आई आई एस आर वार्षिक रिपोर्ट
2010 - 2011

IISR Annual Report
2010 - 2011

भारतीय मसाला फसल
अनुसंधान संस्थान
कालिकट

भारतीय कृषि
अनुसंधान परिषद
नई दिल्ली

Indian Institute of
Spices Research
Calicut

Indian Council of
Agricultural Research
New Delhi

Correct citation
Indian Institute of Spices Research, Annual Report 2010-11, Calicut

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

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ISBN : 13 - 978 - 81 - 86872 - 36 - 9

June 2011

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

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प्रस्तावना

मुझे वर्ष 2010 -11 की वार्षिक रिपोर्ट प्रस्तुत करने में अत्यधिक प्रसन्नता हो रही है। निजी तौर पर यह मेरी अन्तिम रिपोर्ट है। मैंने 2002 में निदेशक का पदभार ग्रहण किया था। तब से यह मेरी निरन्तर 10 वीं रिपोर्ट है। राष्ट्रीय सक्रिय जननद्रव्य को सभी अधिदेश फसलों को अखिल भारतीय समन्वित मसाला अनुसंधान केन्द्रों तथा एन बी पी जी आर से नये जननद्रव्यों को सम्मिलित करके समद्ध बनाया। काली मिर्च की पोल्लू प्रतिरोधकता तथा उन्नत कैरियोफिलिन क्रोसेस के लिये संकर प्रजाति ब्लोक की स्थापना की गयी। इलायची में कोक्के कैन्डु का कारक नैनो वाइरस के रूप में पहचान की गयी जो बनाना ब्राक्ट मोसाइक विषाणु के लगभग समान है। इलायची कीं ब्लाइट की अधिक प्रतिरोध क दो अक्सशनों (आई सी - 349613, आई सी- 349688) की पहचान की गयी। पोटिंग मिश्रण को मिश्रित करने के लिये सी आई ए ई, कोयम्बतोर के सहयोग से पोटिंग मिश्रण मशीन का निर्माण किया गया।

हल्दी में, मृदा में ज़िंक का छिडकाव करने पर राईसोम की उपज तथा कुरकुमिन में वृद्धि होती है। काली मिर्च और अदरक में परम्परागत उर्वरक डालने की अपेक्षा मृदा परीक्षण के आधार पर निर्धारित पोषणों का प्रयोग करने पर उपजता में 15-47% की वृद्धि हुई। प्ररोह बेधक के डिम्भक को शत प्रतिशत 72 घंटों में नाश करने वाले कीट नाशक सूत्रकृमियों की पहचान की गयी। जायफल अक्सेशन सं 9-71 (आई एन जी आर 10142) को अधिक सबिनेन (सबिनेन तथा जावित्री तेल में क्रमशः 45.0% तथा 41.9%) के लिये एन बी पी जी आर के साथ पंजीकृत किया। प्रजनन विधि द्वारा गार्सीनिया की तीन स्थनीय उपजातियों का उच्च स्तर के तने तथा प्रचुरोद्भवन मूल के साथ उत्पादन किया गया।

मूल्यांकन अध्यन से यह ज्ञात हुआ कि अल्प अवधि की फसलों में सिंचाई सुनिश्चित, पूर्व कालीन रोपण करने वाले–क्षेत्रों के लिये उपयुक्त, कुरकुमिन की अधिक मात्रा, रोग सहिष्णुता तथा स्थिर उपज के कारण कृषक स्थानीय कल्टिवारों की अपेक्षा आई आई एस आर प्रजातियों को ज्यादा अपनाते है। कृषि विज्ञान केन्द्र एवं एटिक द्वारा किसानों के लिये कार्यक्रमों को आयोजित किया जिसमें 6750 कृषक लाभान्वित हुये। मसाला उत्पादन तकनीकियों के विभिन्न विषयों पर पन्द्रह ओडियो एवं तीन वीडियो फिल्मों को विकसित किया गया। किसानों के खेतों में मिडिया भ्रमण तथा तकनीकियों को लोकप्रिय करने के लिये संस्थान में किसान मेले का आयोजन किया गया।

यह मेरा सौभग्य है कि, मैं, डा. एस. अय्यप्पन, महानिदेशक, भारतीय कृषि अनुसंधान परिषद द्वारा दिये गये प्रोत्साहन एवं सहायता के लिये उनका धन्यवाद प्रस्तुत करूं। परन्तु डॉ. एच. पी. सिंह, उप महानिदेषक (बागवानी) के अत्यधिक प्रोत्साहन एवं मार्गदर्शन के बिना हम यह अर्जित नहीं कर सकते थे। हम डा. उमेश श्रीवास्तवा, सहायक महानिदेशक (बागवानी-II) को उनके द्वारा दी गयी सभी सहायताओं के लिये आभार प्रस्तुत करते हैं। मैं इस संस्थान की शोध सलाहकार समिति के अध्यक्ष एवं सदस्यों को शोध कार्यक्रमों की समीक्षा करने एवं उनके द्वारा दिये गये सुझावों के प्रति समान रूप से कृतज्ञता प्रस्तुत करता हूँ। मैं संस्थान के अधिकारियों एवं कर्मचारियों, द्वारा किये गये कार्यों की सराहना करता हूं। मैं वार्षिक रिपोर्ट का संकलन करने पर सम्पादकों की प्रशंसा करता हूँ।

कालिकट
दिनांकः 01.06.2011

(वी. ए. पार्थसारथी)
निदेशक

PREFACE

I have great pleasure in presenting this Annual Report 2010-11. At personal level, this is the last report I am presenting since I took over as Director in 2002. This is the 10th consecutive report presented by me. The National Active Germplasm (NAGs) on all the mandate crops have been enriched with additions from centers of AICRP on Spices and NBPGR. The causal agent of 'kokke kandu' of cardamom has been identified as a nano virus with closest resembling group as Banana bract mosaic virus (BBrMV). Two cardamom accessions (IC 349613, IC 349588) that are highly resistant to leaf blight were identified. A machine for mixing and vending potting mixture was fabricated in collaboration with CIAE, Coimbatore.

In turmeric, application of zinc in soil has increased the rhizome yield and curcumin content. Targeted application of nutrients based on soil test results increased yield by 15-47% over conventional fertilizer recommendation in black pepper and ginger. Potential entamopathogenic nematode strains causing 100% mortality within 72 h on shoot borer larvae were identified. Nutmeg accession A9-71 (INGR10142) was registered with NBPGR for high sabinene (45.0% and 41.9% sabinene in nut and mace oil, respectively). Propagation method to produce plantlets with high level of shoot and root proliferation in three endemic species of garcinia was standardized.

The impact assessment studies showed that short duration nature of the varieties (compared to local ones), suitability for early planting in places with assured irrigation, high curcumin content, relative disease tolerance and stable yield are the reasons for the large scale adoption of the IISR varieties by farmers. The KVK and ATIC conducted programmes to the farmers' need and trained more than 6750 beneficiaries. Fifteen audio capsules and three video films were developed on different aspects of spice production technologies. Media visits were organized to farmer's plots and Kissan Mela cum Technology Expo was held at the institute for popularization of technologies.

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 executing our programmes. I appreciate the editors for having compiled and brought out this compilation.

Calicut
Date: 01 June 2011

V.A. Parthasarathy
Director

सारांश

काली मिर्च

फसल सुधार

जननद्रव्य संसाधन

आलप्पी जिले के तीन प्रमुख तालूकों जैसे कारतिकपल्ली, अम्बलपुशा तथा चेरतला से एक सौ तीन अक्सेशनों को संचित किया। संचयन स्थानों की ऊंचाई का अन्तर - 2 मी. (समुद्र तट से नीचे) से 7 मी. समुद्र तट से उपर था। कुल परिरक्षित संग्रहों की संख्या 2695 (जंगली काली मिर्च - 1286, कल्टिवर्स - 1400, विदेशी - 9) है। वैकल्पिक जननद्रव्य केन्द्र इलायची अनुसंधान केन्द्र, अप्पंगला में लगभग 100 अक्सेशनों को रोपित किया गया। चेलवूर में मूल्यांकन के लिये पोल्लू प्रतिरोधक संकर संयोजनों (शुभकरा ग संग्रह 816) का रोपण किया गया। अधिक कैरियोफिलिन संयोजन (शुभकरा ग संग्रह 1089) के दो सौ संकर संततियों को चेलवूर में भी रोपण किया गया।

विमोचित प्रजातियों की पहचान के लिये आई एस एस आर प्रोफाइल को विकसित करना काली मिर्च की 16 प्रजातियों को 14 प्राइमर्स के साथ मानक प्रोफाइलों का विकास एवं प्रजातियों की पहचान के लिये आई एस एस आर प्रोफाइल को विकसित किया। कुछ प्रजातियों के लिये प्रजाति विशिषट बैंड का निरीक्षण किया गया। काली मिर्च की विमोचित सभी प्रजातियों के लिये प्रजाति विशिषट बैंड द्वारा पहचान का कार्य प्रगति पर है।

