OFT programmes carried out during the period are listed below:

- *Control of foot rot disease of black pepper using* biocontrol consortium
- Assessment of mixed crop of nutmeg variety Vishwashree grafts in coconut garden
- Management of coconut stem bleeding using *Hexaconazole*
- Fertility in anoestrus cows following CIDR treatment

Fig. 15.2. OFT programmes of KVK (a) *Azolla* cultivation (b) Broiler goat production

EDUCATION AND TRAINING

Post graduate studies

Ph.D

Jayashree E, 'Studies on mechanization of field level post harvest operations in ginger (*Zingiber officinale*) with reference to washing, peeling and drying', Tamil Nadu Agricultural University, Coimbatore.

Bhadra Murthy V, 'Identification, molecular characterisation and development of diagnostics for the viruses associated with vanilla (*Vanilla planifolia* Andrews)', Mangalore University

Hareesh P. S, 'Molecular characterization and seed transmission of the *Badnavirus* infecting black pepper (*Piper Nigrum* L.) in India', Acharya Nagarjuna University

Elizabeth Thomas, 'Biochemical and molecular characterization of major traded spices to augment the trade through geographical indication', Mangalore University

Gobinath P 'Biochemical and molecular characterization of chilli (*Capsicum annuum* L) for variability with special emphasis on colour and pungency', Mangalore University

Balaji S, '*In silico* analysis and drugability of the compounds from the family *Zingiberaceae*', Mangalore University

M.Sc./M.Phil projects

Nineteen students from various universities undertook their M.Sc. project work in Biotechnology, Biochemistry, Microbiology, Bioinformatics and Plantation Management and one student has joined for M.Phil project work in Biotechnology.

Post M.Sc. training

Three students undertook Post M.Sc. training in various techniques of Microbiology and Biotechnology.

Summer training for M.Sc. students

Nine students participated in the one month summer training course on Biochemistry, Biotechnology and Bioinformatics, jointly organized by HRD Cell and CPC during 6th May to 5th June 2009.

Awards

J.S. Pruthi award for the best research paper published in Journal of Spices and Aromatic Crops, 2008, Vol 17 (3): 215-222, entitled 'Development of SCAR marker for *Phytophthora* resistance in black pepper (*Piper nigrum* L.)' authored by Anandaraj, M., Chandran, S., George, R.S., Bhat, A.I. and Bhai, R.S.

The H S Mehta memorial best poster award for the paper "A SCAR marked based method for sex determination in dioecious betel vine" authored by T.E. Sheeja, K. Himabindu, P. Anto, K. Dhanya, S. Siju and T. Vasantha Kumar.

Visits abroad

Name of the staff	Year of visit and duration	Name of country visited and type of visit	Remarks
Dr. B Sasikumar	2008-2010 (2 years)	Guyana as Spice technology expert	Spice technology expert
Dr. D Prasath	2009-2010 (1 year)	University of Guelph, Canada under DST-BOYSCAST programme	Applied genomics (isolation and characterization of disease resistant genes)
Dr. A Kumar	2009-2010 (1 year)	Wageningen University, The Netherlands under DBT-Overseas Associateship	Biotechnology and Molecular Biology and Bacterial genomics
Dr. Santhosh J Eapen	2009 (15 days)	Vietnam, FAO consultancy	First hand information about black pepper cultivation in Vietnam