पाईपर के ट्रान्स्क्रिप्टोम से ई एस टी डेटा सीक्वन्स की क्रियात्मक व्याख्या *पाईपर कोलुब्रिनम* तथा *पी. नाईग्रम* के ट्रान्स्क्रिप्टोम से व्युत्पन्न सीक्वन्सों एवं क्रियात्मक व्याख्या के संयोजनों की सहायता से द्वितीय उपचाप चालकोन आईसोमेरैस, चालकोम सिन्थैस, सिनामेट 4. हाइड्रोओक्सिलेस, सिनामोयिलदृसी ओ ए रिडक्टेस, जिरानिल जिरानील पाइरोफोस्फेट सिन्थैस एच एम जीदृसी ओ ए रिडक्टेस, लिकोपेनि ताईक्लेस, फिनाइलेनिने अमोनिया की पहचान में सहायक होता है तथा ट्र.न्सलडोटेस जीन्स द्वितीय उपापचय की प्रक्रिया में सम्मिलित होते हैं।

आर जीन्स के एन बी एस मोटिफ्स द्वारा विकृत प्राइमर्स का उपयोग करके प्रतिरोधक जीन की क्लोनिंग काली मिर्च में आर जीन्स से संबन्धित खण्डों को परिवर्धित करने के लिये विकृत प्राइमर्स का प्रयोग करते हैं। काली मिर्च की मध्यम प्रतिरोधक एवं सहिष्णु प्रजातियों तथा पाईपर स्पीसीसों को आठ जोडी ; 64 संयुक्त विकृत प्राइमरों को उपयोग खण्डित करने के लिये *कैप्सीकम अन्नुम, सी. चाइनीन्स, निकोटियाना टैबाकम, सोलैनम डमिसम* तथा *एस. ट्यूबरोसम* से छः फाइटोफ्थोरा प्रतिरोधक जीन के एन बी एस– एल आर आर क्षेत्र में परिरक्षित एवं रूपांकित किया। 520 बी पी उपजों की क्लोनिंग तथा सीक्वन्सिंग करने पर एन बी एस. एल आर आर प्रकार रोग प्रतिरोधक प्रोटीन, केवल 50% समानता प्रकट करते हैं। काली मिर्च के मध्यम प्रतिरोधक प्रजाति पी. 24-04-57: *सोलानम ट्रिलोबाटुम* एन बी एस . एल आर आर तथा आई आई एस आर शक्ति को रोग प्रतिरोधक प्रोटीन ब्रासिका रैपा सब स्पीसीस पेकिनेनसिस की 48% पहचान होती है।

फाइटोफ्थोरा प्रतिरोधकता

मेपिंग संख्या के संगत के रूप में बावन पंक्तियों को पर्ण, तना, तथा मूल संचारण रीति को छान बीन करने के लिये चयन किया गया। कुम्बलचोला (अक्से. संख्या. 1114) को फाइटोफ्थोरा बाधा के प्रतिरोधक अंकित किया गया। यह अक्सेशन पोल्लू बीटल एवं सूखापन के प्रतिरोधक भी है। *पी. कोलुब्रिनम* (178नं) के बीज पौधों को *पी. कैप्सीसी* के साथ छान बीन करने पर ज्ञात हुआ कि 21 पौधे फाइटोफ्थोरा प्रतिरोधक, 2 पौधे अति संवेदनशील तथा बाकी सामान्यतया प्रतिरोधक है।

फसल उत्पादन

प्रकाश तीव्रता का प्रभाव

काली मिर्च उपजता में प्रकाश तीव्रता के प्रभाव पर अध्ययन करने पर यह प्रकट हुआ कि प्रकाश तीव्रता 500 से 800 μ मोल्स मी.$^{-2}$ सेकेंड -1 अधिकतम उपज (5 कि. ग्राम / बेल) का उत्पादन करते है। 200 - 300μ मोल्स मि.$^{-2}$ सेकेंड -1 की तीव्रता में बेलों ने 3.4 कि. ग्राम / बेल का उत्पादन किया जो मडिकेरी में 100μ मोल्स मि.$^{-2}$ सेकेंड पर उत्पादित 1.8 कि. ग्राम / बेल के निकटतम है।

लक्षित उपज के लिये पोषण की आवशयकता

एन पी के की प्रारंभिक उर्वरता स्तर के आधार पर 5, 7-5 तथा 10 कि. ग्राम / मानक उपज मिलने के लिये उर्वरकों

की मात्रायें लक्षित की तथा पन्नियूर दृप्पर मेडिकेरी के मृगराजेन्द्रा एस्टेट में प्रयोग किया गया। अंकित किये उपज का स्तर 7.0, 8.7 तथा 9.7 कि. ग्राम / मानक है जिसका अन्तर क्रमः 40.2ए 15.6 तथा - 2.9 है। लक्षित समीकरण के द्वारा सभी लक्षित उपज के लिये पोशण की अनिवार्यता न्यूनतम समीकरण के साथ पहले ही देखी थी। सामान्य सिफारिशों की तुलना में लक्षित पोशण सिफारिशों के उपरान्त 6.3 - 47.3ः उपजता में वृद्धि अंकित की गयी।

पोटिंग मिश्रण मशीन

सी आई ए इ, कोयम्बतोर के सहयोग से एक मशीन का निर्माण किया, जो मिश्रण, चूर्ण करना, छलनी तथा पोली बैगों में आवशयक मात्रा में मिश्रण सामग्रियों को भराने की क्षमता रखती है। इस मशीन में 3 एच पी मोटर, फीड होपर, पैडल्स, छलनी ट्रै, तथा इलक्ट्रोनिक उपकरण आदि है। मशीन में मृदा, ग्रैनाइट पाउडर तथा एफ वाई एम को 2:1:1 अनुपात में तैयार कर सकते है। मशीन एक दिन में 1600 बैग भर सकती है जबकि एक दिन में दो आदमी कुल 600 बैग ही भर सकते हैं।

फसल संरक्षण

फाइटोफ्थोरा चरित्रांकन

फाइटोफ्थोरा के इक्कीस नये संग्रहों को सम्मिलित करने के बाद इस वर्ष फाइटोफ्थोरा के राष्ट्रीय संग्रहालय में कुल 305 हो गये। फाइटोफ्थोरा के सत्तर वियुक्तियों को उनके कोलोनी रूप विज्ञान के आधार पर चरित्रांकित किया, जबकि 42 को उनके स्पोरांगियल रूप विज्ञान तथा 37 को उनकी रोग जनकता के आधार पर चरित्रांकित किया गया। काली मिर्च की 137 वियुक्तियों में उग्रता के लिये अध्ययन में 110 अधिक उग्रता वाली तथा 10 को उग्रता रहित अंकित किया गया। 86 संग्रहों में, ए आई मेटिंग प्रकार (66. 3%) प्रभावशाली था। इक्यासी वियुक्तियों का मेटालैक्सिल - एम ज़ेड संवेदनशीलता का परीक्षण किया तथा ईसी 50 एवं ईसी 90 का मान का अन्तर क्रमशः 0.0002 से 14.4 पी पी एम तथा 1.1-68.5 पीपीएम था।

आनुवंशिक विविधता

फाइटोफ्थोरा की 126 काली मिर्च वियुक्तियों का आनुवंशिक विविधता का 20 एस एस आर मार्केर्स द्वारा अध्ययन किया तथा डेन्ड्रोग्राम तैयार किया गया। विविधता का डेन्ड्रोग्राम यह सूचित करता है कि वियुक्तियों के बीच उच्च विविधता तथा 5 प्रमुख वर्गों को फिर 40 लघु वर्गों में विभाजित किया। काली मिर्च में *पी. कैप्सीसी* वियुक्तियों में एस एस आर मार्केर्स द्वारा विविधता के लिये किया गया यह पहला अध्ययन है।

काली मिर्च की *पी. कैप्सीसी* वियुक्तियों को PcapF-PcapR विशिष्ट प्राइमर के साथ छान बीन किया। सभी वियुक्तियों में 573 बी पी का अपेक्षित एम्प्लिकोन प्राप्त हुआ।

जीनोमिक्स

जैवसूचना मध्यस्थता पद्धति में तीन प्राइमर्स के एक सेट का रूपांकन किया तथा इन तीनों प्राइमर्सों मे एक सेट प्राइमर ELICPHYF6 तथा ELICPHYR6 में 250 बी पी प्राप्त हुआ, इसका सीक्वन्स डेटाबेस से *पी. कैप्सीसी* के अल्फा एलिसिटिन के साथ अच्छी तरह मैच होता है। *पाइपर कोलुब्रिनम* से जीन के लक्षित क्लोनिंग का उपज 143 बी पी जीन उपजें है जो विभिन्न पौध जातियों में पहचान किये जा चुके WRKY प्रतिलेखन घटक में पहले ही पहचान किये जा चुके है। पर्ण कोशों में प्रकट होने वाला ट्रान्स्क्रिप्टेस के प्राथमिक ट्रान्स्क्रिप्टोम विश्लेषण फाइटोफ्थोरा से यह चुनौती लेकर प्रकट किया कि कई स्ट्रस निवेशित जीन, दूसरी उपापचयों से संबन्धित है। ट्रान्स्क्रिप्शन घटकों की एक प्रजाति, स्ट्रस निवेशित जीन्स एवं जीन संबन्धित को महत्वपूर्ण समानता के साथ दूसरी उपापचयों को, जो अन्य पौधों में चरित्रांकित है, भी पहचान किया गया।

जैव नियन्त्रण एजेंटों का मूल्यांकन

काली मिर्च से कुल उपलब्ध 125 वियुक्तियों से एन्डोफाइटिक कवकों की पैंतालीस वियुक्तियों को अलग किया। इन 45 वियुक्तियों में *पी. कैप्सीसी* के प्रति इन विट्रो परीक्षण करने पर नौ वियुक्तियों ने 70% से अधिक प्रतिरोधकता अंकित किया। एन्डोफाइटस वियुक्तियों के लिये परीक्षण करने के लिये तीन माईकोलोजिकल मीडिया में से माल्ट ऐक्स्ट्राक्ट अगर (एम ई ए) उत्तम था। विभिन्न स्थानों से लिये पन्द्रह ट्राइकोडेरमा वियुक्तियों को *पी. कैप्सीसी* के प्रति इन विट्रो परीक्षण किया तथा फाइटोफ्यूरा 7 के अतिरिक्त अन्य सभी वियुक्तियों में रोगाणु के प्रति >50% प्रतिरोधकता अंकित की गयी।

काली मिर्च (बी आर बी 3, बी आर बी 13 तथा बी आर बी 49) तथा अदरक (जी आर बी 35, जी आर बी 68 तथा जी आर बी 70) से प्राप्त राइज़ोबैक्टीरिया वियुक्तियों का चरित्रांकन किया तथा *पी. कैप्सीसी* के विरूद्ध क्रियाशीलता का अध्ययन किया गया। एसीटोन + ईटोएसी सार प्राप्त

करने के पश्चात् तथा रोगाणों के प्रति मूल्यांकन किया जिनमें जी आर बी 68 से प्राप्त प्रतिजैविक आशाजनक थां।

काली मिर्च में पौधों की वृद्धि एवं रोग दमन पर वर्मीकम्पोस्ट में जैव नियन्त्रण एजेंट एवं जैव उर्वरकों के संयोजन की अनुकूलता के प्रभाव के लिये ग्रान हाउस में परीक्षण किया। पौधों की वृद्धि में आई आई एस आर 853 (*प्स्यूडोमोनास एरूगिनोसा*) + *ट्राइकोडेरमा हरज़ियानम* +जैव उर्वरक का संघटन अधिक आशाजनक अंकित किया गया। लेकिन, निम्नतम रोग आपतन आई आई एस आर 6 (*पी. फ्लूरोसेंस*) जैव उर्वरक डालने पर प्राप्त हुआ। *पी. कैप्सीसी, रैडोफोलास सिमिलिस* तथा *मेलोयिडोगिन इनकोग्निटा* के प्रति खेत में एन्डोफाइटिक जैव नियन्त्रण एजेंट टी सी 10 (कैरटोबैक्टीरियम) + मेटालेक्सिल - एम ज़ैड तथा बी पी 17 (*बैसिलस मेगाटेरियम*) + फेराट डालना आशाजनक था तथा इसमें अधिकतम उपजता भी अंकित की गयी। टी सी 10 मेटालेक्सिल - एम ज़ैड उपचार में 6.498 कि. ग्राम / बेल (साफ) उपजता प्राप्त हुई जो रासायनिक नियन्त्रण की तुलना में 1.930 कि. ग्राम है। इस अवधि में उपचार करते समय फाइटोफ्थोरा खुर गलन या मृदु म्लानी जैसी कोई आपतन अंकित नहीं किया गया।

विषाणु रोग

पाइपर येल्लो मोटाइल विषाणुओं के वाइरस के वाहक ट्रान्सफोरमेन्टस की पहचान

सेन्स तथा सेन्स रहित दोनों रचनाओं से प्राप्त हारडन किये सभी पौधों में पी सी आर के विषय में डोट ब्लोट एवं दक्षिण संकरण ट्रान्स्जन के प्रभाव की पुष्टि करते हैं। सेन्स रचना की बातों में छान बीन किये सभी 30 पौधे पी सी आर में अनुकूल है जबकि सेन्स रहित रचना में छान बीन किये 78 पौधों में 62 पौधे पी सी आर में अनुकूल परीक्षण किया। चयन किये पी सी आर अनुकूल पौधे डोट ब्लोट अस्से से संबन्धित है जो यह दिखाता है कि 30 पौपौधों में, 24 सेन्स रचना में अनुकूल है तथा छान बीन किये सेन्स रहित रचना के 44 पौधों में, 38 अनुकूल है। दक्षिण संकरण विश्लेषण में सेन्स रचना के विषय में, दो पौधे (छान बीन किये 10 में से) अनुकूल चिनह दिखाता है जहां परीक्षण किये सात में से चार सेन्स रहित रचना में अनुकूल दिखाते है।

कुकुम्बर मोसाइक विषाणुओं प्रोटीन आवृत के वाहक ट्रान्सफोरमेन्टस की पहचान

छान बीन किये 109 पौधों में 104 पी सी आर परीक्षण में सुनिश्चित थे। डोट ब्लोट के तात्पर्य से 80 पौधों में से 43 के आशवादी संकेत थे तथा परीक्षण किये सभी नौ पौधे दक्षिण संकरण में सुनिश्चित थे।

पी वाई एम ओ वी के साथ ट्रान्सजेनिक पौधों का संचारण

पी वाई एम ओ वी के सेन्स तथा सेन्स रहित दोनों रचनाओं से प्राप्त ट्रान्सजेनिक पौधे मीली बग (*फेरिसिमा वाइरगेटा*) को एक वेक्टर के रूप में प्रयोग करने पर पी वाई एम ओ वी के साथ संचार किया। संचारण के 60 दिनों के बाद पी सी आर विधि द्वारा पौधों में पी वाई एम ओ वी के प्रभाव की छान बीन की गयी। सेन्स से बने संचार को पी वाई एम ओ वी के वाहक 24 पौधों में से 12 पौधे पी सी आर प्रतिक्रिया में सुनिश्चित है जबकि परीक्षण किये 12 पी सी आर में आशावादी है। चुनौतियों का संचारण किये 60 पौधों के पी वाई एम ओ वी सेन्सरहित संरचना में 45 पी सी आर में विषाणु के सकारात्मक है जबकि 15 पौधे पी सी आर में प्रतिकूल है।

सीक्रटोम विश्लेषण

β -1ए 4 एन्डोग्लूकानेस, सूत्रकृमियों में एक प्रमुख कार्यदर्शी सेल्लुलोस एनज़ाइम है, जिसे ई एस टी विश्लेषण के द्वारा *आर. सिमिलिस* में चिन्हित किया गया। लक्षित प्रोटीन β -1ए 4 एन्डोग्लूकानेस तथा कुछ रसायन के प्रति 10 पादप रसायन एवं 17 जीवाणु उपापचय का डोकिंग अध्ययन किया गया तथा न्यूनतम डोक स्कोर को लघू सूचि किया। *आर. सिमिलिस* को परीक्षण धटक के रूप में लेकर पांच फिनोलिक संघटक जैसे सिन्नामिक एसिड, कौमारिक एसिड, फेरूलिक एसिड, कफेयिक एसिड तथा एन वी ए (एन–वानिलिलनोनामिडे) की चार सांन्द्रताओं द्वारा इन विट्रो परीक्षण आयोजित किया। इनमें से, अधिकतम मृत्यु दर फेरूलिक एसिड (70.67%) में तत्पश्चात् कौमारिक एसिड (65%) तथा कफेयिक एसिड (48%) में प्राप्त हुई। सूतकृमियों की मृत्यु सीधे तौर पर योगिक समंद्रताओं पर आनुपातिक है।

प्रतिरोधियों का मूल्यांकन

छः जीवाणुओं (जी आर बी 35 – *बैसिलस अमिलोलिक्वफेसिन्स*, जी आर बी 68 – *सेराटिया मारससेंस*, जी आर बी 70 – *एन्टरोबैक्टर डिस्सोल्वन्स*, बी आर बी 3– *माइक्रोकोकस* स्पीसीस., बी आर बी 13 – अज्ञात तथा बी आर बी 49– *सेराटिया* स्पीसीस) से अपरिष्कृत संवर्धन

निस्पन्द को सूत्रकृमि नाशक के लिये इन विट्रो परीक्षण किया। बी आर बी 13 (40 µl/मि. लि.) 24/घंटों में *आर. सिमिलिस* को 100% नाश करने की क्षमता है।

एन्थ्राक्नोज़ – चरित्रांकन

काली मिर्च में आक्रमण करने वाले *कोलेटोट्राइकम ग्लोयियोस्पोरियोयिड* वियुक्तियों में बी पी 10, बीपी 15, बी पी 22, बी पी 24 तथा बी पी 26 को आक्रमणशील वियुक्तियों के रूप में पहचान की गयी। काली मिर्च में *सी. ग्लोयियोस्पोरियोयिड़स* की आक्रामक वियुक्तियों में लक्षण का अध्ययन करने के लिये काली मिर्च के 12 कल्टिवर्स / प्रजातियों संचारण किया गया। चित्ती के चारों ओर के पीलापन तथा चित्ती के व्यास के आधार पर लक्षणों की विविधता को चरित्रांकन किया।

पोल्लीबेटा में काली मिर्च को संक्रमण करने वाले *सी. ग्लोयियोस्पोरियोयिड़स* के प्रतिरोधक वियुक्तियों अथवा कवगनाशी के संवेदनशीलता खेतों की जनसंख्या में अंकित की गयी तथा इन क्षेत्रों से पृथक की गयी वियुक्तियां बोर्डियो मिश्रण एवं कारबेनडासिम की संस्तुत मात्रा के प्रति सहिषणु है।