Training programmes/ workshops attended by the staff

Name of the staff	Name of the training	Duration	Organized by
Dr. S J Ankegowda	Right to Information Act, 2005	29-30 May 2009	Institute of Public Administration, Bhubaneswar
Dr. C K Thankamani	IPR – Patents	22-26 June 2009	NIIPM, Nagpur
Dr. M S Madan	Public-Private Partnerships for Innovation in Agriculture	1-7 July 2009	NAARM, Hyderabad
Dr. T R Usharani	Perl scripting for genome analysis	10-14 August 2009.	CPCRI, Kasaragod
Dr. S Shanmugavel and Mr. V L Jacob	Right to Information Act – 2005	19-20 August 2009	ISTM, New Delhi
Dr. P Rajeev	Impact Assessment of Improved Agricultural Technologies	26-28 August 2009	NCAP, New Delhi
Mr. V L Jacob and Mr. C Venugopalan	Special Programme on Pension and other Retirement benefits	05-09 October 2009	ISTM, New Delhi
Dr. S Hamza	Natural Resource Management of S & T Departments, Govt. of India	5-11 October 2009	Indian Institute of Public Administration, New Delhi
Dr. S Devasahayam	Vigilance administration	29-31 October 2009	NAARM, Hyderabad.
Dr. T John Zachariah and Dr. T K Jacob	Technical aspects of Agricultural Communication and Knowledge Management	16-20 November 2009	IIM, Lucknow
Dr. T R Usharani	Application of Molecular Tools for Crop Improvement	2-22 December 2009	SBI, Coimbatore
Dr. C N Biju	Recent advances in production and delivery system of biopesticides, bioagents and biofertilizers	05-25 January 2010	Dr. PDKV, Akola
Mr. K Jayarajan	IT-based Decision Support Systems for Multimedia Content Development	20-30 January, 2010	NAARM, Hyderabad.
Mr. C Padmanabhan and Mr. V L Jacob	Technical and Administrative Support for Consortia based Research in Agriculture	22-27, February 2010	NAARM, Hyderabad
Dr. K N Shiva	Priority Setting, Monitoring and Evaluation for Innovation in Agriculture	22-26 March 2010	IIM, Lucknow

CONSULTANCY PROCESSING CELL

During 2009-10, the Consultancy Processing Cell (CPC) took up various analytical services such as analysis of soil, plant, manures, analysis for biochemical properties, 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. One month summer training course on Biochemistry, Biotechnology and Bioinformatics for 9 M.Sc. students was jointly organized by HRD Cell and CPC during 6th May to 5th June 2009. During the year, the total receipt through consultancy was around Rs 2.75 lakh with a major share of 47% from analysis of samples for nutrients (NPK) and 16% each from biochemical and bio control agents (mainly *Trichoderma* and *Pseudomonas*). Other consultancy services like Summer Training to MSc students (18%), visits of scientists to private farms based on requests (4%) etc., also contributed to the CPC revenue.

OFFICIAL LANGUAGE IMPLEMENTATION COMMITTEE ACTIVITIES

The Official Language Implementation Committee (OLIC) meets once in every quarter and reviews the official language implementation activities of the institutes. Quarterly, half yearly and annual reports on official language activities of the institutes prepared and sent to ICAR, New Delhi, TOLIC, Calicut and Regional Implementation Office, Cochin. Four workshops were conducted on Rules of official language and its implementation, noting and drafting and use of computer in the implementation of official language.

Dr. Urmila Harith, Asst. Director (OL), DARE, New Delhi visited this Institute on 05.02.2010 and inspected official language implementation activities of the institute. Daily a word/ phrase in Hindi and its transliteration in Malayalam and English were displayed on the board.

Hindi week was celebrated during 14-19th September 2009. During the week various competitions *viz*., extempore speech, song, debate, noting and drafting, calligraphy, memory test, anthakshari for the staff members and prizes were distributed to the winners in the valedictory function. Dr. A. Achuthan, Professor, Department of Hindi, Calicut University, Calicut was the chief guest.

Ms. N. Prasannakumari, Hindi translator attended 43rd and 44th meeting of TOLIC. Sri. B. Krishnamoorthy and Dr. K. N. Shiva attended the workshop conducted by TOLIC on 30.11.2009 and 16.02.2010, respectively. Dr. Rashid Pervez, Hindi officer and N. Prasannakumari attended TOLIC subcommittee meeting at SBT, Calicut on 20.10.2009.

During the year, Hindi version of the half yearly publication of Spices News volume 20 (1) January-June, 2009 and 20 (2) July-December, 2009 were published as Masala Samachar. Summary of annual report and project coordinator cell (Spices) were translated in to Hindi and incorporated in IISR and AICRPS annual report. Also published *Anusandhan ke Mukhya Ansh* (2008-09) and pamphlets in Hindi on ginger (*Adarak*), turmeric (*Haldi*) and black pepper (*Kalimirch*).