जानपदिक विज्ञान

दैनिक न्यूनतम तथा अधिकतम तापमान का एन्थ्राक्नोज़ रोग आपतन के साथ नकारात्मक सम्बन्ध है जबकि वर्षा तथा वर्षा दिवसों में परस्पर सकारात्मक सम्बन्ध है। अधिकांश बेलों में मई-जून में रोग प्रारंभ होकर अगस्त में संक्रमण अधिक होता है। यह रोग आरोही प्ररोहों के नरम पत्तों पर छोटे गोलाकार नेक्रोटिक चित्ती के रूप में प्रारम्भ होता है जिससे यह ओरथोट्रोपिक तथा प्लागियोट्रोपिक शाखाओं तथा स्पाइकों की ओर बढता है जिसके फलस्वरूप पत्ते तथा स्पाइक झडने लगती है।

जैव नियन्त्रण एजेंटों का मूल्यांकन

अप्पंगला (करनाटक), इदुक्की एवं वयनाडु (केरल) तथा वालपराई (तमिलनाडु) में इलायची तथा काली मिर्च बागों से संचित मृदा नमूनों से बत्तीस *ट्राइकोडेरमा* स्पीसीसों को वियुक्त किया गया। इन वियुक्तियों में से प्राप्त डब्ल्यू वाई डी टी 11 आशाजनक वियुक्ति के रूप में पहचान की गयी। वियुक्ती से प्राप्त कल्चर फिल्ट्रेट कोनिडियल अंकुरण,उत्पत्ति तथा सी. *ग्लोयियोस्पोरियोयिड़स* के मेलानिज़ेशन में प्रतिकूल प्रभाव डालता है। यह वियुक्ति काली मिर्च बागों में सामान्यतया प्रयुक्त होने वाले मेटालक्सिल + मैनकोज़ेब (संस्तुत मात्रा) के साथ अनुकूल है।

पादप सारों का मूल्यांकन

प्रयोगशाला में दूषित खाद्य तकनीकियों द्वारा *सी. ग्लोयियोस्पोरियोयिड* (इलायची तथा काली मिर्च) के प्रति स्थानीय 35 पौधों के स्पीसीसों के सारों (2.5%, 5%, 10% तथा 20%, का मूल्यांकन किया गया, जिनमें *सोलानम नाइग्रम, एस. टोरवम* तथा *अज़ाडिराक्टा इंडिका* के सार आशाजनक थे। लक्षित रोग कारकों के हाइफे भी अस्वाभाविक हाइफल शाखायें, हाइफल अग्र भाग का फूलना तथा वोकुलैज़ेशन जैसे संशेधन प्रकट करते है।

कवगनाशियों का मूल्यांकन

इलायची तथा काली मिर्च में आक्रमण करने वाले *सी. ग्लोयियोस्पोरियोयिड़स* के प्रति नौ कवगनाशियों का इन विट्रो मूल्यांकन करने पर, यह ज्ञात हुआ कि हेक्साकोनाज़ोल तथा कारबैनडाज़िम मैनकोज़ेब रोग कारकों के प्रति आशाजनक थे।

इलायची

फसल सुधार

जननद्रव्य अभिलक्षण

इलायची खेत जीन बैंक को 103 नये अक्सेशनों (केरल कृषि विश्वविद्यालय, पाम्पाडुमपारा से 73 अक्सेशन, आर आर, एस, मुडिगरे से 30 अक्सेशन) को सम्मिलित करने के पश्चात् कुल जननद्रव्यों की संख्या 550 हो गयी। पचास अक्सेशनों का रूपवैज्ञानिक आधारित चरित्रांकन किया गया। अक्सेशन आई सी 547206 तथा आई सी 584093 को अधिक उपज एवं अधिक कैप्स्यूल प्रति पौधे के लिये करने के लिये लघु सूची बद्ध किया।

संकरों का मूल्यांकन

एफ$_1$ संकर संततियों के प्राथमिक मूल्यांकन परीक्षण (पी ईटी) – I (19 संयोजन) तथा पी ईटी–II (10 संयोजन) के 3 परंपरागत फसलों के उपजों का विश्लेषण करने पर आई सी 584097, आई सी 584098 तथा आई सी 54722 जैसे 3 उच्च उपज वाली संकरों की पहचान की गयी। इन संकरों से यह नियन्त्रण (सीसीएस1 तथा न्जल्लानी गोल्ड) की अपेक्षा 20-40% अधिक फसल उपज प्राप्त हुई है। बहुस्थानीय परीक्षण के आधार पर एन एच वाई –10 तथा एम ए –18 दूसरों की अपेक्षा उत्तम है।

कैट्टे प्रतिरोधकता के लिये संबन्धित आणविक मार्केर्स का अध्ययन

चार एस एस आर प्राईमेर्स जैसे, आर एम 01 आर एम 72, आर एम 131 तथा आर एम 117 का प्रयोग करके जी जी (सुग्राह्य) की अभिभावकीय बहुरूपता तथा एन के ई 12 (प्रतिरोधक) में अभिभावकीय में बहुरूपता का पता लगाने में असफल हुये। चौबीस मकिर्सों में, दो (866, 815) क्रमषः सुग्राह्य एवं प्रतिरोधक अभिभावकों में प्रत्येक 350 बी पी तथा 250 बी पी का पोलीमोरफिक बैंड प्रकट होता है। सात प्राइमेर्स प्रविधि उत्पादन बनाने में असफल हुये। जबकि बाकी में से एक ने मोनोमोरफिक आकृति दी। जी जी तथा एन के इ 12 के बीच संकर करने पर प्राप्त बीस एफ$_2$ मेपिंग को कैट्टे संचारण अध्ययन के लिये एफिड के साथ संचारण किया गया।

रूपवैज्ञानिक चरित्रांकन

छोटी इलायची के अधिकतम विविधता दर्शने वाले एक सौ दस जीन प्रकारों को चयन किया, जिनमें 12 विमोचित प्रजाति, 10 किसानों की प्रजाति, 4 संबन्धित जाति तथा 5 विशिष्ठ प्रजाति का चयन किया तथा आई पी जी आर आई डिस्क्रिप्टर एवं डस मार्गदर्शन के आधार पर लगभग 46 वर्गीकरण तथा सस्य विज्ञान का मुख्य लक्षणों का एक वर्णनकर्ता तैयार किया। चालीस रूपवैज्ञानिक तथा वनस्पति सम्बन्धी डेटा अंकित किये गये।

आणविक चरित्रांकन

प्रतिबन्धन बंधाव, माइक्रोसाटलाइट समवृद्धि तथा प्रतिरूपण पूरा किया। क्लोन किये 32 उपजों के अनुक्रमण में से 8 माइक्रोसाटलाइट प्रत्यक्ष हुये। प्राइमर का रूपांकन का कार्य प्रगति पर है। अनुक्रमण सूचना के लिये ईएसटी डेटा आधारित शोध में अदरक में होने वाले माइक्रोसाटलाइट के 94 एस एस आर प्रार्थक प्रकट हुये। 20 प्राइमरों को रूपांकित किया गया। इन में से सात को इलायची में पी सी आर उत्पाद को परिवर्धित करने तक केवल एक जीन प्रकार के बीच पोलीमोरफिसम के लिये उपयुक्त पाया गया।

छोटी इलायची के 100 जीन प्रकारों के आई एस एस आर प्रोफाइलिंग को 25 आई एस एस आर प्राइमर्स का उपयोग करके विकसित किया। अन्तरसंबन्धित डेन्ड्रोग्राम तैयार किया। छोटी इलायची के लिये जब अदरक ई एस टी एस एस आर का परीक्षण किया तब कुछ पोलीमोरफिक मार्केर्स अंकित किये गये।

फसल उत्पादन

संकरों का मूल्यांकन

आर्द्रता की विशेष संदर्भ में सुगन्धित तेल की मात्रा का आकलन करने के लिये आठ संकर संयोजनों का मूल्यांकन किया, बोल्ड × (जीजी × सी सी एस1) तथा (जीजी × सी सी एस1) × बोल्ड ने स्ट्रस अवस्थाओं में अधिक तेल मात्रा अंकित की गयी। सुगन्धित तेल की मात्रा की गणना के लिये पच्चीस जननद्रव्य अक्सेशनों का मूल्यांकन किया जिसका अन्तर 3.5-6% है। अक्सेशन 547200 ने अधिक तेल की मात्रा अंकित की गयी, तत्पश्चात् 5.5% अक्सेशन 547201 में थी। इलायची जीन प्रकार तथा (जीजी × सी सी एस 1) × बोल्ड एवं बोल्ड × 547219 के सूखा सहिषणुता का परीक्षण के लिये पत्ते मोडने का परीक्षण करने पर मुडने में अधिक समय लिया।

फसल संरक्षण

विषाणु रोग - चरित्रांकन

लीफ डिप अतिसूक्ष्म परिमाण सूक्ष्मदर्शी के आधार पर *कोक्के कन्डु* के कारका एजेंट एवं नैनो वाइरस में निकट समबन्धा है। *कोक्के कन्डु* रोग बाधित नमूनों में नैनो वाइरस के प्रभाव की पुष्टि के लिये प्राइमर्स का रूपांकन किया। क्लोरोटिक स्ट्रीक रोग को लक्षण युक्त पौधों से प्राप्त नमूनों में लीफ डिप अतिसूक्ष्म परिमाण सूक्ष्मदर्शी से फ्लक्सस विरियन्स सदृश पोटीवाइरस प्रकट होता है।

प्राइमर जोडी के साथ अनुक्रम एवं प्लान्ट विश्लेषण से यह ज्ञात हुआ है कि, पोटी वाइरस (डब्ल्यू सीआईईएन) तथा पोली(ए) का लक्षित परिरक्षित क्षेत्र बनाना ब्राक्ट मोसाइक वाइरस (बीबीआरएमवी) निकटतम सम्बन्धी वर्ग का है। विशिष्ट प्राइमर्स का लक्ष्य प्रोटीन आवृत बीबीआरएमवी का 950 बी पी आकार का उत्पादन तैयार करना है। प्रोटीन आवृत जीन की अनुक्रम विश्लेषण द्वारा बीबीआरएमवी वियुक्ति के साथ >94% जबकि पोटी वाइरस स्पीसीस के साथ <60% पहचान की गयी। जिससे यह ज्ञात होता है कि कारक वाइरस बीबीआरएमवी का एक स्ट्रेन है। पौधों में वाइरस का पता लगाने के लिये एक अच्छा आर टी – पी सी आर आधारित विधि वकसित की।

वितरण

दक्षिण भारत के प्रमुख इलायची उगाने वाले क्षेत्रों में किये गये सर्वेक्षण से इलायची में बीबीआरएमवी की बाधा करनाटक, केरल तथा तमिलनाडु में प्रबल है तथा रोग आपतन का

अन्तर 0-15% है। शिराओं के साथ क्लोरोटिक स्ट्रीक प्रत्यक्ष होने पर रोग का चरित्रांकन किया जाता है। अतः क्लोरोटिक स्ट्रीक जैसा नाम इस रोग के लिये प्रस्तावित किया गया।

पर्णों की अंगमारी – चरित्रांकन

रोग बाधित नमूनों से प्राप्त *कोलेटोट्राइकम स्पीसीस* की वियुक्ति का के चरित्रांकन कोलोनी के रंग के आधार पर किया तथा भूरा, सफेद, भूरेयुक्त सफेद, भूरेयुक्त ओलिव तथा पीलायुक्त गुलाबी जैसे पांच वर्गों में स्पष्ट किया, जिनमें अधिकतम वियुक्तियों की संख्या वर्ग IV, भूरेयुक्त ओलिव में थी। *सी. क्लोयियोस्पोरियोयिड्स* बाधित इलायची वियुक्तियों के बीच सीडी 2, सीडी11, सीडी 25, सीडी 27 तथा सीडी 30 वियुक्तिया आक्रमणशील है।

प्रतिरोधकता

पर्ण अंगमारी का स्वाभाविक आपतन 328 जननद्रव्य अक्सेशनों में अंकित किया तथा उनमें से दो अक्सेशनों में अत्यधिक प्रतिरोधक (आई सी – 349613, आई सी – 349588) थी, जबकि 103 प्रतिरोधक, 95 सामान्यत प्रतिरोधक, 91 सामान्यत सुग्रह्य तथा 2 अत्यधिक सुग्रह्य थी।

प्रकन्द गलन – वितरण

केरल के वयनाडु एवं इदक्की जिलों तमिलनाडु के वालपराई तथा करनाटक के हस्सन एवं कोडगु जिलों में रोग आपतन का अध्ययन करने के लिये सर्वेक्षण करने पर यह ज्ञात हुआ कि, वयनाडु जिले के मेपाडी पंचायत एक संवेदनशील स्थान है। सर्वेक्षण के समय विभिन्न स्थानों से संचित प्रकन्द एवं मूल गलन रोग बाधित 65 नमूनों से बयालीस कवगों को वियुक्त किया। इन्हीं कवगों में *राइज़ोक्टोनिया सोलानी, फ़्यूसेरियम ओक्सिस्पोरियम, फ़्यूसेरियम सोलानी, फ़्यूसेरियम* स्पीसीस, *कोलेटोट्राइकम* स्पीसीस, *पाइथियम वेक्सान्स, बोट्रियोडिप्लोयिडा थियोब्रोमे* तथा छः अज्ञात कल्चर है। सर्वेक्षण में सभी स्थानों स्वस्थ इलायची पौधों से मृदा नमूनों को संचित किया तथा 30 ट्राइकोडेरमा वियुक्तियों को पृथक किया।

जीवाणु म्लानी

केरल के वयनाहु जिले में छोटी इलायची में एक नई जीवाणु म्लानी रोग को अंकित किया गया। फीनोटाइपिक तथा आनुवंशिक चरित्र चित्रण से यह प्रकट होता है कि इसका कारक *आर. सोलानसीरम* बयोवार 3 फाइलोटाइप 1 है। मलटीप्लैक्स पी सी आर आधारित फाइलोटाइपिंग, 16s rDNA तथा recN जीन अनुक्रम आधारित तुलना तथा एम एल एस टी आधारित तुलनात्मक आनुवंषिक विश्लेषण ये यह प्रकट होता है यह स्ट्रेन *आर. सोलानसीरम* के अदरक स्ट्रेन के 100% समान है।

थ्रिप्स– प्रतिरोधकता का स्रोत

इलायची के रूपवैज्ञानिक चरित्र चित्रण जैसे पौधों का प्रकार, ब्राक्ट का स्वभाव (दृढता) तथा लीफ आवरण (कठोर या शिथिल) तथा थ्रिप्स (इलायची का सयोथ्रिप्स) बाधित कैप्स्यूल का आपतन के लिये दो सौ इक्तालीस अक्सेशनों की छान बीन किया गया। रोगबाधित कैप्स्यूल का औसत प्रतिशत मलबार, वाषुका तथा मैसूर प्रकार में क्रमशः 15.0, 23.4 तथा 32.5 था। रोगबाधित कैप्स्यूल का औसत प्रतिशत दृढ अक्सेशनों एवं दृढ रहित ब्रेक्ट में 28. 5 तथा 15.3 तथा कठोर तथा शिथिल लीफ आवरण में क्रमशः 27.7 एवं 14.4 था।

हल्दी

फसल सुधार

आनुवंशिक संसाधन

कुरकुमा स्पीसीसों के एक हज़ार छब्बीस अक्सेशनों को संग्रहालय में अनुरक्षित किया जा रहे है। एन बी पी जी आर शिल्लोंग तथा त्रिश्शूर से संचित दो सौ चवालीस हल्दी अक्सेशनों को रोपण करके उनका अनुरक्षण किया।

बीज संततियों का मूल्यांकन

पिछले वर्ष की उच्च उत्पादन क्षमता वाली 60 बीज संततियों में से 25 प्रकारों ने खेत में उच्च गुणन दर (15 गुणो अधिक) प्रकट किया। दो सौ बत्तीस बीज संततियों के प्रकन्दों में गुणवत्ता पैरामीटर्स, कुरकुमिन, तेल एवं ओलिओरेसिन के लिये अधिक अन्तर प्रकट किया। कुरकुमिन घटकों का अन्तर 0.02 (354/3) से 4.92% (389/1) तथा 23 संततियों में 3% से अधिक कुरकुमिन की मात्रा अंकित की गयी। उनचास संततियों में 20% से अधिक शुष्क उपज प्राप्त हुई।

फसल उत्पादन

जैविक खेती

जैविक तथा एकीकृत प्रबन्धन विधियों के विभिन्न रीतियों में समानात्मक उपज (30.2 एवं 30.6 टन/हेक्टर) अंकित की गयी। जैविक विधि में आलप्पी सुप्रीम प्रजाति में प्रतिभा की अपेक्षा अधिक उपज (17%) अंकित की गयी। एकीकृत रीतियों में मृदा जैविक कारबन, नाइट्रोजन, फोस्फोरस, पोटैशियम, कैल्शियम, मैग्नीशियम तथा ज़िंक की मात्रा थी।

एसिड फोस्फाटेसस तथा डीहाइड्रोजेनस जैसे एनज़ाइम भी एकीकृत रीतियों में अधिक होता है। नियन्त्रण (17.4 टन/हेक्टर) की अपेक्षा जैविक खादों के संयोजन में एफ वाई एम. नीम केक (एन सी). वर्मी कम्पोस्ट (वी सी) उपचार करने पर अधिकतम उपज (32 टन/हेक्टर) तत्पश्चात् एफ वाई एम. बायोडयनामिक फोर्मुलेशन (बी डी 501)+ पंचगरया (पी जी) (26.6 टन/हेक्टर)। मृदा में ओ सी, एन, पी, सी ए, एम जी तथा ज़ैड एन की उपलब्धता तथा अम्ल एवं क्षारीय फोस्फाटेस सक्रियता तथा एफ वाई एम. एन सी. वी सी. पी जी तथा बी डी मात्रा अधिक होती है।