INSTITUTE MANAGEMENT COMMITTEE

1. Dr. V A Parthasarathy, *Director, IISR, Calicut*
2. Dr. Umesh Srivastava, Assistant Director General (Hort.II), ICAR, New Delhi
3. Dr. M. Ananadaraj, Project Co-ordinator (Spices), IISR, Calicut
4. Dr. R.P. Shukla, Principal Scientist (Entomology), CISH, Lucknow
5. Dr. M. Unnikrishnan, Principal Scientist, CTCRI, Thiruvananthapuram
6. Dr. Jagdish Singh, Principal Scientist, IIVR, Varanasi
7. Addl. Director of Agricultural (C.P). Directorate of Agriculture, Vikas Bhavan. Thiruvananthapuram
8. Dean. HC &RI, Periyakulam, TNAU, (TN)
9. Director of Research, Kerala Agricultural University, Thrissur
10. Mr. M J Ummen. Mangalath Parambil House, Arivilanjapoil P O, Alakkode (Via), Kannur
11. Sri. G Rathikumar, Deepthi, Kizhakkekara, Kottarakkara, Kollam
12. *Sr. Finance & Accounts Officer,CMFRI, Kochi*
13. 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 (upto May 2009)
Mr. B. Krishnamoorthy Acting Head, Division of Crop Improvement & Biotechnology Indian Institute of Spices Research Calicut - 673 012, Kerala	Member Secretary (from June 2009)

RECOMMENDATIONS OF RAC 2010

Sl.No.	Recommendation	Comments of the Director
1	Core collections may be worked out using different models available for other crops and elimination of duplicates in black pepper germplasm need to be taken up in a phased manner. (Action: K.V. Saji)	Core collections would be identified based on morphological, biochemical and molecular characteristics, as being followed in other crops.
2	Unexplored areas may be surveyed and collections may be made to fill the gaps in germplasm (if any) in planned manner before it is eroded. (Action: K.V. Saji)	Systematic collection surveys are made to unexplored areas.
3	Development of black pepper with multiple resistance may be given priority as extension of present project on breeding multiple lines. (Action: B. Krishnamoorthy)	As extension of the present project on breeding multiple lines, a new project on Phytofura was initiated with developing black pepper lines resistant to *Phytophthora* and nematodes as one of the objectives.
4	Breeding programmes may be concentrated on genotypes with high quality parameters. (Action: B. Krishnamoorthy)	In all the breeding programmes, quality aspects are kept in mind and all varieties released are having high quality parameters.
5	In targeted yield experiments, economic optimum level of nutrients may be worked out. The reason(s) for the negative response observed at the higher levels of fertilizer need to be investigated (Action: V. Srinivasan)	The economic optimum level of nutrients will be worked out using the existing data and will be validated during the current year.
6	Results of quality parameters may also be included. (Action: K.S. Krishnamurthy)	Data on quality parameters will be included
7	Packaging studies under modified/controlled atmosphere may be conducted (Action: T.J Zachariah)	Suggestion is noted and results will be presented in the coming IRC.
8	Modified patch budding may be tried in nutmeg. The reasons for failure of "bud take" need to be investigated(Action: J Rema)	Will be carried out in the project "Induction of orthotropic shoots in nutmeg"
9	General Comments • In long term experiments, pooled data may be presented especially for yield and quality. • For alternate bearers, yield of six years may be considered (instead of 3 years). • Efforts may be made to identify better performers under changed climatic conditions.	These suggestions are noted and will be followed.

10	Two technologies developed (1. Chemical control of turmeric shoot borer 2. Chemical and biocontrol of turmeric rhizome rot) may be transferred to KVK for field testing. (Action: Programme Coordinator, KVK)	These will be incorporated in the KVK training/demonstration programme
11	Visitors to KVK and the Farm at Peruvannamuzhi may be included in the total number of visitors to IISR, Calicut. (Action: P. Rajeev)	Records are being maintained pertaining to all visitors at KVK which would be compiled periodically for inclusion in the compilation of total visitors to IISR, Calicut.
12	Training programmes organized at KVK, Peruvannamuzhi may be included in the total number of training programmes of IISR, Calicut. (Action: P. Rajeev)	Records of all training programmes are being maintained at KVK and evaluation of the programmes will be carried out under the institute project on 'Training of research and extension personnel'. The training programmes conducted at KVK would also be included in the compilation of total programmes conducted at IISR, Calicut.
13	Farmer to farmer spread of varieties released from IISR need to be further studied. (Action: P. Rajeev)	Case study method will be adopted based on secondary data available where bulk material of seeds has been supplied to farmers in recent years and where there is report or evidence of farmers participation in seed distribution. The seed village concept to be implemented by KVK will also be used to collect the necessary information.
14	Work on investment and returns in research may be confirmed utilizing KVK staff (Consequent on the transfer of the PI) (Action: P. Rajeev)	Since there is no economist in position at IISR, Calicut, this aspect of study will be undertaken after an economist joins.
15	Antioxidant potential of curry leaf may be studied at different maturity stages. (Action: A.Shamina)	This program will be carried out in the current year in the project: Studies on the nutraceutical properties of bioactive compounds in a few spices.
16	Collaboration with suitable institutes under ICMR may be explored for validation of neutraceutical and antifilarial potential of spice compounds. (Action: A. Shamina)	This collaborative work will be taken up as a separate project, preferably with external funding.
17	Neutraceutical properties may be furnished when varieties are recommended for release. (Action: A.Shamina)	Nutraceutical properties will be assayed in released varieties.