उपज एवं गुणवत्ता

हल्दी की प्रतिभा प्रजाति की उपज एवं गुणवत्ता पर ज़िंक तथा बोरोन के प्रभाव का अध्ययन किया। मृदा में ज़िंक को 5 कि.ग्राम/हेक्टर की दर से डालने तथा 0.25% ज़िंक पत्तों पर दो बार फोस्फोरस को संस्तुत मात्रा के साथ छिडकने पर राइसोम की अधिक उपज क्रमशः 17.4 तथा 18.5 कि. ग्राम/3मी.^{2} प्राप्त हुई। फोस्फोरस के अभाव में, मृदा में ज़िंक को 10 कि. ग्राम/हेक्टर तक डालने पर अन्य उपचारों की अपेक्षा अधिक उपजता (20.8 कि.ग्राम/3मी.^{2}) प्राप्त हुई। उसी प्रकार, चूने रहित बोरोन को 1 कि.ग्राम/हेक्टर तक डालने पर राइसोम की उपज (15.7 कि.ग्राम/3मी.^{2}) अधिक प्राप्त हुई। जो नियन्त्रण की अपेक्षा 39% अधिक है। परन्तु चूना डालने पर इसी की उपज में वृद्धि बिना बोरोन के डालने पर प्राप्त हुई। इससे यह सूचित होता है कि मृदा में पी एच ठीक करने पर बोरोन की उपलब्धता अधिक होती है। एक बार पत्तों में बी (0.2%) छिडकने पर अधिक उपज (16.7 कि.ग्राम/3मी.^{2}) तथा चूना अकेला डालने पर अधिक उपज प्राप्त होती है। बोरोन 0.2% की दर से दो बार छिडकने पर कुरकुमिन की मात्रा भी अधिक (5.11%) होती है।

संशोधित संसाधन

परिष्कृत भाप उबालने तथा परम्परागत पानी में उबालने की रीतियों द्वारा हल्दी (प्रतिभा प्रजाति) का संसाधन करने पर परम्परागत रूप से पानी में 40,60,90 मिनट उबालने पर सूखने के लिये 11 दिनों की आवश्यकता होती है जबकि परिष्कृत रूप से 30, 45 तथा 60 मिनट तक उबालने पर क्रमशः 12, 23 तथा 24 दिनों की आवश्यकता होती है। परम्परागत पानी में उबालने की रीतियों द्वारा 40 मिनट उबालने पर हल्दी के राइसोम में अधिकतम कुरकुमिन (5.91%) एवं सुगन्धित तेल (3.61%) की मात्रा होती है। उपचार का समय बढाने पर कुरकुमिन, स्टार्च, सुगन्धित तेल एवं ओलिओरसिन की मात्रा में कमी होती है। राइसोम के 5 मि. मी. के टुकडे करके बिना उपचार के सुखाने पर सुखाने का समय (9दिन) में महत्वपूर्ण अन्तर है। लेकिन कुरकुमिन (5.71%), सुगन्धित तेल (3.07%) की गुणवत्ता में बहुत कमी आ जाती है।

फसल संरक्षण

प्ररोह बेधक– बायोनोमिक्स

तना बेधक का जीवन चक्र का अध्ययन हल्दी के चार प्रतिरोधक तथा चार सुग्राह्य अक्सेशनों पर किया गया। इसकी औसत प्रौढ आयु सुग्राह्य एवं प्रतिरोधक में क्रमशः 3. 8 एवं 4.0 दिन है। चौथे तथा पांचवें अविकसित लार्वा तथा प्यूपा का वज़न प्रतिरोधक अक्सेशनों में क्रमशः 0.144, 0. 114 तथा 0.087 ग्राम है तथा सुग्राह्य अक्सशनों में क्रमशः 0.136, 0.123 एवं 0.085 ग्राम था। परन्तु यह अन्तर सांख्यिकी के आधार पर उतना समर्थक नहीं था।

प्रजातियों का अभिग्रहण

हल्दी की प्रजाति प्रतिभा गुंटूर, आन्ध्रप्रदेश, तथा गुंडल पेट, करनाटक के किसानों के खेत में अच्छा प्रदर्शन कर रही है वही इन में प्रकन्द गलन प्रतिरोधकता तथा स्थानीय प्रकारों (तेकुरपेट और सेलम) की अपेक्षा पानी संलेखन की सहनशील अधिक होता है। गुंटूर में औसत उपज 38.4 टन/हेक्टर तथा गुंडलपेट में 40 टन/हेक्टर प्राप्त होने का अनुमान है।

प्रभाव मूल्यांकन

तमिलनाडु के ईरोड जिले के ईरोड एवं भवानी तालूक में सर्वेक्षण किया, परंपरागत हल्दी क्षेत्रों तथा प्रत्येक तालूक में 25 किसानों को वैज्ञानिक कृषि विधियां अपनाने के स्तर, उच्च उपज वाली विमोचित प्रजातियों तथा उपज एवं किसानों की प्राप्ति में इसके प्रभाव का मूल्यांकन के लिये चयन किया। सर्वेक्षण से ज्ञात हुआ कि सुवर्णा (पी सी टी–8) वर्श 1987 में आई आई एस आर की एक विमोचित प्रजाति, 15 साल के भीतर भवानी तालूक में इस फसल का कुल क्षेत्रफल 80% में खेती होती है, तत्पश्चात् रोमा, उच्च तुंगता अनुसंधान केन्द्र पोटांगी की विमोचित प्रजाति ईरोड तालूक में 40% खेती होती है। अल्प कालीन फसल (स्थानीय ईरोड एवं सेलम प्रजातियों की तुलना में लगभग 10 महीने) सिंचाई करने वाले स्थानों में पहले रोपण करना उचित, अधिक कुरकुमिन मात्रा, स्थानीय कल्टिवर्सों की तुलना में रोग में कमी, स्थिर उपज आदि के कारण

किसानों ने आई आई एस आर प्रजाति सुवर्णा को अपनाया। किसानों की रिपोर्ट के आधार पर परिषकृत प्रजातियों के सिंचित फसलों से भवानी तालूक में 35–40 टन/हेक्टर उपज प्राप्त किया है। पिछले दो सालों में प्रचलित हल्दी के उच्च भाव दर के कारण पांच सालों के भाव दर के लिये क्षेत्र में 11.84 के B:C अनुपात को कार्यान्वित किया गया।

अदरक

फसल सुधार

आनुवंशिक संसाधन

अदरक के पांच सौ पचानबे अक्सेशनों के अतिरिक्त एन बी पी जी आर से प्राप्त 64 अक्सेशनों को अनुरक्षण के लिये रोपण किया। रूपवैज्ञानिक एवं उपजता के आधार पर मूल्यांकन करके सूत्रकृमि सह्य अक्सेशनों का लघु सूचीबद्व किया, इन में से अक्सेशन 219 उच्च उपज तथा सूत्रकृमि सहिष्णुता के आशाजनक था।

कोशिका विज्ञान

केरल के कोल्लम जिले के एक किसानों द्वारा दिये गये (चीन से एक अक्सेशन, अक्से. 891) संग्रह में पौधों का सशक्त रूप विज्ञान, फूलों के रंग स्वरूप में अन्तर, अधिक पराग उपज तथा बडा प्रकन्द है। अभिरंजन द्वारा मूल्यांकन करने पर 58% पराग उपज तथा आभासी अंकुरण 50-58% था। स्टिग्माटिक परत तथा स्टाइल में भी पराग अंकुरण एवं परागों को ट्यूब में वृद्धि का निरीक्षण किया। लेकिन कोई फल नही प्राप्त हुआ। मूल अग्र काशों की कोशिका विज्ञान से प्रकट हुआ कि संचयन 2n=44 के साथ टेट्राप्लोयिड है।

फसल उत्पादन

लक्षित उपज के लिये अपेक्षित पोषण

एन, पी, के, की प्रारंभिक उर्वरता के आधार पर अदरक में 25, 35 तथा 45 कि. ग्राम/5मी^{2} लक्षित उपज प्राप्त करने के लिये उर्वरक की मात्रायें निश्पत्ति की तथा मेडिकेरी में 3–5 बार डाला गया। अपेक्षित पोषण को समझने के लिये तीनों लक्षित उपज स्तरों को 15.7-70.0% का अनुकूल परिवर्तन के साथ सफल रूप से पूर्वानुमानित किया। उत्पादित उपज 42.5, 47.8 तथा 52.0 कि. ग्राम/5 मी^{2} तथा 25, 35 तथा 45 कि. ग्राम/5 मी^{2} क्रमशः लक्षित उपज है।

जैविक खेती

विभिन्न प्रबन्धन विधियों में अधिकतम उपज जैविक विधि (20 टन/हेक्टर) के अधीन खेती में अंकित की गयी। सामान्यतः जैविक प्रबन्धन के अन्तर्गत महिमा तथा वरदा प्रजातियों ने अच्छा प्रदर्शन किया वही रजता की 1उपज 17-19% अजैविक रीति की तुलना में उपज बढी। जैविक विधि के अन्तर्गत मृदा एनज़ाइम की क्षमता अधिक थी। जैविक खाद के संयोजन में, एफ वाइ एम + वी सी + एन सी पी जी + बी डी उपचार में नियन्त्रण (9.7 टन/हेक्टर) की अपेक्षा उपज अधिक (25.6 टन/हेक्टर) अंकित की गयी। प्रमुख पोषण की उपलब्धता तथा अम्ल तथा क्षार फोस्फाटेस एवं डीहाइड्रोजनेस क्षमता एफ वाइ एम + एन सी + वी सी + पी जी एवं बी डी उपचार में अधिक होता है। वरदा से जैविक विधि द्वारा ओलिओरेसिन की मात्रा (3.4%) अधिक अंकित की गयी जबकि अन्य प्रजातियां एकीकृत विधि के अधीन है।

फसल संरक्षण

जीवाणु म्लानी– चरित्रांकन

कालिकट एवं वयनाडु से *रालस्टोनिया सोलानसीरम* बयोवार 3 की पांच नयी वियुक्तियों को संचित करके संग्रहालय में सम्मिलित किया तथा 10–14 दिनों के अन्तराल पर अदरक के पौधों में म्लानी अंकित किया गया। *आर. सोलानसीरम* के मल्टीप्लैक्स पी सी आर फाइलोटाइपिंग आधारित भारत में फाइलोटाइप I का प्रधान हुआ। पश्चिम बंगाल से प्राप्त आलू से प्रयुक्त की गयी एक वियुक्ति को फिलोटाइप II सुग्राहय अमरिका मूल के रूप में पहचान की गयी। *आर. सोलानसीरम* के 21 स्ट्रेनों के मल्टीप्लेकस सीक्वन्स प्रकार की पी सी आर प्रवर्धन एवं हाउस क्लीनिंग जीन (ppsA, adk,gapA,gyrB) तथा उग्रता जीन (hrpB, fliC,egl) के अनुक्रम किया गया। डेटाबेस www.pamdb.org में विकल्पिक प्रलेख के साथ तुलना करने पर *आर. सोलानसीरम* के अदरक स्ट्रेन में कई नवीन थे। मृदा में *आर. सोलानसीरम* का उचित समय पर पी सी आर आधारित पहचान किये मानकीकृत किया।

पोषक प्रतिरोधकता

अदरक के चवालीस उत्परिवर्ती को *आर. सोलानसीरम* के साथ गामा किरणों का संचार किया तथा तीन आवर्ती संचारण के बाद भी दो उत्परिवर्ती प्रतिरोधक क्षमता वाली अंकित की गयी।

रोग प्रबन्धन

अदरक के जीवाणु म्लानी के प्रबन्धन के लिये ग्यारह उपचार,के साथ परीक्षण किया गया। जिसमें दो प्रतिरोधी पौधे (टैजीटस स्पीसीस और ओसिमम सांक्टम) तथा छः एन्डोफाइटिक/राइसोबैक्टीरिया के साथ राइसोम का जैव आवरण तथा एक एक्टिनोमाइसेटस से उपचार करने पर टैजीटस स्पीसीस के साथ पहले रोपण करने पर रोग आपतन कम होता है तथा अदरक की उपज बढा भी सकती है। अदरक की मृदा से नौ एक्टिनोमाइसेटस वियुक्ति को *आर. सोलानसीरम* के प्रति प्रतिरोधकता अंकित की गयी।

प्रकन्द गलन– जैवनियन्त्रण एजेंटों का मूल्यांकन

जी आर बी 68 से प्राप्त एसीटोन्ईटोएसी सार को *पी. माइरियोटिलम* तथा *आर. सोलानसीरम* के प्रति प्रयोगशला में आशाजनक अंकित किया गया।

पी जी पी आर के प्रभाव का पोट परीक्षण करने पर, ज्ञात हुआ कि अकार्बनिक एन पी के उर्वरकों तथा उनके मृदा पोषण संघटन में उनके संयोजनों बी आर बी 13 (एन्टरोबेक्टर स्पीसीस) तथा बी आर बी 23 (माइक्रोकोककस स्पीसीस) को 100% एन पी के (140–50–270 कि. ग्राम/हेक्टर एन पी के) के साथ डालने पर मृदा में मिनरल एन पी तथा विनिमेय के का अधिकतम स्तर पंजीकृत किया। इसके अलावा, पीजीपीआर. एन पी के संयुक्त रूप से डालने के उपरांत माइक्रोबियल बयोमास–सी, – एन, – पी तथा हाइड्रोलिटिक एनज़ाइम क्षमता लगातार बढती गयी। खेत परीक्षण से ज्ञात हुआ कि *बैसिलस एमिलोलिक्वफेसिन्स* (जी आर बी 35) तथा *सेराटिया मारसेसेंस* (जी आर ब 68) को रोग नियन्त्रण एवं पौधे की वृद्धि के लिये आशाजनक है। स्ट्रेन्स जी आर बी 68 (*एस. मारसेसेंस*) तथा जी आर बी 35 (*बी. एमिलोलिक्वफेसिन्स*) को प्रकन्द अंकुरण बढाने एवं अदरक में कम मृदु गलन और जीवाणु म्लानी अंकित की गयी।

प्ररोह बेधक–बयोनोमिक्स

प्ररोह बेधक (*कोनोगीथस पंक्टिफरालिस*) के जीवन चक्र का अदरक के छः प्रतिरोधक एवं छः सुग्राह्य अक्सेशनों पर अध्ययन किया गया। प्रौढों की औसत आयु प्रतिरोधक एवं सुग्राह्य अक्सेशनों में क्रमशः 4.4 तथा 4.9 दिन थी। प्रतिरोधक अक्सेशन में चौथे और पांचवें डिम्भक तथा प्यूपा का वज़न क्रमशः 0.104, 0.104 तथा 0.07 ग्राम है तथा सुग्राह्य अक्सेशनों में 0.127, 0.112 तथा 0.073 ग्राम था। लेकिन इसमें संख्यिकीय दृष्टि से सार्थक नहीं थी।

कीटनाशक स्खकृमियो

ई पी एन स्ट्रेनों की पदमिबजपअपजल आई आईएस आर– ई पी एन01 से 08 को प्ररोह बेधक लारवे के प्रति इन विट्रो में परीक्षण किया। इनमें से आई आईएस आर– ई पी एन 01, आई आईएस आर– ई पी एन 02, आई आईएस आर– ई पी एन 07 तथा आई आईएस आर– ई पी एन 08 को लारवे के प्रति अधिक रोगजनक होते देख लिया इसके कारण 72 घंटों में 100% नश्वरता होती है जबकि आई आईएस आर– ई पी एन 03, आई आईएस आर– ई पी एन 04 तथा आई आईएस आर– ई पी एन 06 ने सभी लारवों को 96 घंटों के अन्दर नष्ट किया।

जायफल

आनुवंशिक संसाधन

पादप जननद्रव्य पंजीकरण समिति ने (एन बी पी जी आर, नई दिल्ली) जायफल जननद्रव्य ए 9–71 (आई सी–537220, आई एन जी आर 10142) को जायफल तेल में अधिक सबिनेन 45.0% तथा जावित्री तेल में 41.9% सबिनेन का पंजीकरण के लिये अनुमोदित किया। इसमे माइरिस्टिसिन (1.9% तथा 1.1%), एलिमाइसिन (0.8: तथा 1%) तथा सैाल (0.1% तथा 3.2%) का स्तर कम होता है।

कलम लगाना

जायफल में ओरटोट्रोफिक कलमों वाली हरे चिप बड्डिंग माइरिस्टिका फ्रैग्रन्स रूटस्टोक पर लगाने पर 90–100% सफलता मिलती है। कलम लगाने का उचित समय अगस्त से नवंबर तक होता है।

कैसिया

विभिन्न भागों के स्क्रेप्ड तथा अनस्क्रेप्ड सूखे छाल में सुगन्धित तेल एवं ओलिओरेसिन की मात्राओं का आकलन करने पर यह ज्ञात हुआ कि स्क्रेप्ड छाल में अनस्क्रेप्ड की अपेक्षा तेल की मात्रा अधिक होती है जबकि ओलिओरेसिन की मात्रा अनस्क्रेप्ड छाल में अधिक होती है।

वैनिला

अन्तः विषिश्ट संकरण

वी. प्लैनिफोलिया × *वी. तहिटेनसिस, वी. तहिटेनसिस* × *वी. प्लैनिफोलिया* तथा *वी. तहिटेनसिस* के स्व संततियों की पचास अन्तः विशिष्ट संकरों को एक्स विट्रो में स्थापित किया। वैनिला स्पीसीस (अन्डमान तथा निकोबार

द्वीप) –सफेद फूलवाली × *वी. एफिल्ला* की एक अन्तः विशिष्ट संकर से आठ वर्ष पश्चात् पुश्पित हुआ उसका अनुरक्षण किया जा रहा है। यह पुष्प वैनिला स्पी. (अण्डमान निकोबार) के पुष्प से छोटा परन्तु *वी. एफिल्ला* के पुष्प से बडा है। उनके प्रत्येक इनफ्लोरेसेन्स में 6–8 फूल है। फूलों का रूप एवं रंग *वी. एफिल्ला* के समान है, लेकिन लेबल्लम फ्रिल वैनिला स्पीसीस (अण्डमान तथा निकोबार) की तरह है। यह पौधे प्रारंभिक वर्षों मैं बिना पत्तों के थे, परन्तु बाद में, वैनिला स्पीसीस (अण्डमान तथा निकोबार) के पत्तों की तरह छोटे पत्ते प्रकट हुये। इससे यह ज्ञात होता है कि *वी. एफिल्ला* को नर पौधे के रूप में प्रयोग करने पर सशक्त प्रभाव पडता है।

मसाला सत्तों का आकलन

गार्सीनिया इंडिका, जी. गम्मिगट्टा, इमली तथा करी पत्तियों के सारों का ओक्सीकरण गुणों को जैसे तुरन्त निष्कर्ष निकालने के बाद, निष्कर्षण के एक वर्ष पश्चात् तीन महीने के अन्तराल में, विभिन्न समय काल में तुलनात्मक अध्ययन किया। जिसमें फोस्फोमोलिब्डिनम रीति, डीपीपीएच रेडिकल स्केवेन्जिंग प्रतिभा प्रारंभ तथा एफ ई (III) से एफ ई (II) कम करने की क्षमता तथा कुल फिनोल की मात्रा का आकलन किया गया। सार निष्कर्षण के छः महीने पश्चात् ओक्सीकरण रोधी पैरामीटर्स में प्रबल गिरावट अंकित की गयी। करी पत्तियों के सुगन्धित तेल कीमोप्रोफाइलिंग करने पर ज्ञात हुआ कि टी–कैरियोफिलिन जो सार निष्कर्षण के N महीने बाद 26% था वह नौ महीने बाद कुल 0.5% की हानि अंकित की गयी।