18	High quality planting materials and the improved technologies developed at IISR need to reach farmers through the State Department of Agriculture, NHB and Spices Board who are in touch with the farmers. KVK may take a lead in this in this regard. (Action: Programme Coordinator, KVK)	Planting materials of spices are produced under NHM and seed project and sold through the farm/KVK/ATIC. For others such as fruits, flowers, etc. KVK Revolving Fund is involved. KVK is involved to develop seed villages to produce certified seeds.
19	Information/data on varietal/technology spread need to be collected. KVK staff may be utilized for the study and compilation. (Action: P.Rajeev)	Estimates of varietal spread of black pepper have been worked out based on the secondary data on distribution of nuclear planting material from IISR, Calicut. The work will be continued in ginger and turmeric under the institute project 'A study on diffusion, adoption and impact of varieties released from IISR and scientific crop management practices' in association with AICRPS.
20	The Database on Spices may be linked with that of TNAU (Dr. Anandaraja of TNAU) to get daily updates of price of spices. (Action: P. Rajeev)	The KVK website will be hyper linked with TNAU website to obtain daily updates of price of spices.
21	For mechanization of farm operations, selection of instruments/small equipment / designs available in the internet may be explored. (Action: E. Jayashree)	The suggestion will be considered along with the list circulated by Head (Engin.) IIHR.
22	Identification of varieties suited to the changing climatic conditions need to be given importance. Varieties and technologies to meet moisture stress need to be developed. Breeding for drought tolerant varieties should be given priority.	A new project on Evaluation of cardamom genotypes for yield and quality attributes under moisture stress condition has been initiated during 2010 IRC.
23	Effective collaboration with ICAR complex NEH Region is needed for developing location-based technologies. AICRP centers in this region may also be involved.	Under AICRPS, new centres have been sanctioned at ICAR Complex as well as at CAU.
24	Production of nucleus planting materials needs further emphasis. Programmes may be initiated for multiplication by certified nurseries, with the help of State Agriculture Department/Spices Board. (Action: Head, Crop Production)	Same as Point 18
25	Linkages with spice industries need to be strengthened through continuous and persistent efforts. Scientist-industry interface meeting may be arranged to get feedback on research requirement from industry people.	This suggestion will be followed when next interface with stake holders is held.

RESEARCH PUBLICATIONS

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3. Ankegowda S J and Krishnamurthy K S. 2008. Evaluation of small cardamom accessions for moisture stress. *Journal of Spices and Aromatic Crops*, 17: 172-176.

4. Ankegowda S J, Kandiannan K and Venugopal M N. 2010. Rainfall and temperature trends- A tool for crop planning, *Journal of Plantation Crops*, 38: 57-61.

5. Aravind R, Kumar A, Eapen S J and Ramana K V. 2009. Endophytic bacterial flora in root and stem tissues of black pepper (*Piper nigrum* L.) genotype: isolation, identification and evaluation against *Phytophthora capsici*. *Letters in Applied Microbiology* 48: 58

6. Aravind R, Dinu A, Eapen S J, Kumar A and Ramana K V. 2009. Isolation and evaluation of endophytic bacteria against plant parasitic nematodes infesting black pepper (*Piper nigrum* L.). *Indian Journal of Nematology*, 39: 211 – 217.

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9. Bhadramurthy V, Anju George, Bhat A I and Shiva K N. 2009. Coat protein gene sequence studies suggest that *Cucumber mosaic virus* infecting paprika (*Capsicum annuum* L.) in India belongs to subgroup IB. *Archives Plant Pathology and Plant Protection*, 42: 857-863.

10. Bhat A I, Siljo A, Jiby M V, Thankamani C K and Mathew P A. 2009. Polymerase chain reaction (PCR) based indexing of black pepper (*Piper nigrum* L.) plants against *Piper yellow mottle virus*. *Journal of Spices and Aromatic Crops*, 18: 28-32.

11. Bobby Paul, Balaji S, Sathyanath V and Eapen S J. 2009. JUZBOX: A web server for extracting biomedical words from the protein sequence. *Bioinformation* 4: 179-181.

12. Chandrasekar A, Riju A, Sithara K, Anoop S and Eapen S J. 2009. Identification of single nucleotide polymorphism in ginger using expressed sequence tags. *Bioinformation* 4: 119-122.

13. Chandrasekar A, Riju A, Sithara K, Anoop S and Eapen S J. 2009. Single nucleotide polymorphisms (SNPs) and indels in expressed sequence tag libraries of turmeric (*Curcuma longa* L.). *Online Journal of Bioinformatics* 10: 224-232.

14. Devasahayam S, Koya K M A, Anandaraj M, Thomas T and Preethi N. 2009. Distribution and ecology of root mealybugs associated with black pepper (*Piper nigrum* Linnaeus) in Karnataka and Kerala, India. *Entomon*, 34: 147-154.

15. Dhanya K, Syamkumar S and Sasikumar B. 2009. Development and application of SCAR marker for the detection of papaya seed adulteration in traded black pepper powder. *Food Biotechnology*, 23: 97–106.

16. Dhanya K and Sasikumar B. 2010. Molecular marker based adulteration detection in traded food and agricultural commodities of plant origin with special reference to spices. *Current trends in Biotechnology and Pharmacy*, 4: 454-489.

17. Dinesh R, Srinivasan V, Hamza S and Manjusha A. 2010. Short-term effects of organic manures and biofertilizers on biochemical and microbial characteristics of soils under turmeric (*Curcuma longa* L.). *Bioresource Technology*. 101: 4697-4702.

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19. Elizabeth Thomas, Jaleel Kizhakkayil, John Zachariah T, Syamkumar S and Sasikumar B. 2009. GC MS analysis of essential oil of export grade Indian, Gautemalan and Sri Lankan cardamoms. *Journal of Medicinal and Aromatic Plant Sciences*, 31: 206-208.

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21. Hareesh P S and Bhat A I. 2010. Seed transmission of *Piper yellow mottle virus* in black pepper (*Piper nigrum* L.). *Journal of Plantation Crops*, 38: 62-65.

22. Jaleel K and Sasikumar B. 2009. Variability for quality traits in a global germplasm collection of ginger (*Zingiber officinale* R.). *Current Trends in Biotechnology and Pharmacy*, 3: 254-259.

23. Jaleel K and Sasikumar B. 2010. Genetic diversity analysis of ginger (*Z.officinale* R) germplasm based on RAPD and ISSR markers. *Scientia Horticulturae*, 125: 73-76.

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28. Lincy A K, Jayarajan K and Sasikumar B. 2008. Relationship between vegetative and rhizome characters and final rhizome yield in micropropagated ginger plants (*Zingiber officinale Rosc.*) over two generations. *Scientia Horticulturae*, 118: 70–73.

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31. Nair R R and Sasikumar B. 2009. Chromosome number variation among germplasm collections and seedling progenies in turmeric, *Curcuma longa* L. *Cytologia*, 74: 153–157.

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33. Prasath D and Ponnuswami V. 2008. Determination of F_1 hybrid purity of *Capsicum annuum* L. using RAPD markers. *Vegetable Science*, 35: 190 – 191.

34. Prasath D and Venugopal M N. 2009. Compound inflorescence cardamom (*Elettaria cardamomum* Maton) in India. *Genetic Resources and Crop Evolution*, 56: 749-753.

35. Rajeev P and Kurup K N. 2009. Integrated disease management in black pepper -A study on technology diffusion and impact. *Agriculture Extension Review*, 21: 153-157.

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41. Sandeep Varma R, Johnson George K, Balaji S and Parthasarathy V A. 2009. Differential induction of chitinase in *Piper colubrinum* in response to inoculation with *Phytophthora capsici*, the cause of foot rot in black pepper. *Saudi Journal of Biological Sciences*, 16: 11-16.

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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. XXVIII 813: Conservation and characterization of *Piper* germplasm (2008-2014) [K V Saji and R Senthil Kumar]
2. Gen. XIX (813): Conservation, characterisation, evaluation and improvement of Zingiber and Curcuma Spp (2007-2012) [K N Shiva and K V Saji]
3. Gen. IX (813): Conservation and characterization of cardamom germplasm (2007-2012) [R Senthil Kumar and C N Biju]
4. Gen. XXVI (813): Evolving high yielding and high quality nutmeg clones by selection (2007-2011) [B Krishnamoorthy and J Rema]
5. Gen. XXVII (813): Improvement of Chinese cassia (*Cinnamomum cassia*) by selection (2007-2010) [B Krishnamoorthy and R Senthil Kumar]
6. Gen. XVI (813): Maintenance, enhancement and characterization of genetic variability in vanilla (*Vanilla planifolia* Andrews) (2005-2010) [R Ramakrishnan Nair and P A Mathew]
7. 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]

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

1. Gen. XVII (813): Breeding black pepper for high yield and caryophyllene (2007-2010) [K V Saji and T John Zachariah]
2. Gen. XVIII (813): Breeding black pepper for *Phytophthora* resistance (2007-2011) [K Nirmal Babu and T E Sheeja]
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]
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. IV (813): Nutrient budgeting for improved varieties of spices (2005-2010) [V Srinivasan, R Dinesh, S J Ankegowda and S Hamza]
2. Agr. XXVIII (813): Input use efficiency in turmeric in relation to quality (2007-2010) [K Kandiannan and V Srinivasan]
3. SSC V(813): Studies on allelopathy in tree species-black pepper interactions (2009-2013) [R Dinesh and S Hamza]

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

1. Phy. VIII (813): Mechanism of drought tolerance in cardamom and black pepper (2005-2010) [S J Ankegowda and K S Krishnamurthy]
2. Phy. IX (813): Investigation on factors controlling spiking in black pepper (2008-2011) [K S Krishnamurthy and S J Ankegowda]
3. 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, T John Zachariah and K N Shiva]
2. PHT. IV (813): Evaluation for physical and biochemical quality of spices (2005-2010) [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]
4. Org. Chem. III (813): 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/ A Ishwara Bhat]

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. 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]
2. 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) [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. 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, K Jayarajan]

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. (2006-2010) [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 (2009-2012) [K Nirmal Babu, R Senthil Kumar, T E Sheeja and T R Usha Rani]

3. DBT-CP 4: Accredited Test Laboratory (ATL) under the national certification system for tissue culture raised plants (NCS-TCP) (2008-2011) [A Ishwara Bhat and K Nirmal Babu]
4. DBT-CP 3: Genetic transformation of black pepper to confer resistance against viruses (2006-2010) [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 (2006-2010) [M Anandaraj and R Dinesh, N K Leela and A Kumar]
2. ICAR-CPPHT-1: Network Project on Organic Farming (2007-2012) [V Srinivasan, C K Thankamani, A Kumar and T John Zachariah]
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]
5. Outreach Programme on Management of sucking pests in Horticultural Crops: (2009-2012) [TK Jacob and S Devasahayam]
6. Outreach Programme on Diagnosis and Management of Leaf Spot Diseases in Field and Horticultural Crops (2009-2012) [C N Biju and R Praveena]

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]
2. Collaborative project: Development of potting machine for spices nursery (2009-2010) [C K Thankamani and M Muthamil Selvan]

v) National Agricultural Innovation Project, New Delhi

1. NAIP-CPPHT-1: Studies on cryogenic grinding for retention of flavour and medicinal properties of some important Indian spices (2009-2012) [T John Zachariah and N K Leela]
2. NAIP-SS-I: 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]
3. NAIP SS-II: Mobilizing Mass Media Support for Sharing Agro-Information (2009-2012) [M S Madan, P Rajeev, T K Jacob]

PERSONNEL

Headquarters

Scientific

Sl.No.	Name	Designation
1	Dr. V.A. Parthasarathy	Director
2	Dr. M. Anandaraj	Project coordinator (Spices)
3	Dr. B. Chempakam	Head, Crop Production
4	Dr. S. Devasahayam	Head, Crop Protection
5	Mr. B. Krishnamoorthy	Principal Scientist (Plant Breeding)
6	Dr. K. Nirmal Babu	Principal Scientist (Plant Breeding)
7	Dr. M.S. Madan	Principal Scientist (Agri. Economics) - upto July 09
8	Dr. T. John Zachariah	Principal Scientist (Biochemistry)
9	Dr. B. Sasikumar	*Principal Scientist (Plant Breeding) – on deputation*
10	Dr. T.K. Jacob	Principal Scientist (Entomology)
11	Dr. J. Rema	Principal Scientist (Horticulture)
12	Dr. Johnson K. George	Principal Scientist (Gen. & Cytogenetics)
13	Dr. C.K. Thankamani	Principal Scientist (Agronomy)
14	Dr. R. Dinesh	Principal Scientist (Soil Fert/Chem/Microbiol)
15	Dr. R. Ramakrishnan Nair	Sr. Scientist (Gen. & Cytogenetics)
16	Dr. R. Suseela Bhai	Sr. Scientist (Plant Pathology)
17	Dr. K. Kandiannan	Sr. Scientist (Agronomy)
18	Dr. P. Rajeev	Sr. Scientist (Agril. Extension)
19	Dr. K.S. Krishnamurthy	Sr. Scientist (Plant Physiology)
20	Dr. Santhosh J. Eapen	Sr. Scientist (Nematology)
21	Dr. N.K. Leela	Sr. Scientist (Org. Chemistry)
22	Dr. A. Ishwara Bhat	Sr. Scientist (Plant Pathology)
23	Dr. A. Kumar	Sr. Scientist (Plant Pathology) – on deputation upto Feb 2010
24	Dr. V. Srinivasan	Sr. Scientist (Soil Soil Fert/Chem/Microbiol)
25	Dr. A. Shamina	Sr. Scientist (Bio chemistry-PS)
26	Dr. K.V. Saji	Sr. Scientist (Economic Botany)
27	Dr. K.N. Shiva	Sr. Scientist (Horticulture)
28	Dr. T.E. Sheeja	Sr. Scientist (Biotechnology)
29	Dr. D. Prasath	Sr. Scientist (Horticulture) – on deputation from May 2009
30	Dr. Rashid Pervez	Sr. Scientist (Nematology)

Technical Officers

1	Dr. Johny A. Kallupurackal	Technical Officer (T9)
2	Dr. Hamza Srambikkal	Technical Officer (Lab) (T7-8)
3	Dr. Utpala Parthasarathy	Technical Officer (T7-8)

4	Mr. M.M. Augusthy	Technical Officer (T6)
5	Mr. K. Jayarajan	Technical Officer (Stat.) (T5)
6	Mr. M. Vijayaraghavan	Technical Officer (T5) (Workshop)
7	Mr. K.T. Muhammed	Technical Officer (T5) (Farm)
8	Mr. V. Sivaraman	Technical Officer (T5) (Farm)
9	Dr. C.K. Sushama Devi	Technical Officer (T5) (Lib.)
10	Ms. N. Prasannakumari	Technical Officer (T5) (Hindi Translator)
11	Mr. A. Sudhakaran	Technical Officer (T5) (Artist-cum-Photographer)

Administration

1	Mr. V.L. Jacob	Asst. Fin. & Accts. Officer
2	Mr. C.P. Padmanabhan	Asst. Admn. Officer – wef July 09
3	Ms. P.V. Sali	Private Secretary
4	Mr. K.G. Jegadeesan	Asst. Fin. & Accts. Officer

IISR Experimental Farm, Peruvanamuzhi

Scientific

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

Technical Officers

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

Krishi Vigyan Kendra

Technical Officers

1	Mr. P.S. Manoj	(T7) (Horticulture)
2	Dr. S. Shanmugavel	(T7-8) (Veterinary Science)
3	Mr. K.M. Prakash	(T7-8) (Agronomy)
4	Dr. B. Pradeep	T6 (Fisheries)
5	Ms. A. Deepthi	T6 (Home Science)

IISR Cardamom Research Centre, Appangala

Scientific

1	Dr. M. N. Venugopal	Principal Scientist (Plant Pathology) – upto Oct 09
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)
5	Dr. T.R. Usha Rani	Scientist (Biotechnology)
6	Dr. R. Praveena	Sceintsit (Plant Pathology)

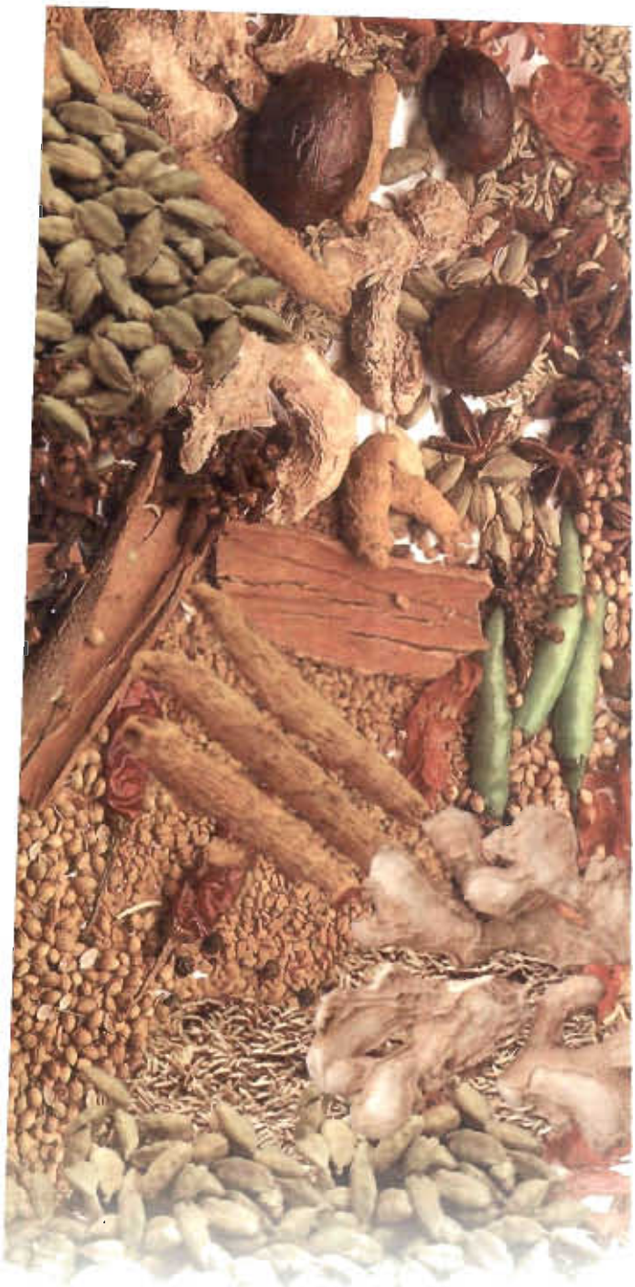
Administration

1	Mr. V. Vijayan	Asst. Admn. Officer

WEATHER DATA – 2009

Cardamom Research Centre, Appangala, Madikeri.				
Month	Temperature (°C)		Rainfall (mm)	Rainy days (no.)
	Maximum	Minimum		
January	29.2	12.2	0.0	0
February	30.9	15.4	0.0	0
March	31.0	17.4	80.2	6
April	30.8	20.1	49.9	3
May	30.6	19.7	72.5	9
June	25.5	18.7	228.8	18
July	22.6	18.3	1589.3	28
August	24.7	18.7	364.0	25
September	25.0	18.5	288.8	17
October	26.5	17.3	206.5	7
November	26.6	17.8	89.6	10
December	26.4	16.9	39.2	2
Average/Total	27.5	17.6	3008.8	125

IISR Experimental Farm, Peruvannamuzhi, Calicut.				
Month	Temperature (°C)		Rainfall (mm)	Rainy days (no.)
	Maximum	Minimum		
January	34.1	19.5	0.0	0
February	34.2	19.7	0.0	0
March	34.8	22.7	112.0	5
April	34.6	23.6	119.6	9
May	32.9	23.9	398.4	14
June	29.9	23.2	680.8	19
July	26.6	22.4	1986.6	29
August	28.5	22.7	587.6	29
September	28.9	23.1	676.0	24
October	31.6	22.6	421.6	11
November	31.9	22.6	301.2	12
December	32.9	21.2	136.6	6
Average/Total	31.8	22.3	5420.4	158



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