पके हुये या नरम करी पत्तियों में सुगन्धित तेल की तुलना करने पर ज्ञात हुआ कि पके हुये तथा नरम की पत्तियों में क्रमशः टी कैरियोफिलिन की 33% तथा 35%, β- फिलेन्ड्रेन तथा α – सेलिनेन की मात्रा क्रमशः 11% तथा 9% होती है। नरम तथा पके हुये करी पत्तियों में सुगन्धित तेल की उपज तथा कुल फिनोल की मात्रा में बहुत अन्तर था। सुगन्धित तेल की डीपीपीएच रेडिकल स्कावन्जिंग क्षमता तथा नरम पत्तियों में पानी का सार के पके हुये पत्तों (क्रमशः 78% तथा 52%) की अपेक्षा बहुत अधिक है, जबकि एफ ई (III) से एफ ई (II) सुगन्धित तेलों की सक्रियता को कम करती है तथा नरम पत्तियों का ईथनोल सार पकी हुी पत्तियों की अपेक्षा में अधिक (83% तथा 45% क्रमशः) था।

जैवसूचनायें

पी. कैप्सीसी तथा *आर. सिमिलिस* का सीक्रोटोम विश्लेषण किया गया। *आर. सिमिलिस* ईएसटी की जांच करने पर 214 कार्यदर्शी प्रोटीनों की पहचान की गयी और उनके कार्य प्रगति पर है। इन्हीं कार्यदर्षी प्रोटीनों से लगभग 45ः सूत्रकृमियों से सामन्ता थी। *पी. कैप्सीसी* से ग्लूकानेस इनहिबिटर प्रोटीन (जीआईपी) तथा एन्डो β-1ए3- ग्लूकानेस के साथ अन्तः क्रिया का संरचनात्मक एवं डोकिंग द्वारा अध्ययन किया गया।

डेटाबेस विकास

अदरक एवं हल्दी जननद्रव्य अक्सेशनों पर नये डेटाबेस विकसित करके संस्थान के सरवर में पोषित किया। फाइटोलिब, डेटाबेस का साहित्य, का प्रसार को *रालेस्टोनिया फ्यूसेरियम* पर लेख सम्मिलित करने के लिये विस्तार किया। फाइटोपीडी को विकास क्रिया यह पोलीमरेस चयिन रियाक्शन प्राइमर सेट का एक संग्रह है, जिससे फाइटोफथोरा स्पीसीस की पहचान एवं चिन्हित करने के लिये बहुत उपयोगी है। इसके साहित्य में प्रकाशित फाइटोफथोरा के 30 से अधिक स्पीसीसों के लिये सभी विश्वव्यापी प्राइमर्स तथा स्पीसीस विशिष्ट प्राइमर्स सम्मिलित है।

राष्ट्रीय परामर्श सम्मेलन

होर्ट इनफोरमाटिक्स 2010, बागवानी में जैवसूचनाओं पर राष्ट्रीय परामर्श सम्मेलन को 11–12 अक्तूबर 2010 को आयोजित किया। इसमें 30 से अधिक अनुसंधान संस्थानों से लगभग 90 प्रतिनिधियों ने भाग लिया। सम्मेलन के दौरान चार तकनीकी सत्रों में विन्नि वैज्ञानिकों द्वारा 16 व्याख्यान दिये तथा 23 पोस्टरों को प्रदर्शित किया गया।

विस्तार

संस्थान का विस्तार एवं प्रशिक्षण कार्यक्रम एटिक द्वारा संचालित हुई। एकल विंडो प्रणाली द्वारा तकनीकी सेवायें दी गयी। रिपोर्टाधीन वर्ष में, इस केन्द्र ने 2769 किसानों को कृषि सलाहें दी 1175 छात्रों ने संस्थान का भ्रमण किया। रोपण सामग्रियों, जैव एजेंटों, मसाला उपजों तथा प्रकाशनों को क्रय करके 2,46,725 रुपये का राजस्व प्राप्त किया।

संस्थान ने सी पी सी आर आई, कासरगोड, बागवानी विभाग, महाराष्ट्रा तथा कृषि विभाग, पंजाब में प्रायोजित तीन प्रशिक्षण कार्यक्रम को कैंपस में आयोजित किया। जिनमें 35 वैज्ञानिकों, अधिकारियों तथा प्रगतिशील किसानों ने भाग लिया। कैंपस के बाहर एक प्रशिक्षण कार्यक्रम बागवानी मिशन के अन्तर्गत उत्तर पूर्व हिमालयन राज्यों के लिये गुआहटी, असम में आयोजित किया, जिसमें विभिन्न कृशि विज्ञान केन्द्रों के 23 विषय विशेषज्ञों तथा 27 प्रगतिशील किसानों ने भाग लिया। संस्थान ने तीन अन्तर्राष्ट्रीय तथा तीन क्षेत्रीया राज्य स्तर पर आयोजित प्रदर्शनियोंधकिसान मेलाओं में भाग लिया। वयनाडु जिले में ग्रामीण संसाधन केन्द्रों के साथ दो वीडियो सम्मेलन वीसाट सुविधाओं द्वारा आयोजित किया जिसमें 105 किसानों ने भाग लिया।

कृषि सूचनाओं के विस्तार के लिये मोबिलाइसिंग मास मीडिया

- गुंडलपेट (हल्दी), अप्पंगला (काली मिर्च) तथा कायंकुलम (नारियल) के किसानों के खेतों में मीडिया भ्रमण आयोजित किया गया।
- तीस से अधिक सफल गाथायें तथा 75 नये मदों को प्रिन्ट माध्यम (मीडिया मीट, किसान मेला, सफल कथायें, मीडिया भ्रमण, प्रचारित तकनीकियां आदि) द्वारा दिया गया।
- रेडियो वार्ताओं पर आधारित चार कार्यक्रम, 6 दूरदर्षन कार्यक्रम, तथा अदरक, हल्दी, काली मिर्च तथा इलायची के औषधीय मूल्यों पर कार्यक्रमों का चार वषतान्तों को क्षेत्रीय टीवी चैनलों में प्रस्तुत किया।
- आकाशवाणी, कालिकट द्वारा पन्द्रह कार्य प्रसारित किये गये।
- काली मिर्च उत्पादन– एक सफल कथा (मलयालम, अंग्रेज़ी, हिंदी), प्रतिभा उत्पादक – उत्पादन के बाद वाली दशायें तथा ब्रोयिलर बकरी तकनीकी – उत्पादन के बाद वाली दशायें की सफल कथाओं की तीन वीडियो फिल्म बनाई गई। ।

कृषि विज्ञान केन्द्र

प्रशिक्षण

बागवानी, मत्स्य पालन, मुर्गी पालन, पशुधन तथा खाद्य तकनीकियों के नौ खेतीगत परीक्षण तथा आठ महत्वपूर्ण प्रदर्शनी का कार्य प्रगति पर है। प्रस्तुत वर्ष विभिन्न विषयों में एक सौ छियासठ प्रशिक्षण कार्यक्रम आयोजित किये गये जिन में 4026 किसानों, बेरोज़गार युवाओं तथा महिलाओं ने भाग लिया। अदरक के दो तथा हल्दी के तीन किसानों के खेतों में बीज उत्पादन भागी दारी कार्यक्रम आयोजित किया तथा प्राप्त बीज राइसोम को क्रमशः 42 एवं 69 किसानों को क्रय किया। किसानों के लिये आयोजित पांच प्रदर्शनियों तथा छः अध्ययन दौरे में कृषि विज्ञान केन्द्र ने भी भाग लिया।

कार्षिक सांकेतिक दर्शनम

जनुवरी 27 से 29 तक आई आई एस आर, चेलवूर केंपस में कार्षिक सांकेतिक दर्शनम 2011, किसान मेला एवं तकनोलोजी एक्स्पो को आयोजित किया। श्री. के. के. राघवन, संयुक्त रबड उत्पादन आयुक्त, रबड बोर्ड, कालिकट ने मेले का उद्घाटन किया। डा. वी. ए. पार्थसारथी, निदेशक, आई आई एस आर उद्घाटन सत्र के अध्यक्ष थे। डा. आई. जोण कुट्टी, असोशियट निदशक अनुसंधान, केरल कृशि विश्व विद्यालय, कोरपोरेशन काउनसिलर, श्री एम. पी. हमीद तथा डा. सी. वी. सायराम, प्रधान वैज्ञानिक, कृशि आर्थिकी, आंचलिक निदेशक यूनिट, कृषि विज्ञान केन्द्र, बैंगलोर ने इस अवसर पर अपने विचार प्रकट किये। विभिन्न संगठनों के पन्द्रह प्रदर्षनी स्टालों में उनकी तकनीकियों तथा उत्पादनों का प्रदर्षन हुआ। तीन दिवसीय कार्यक्रम में 200 से अधिक किसानों तथा 500 छात्रों ने भाग लिया। स्कूल छात्रों के लिये कृषि संबम्धी एक प्रश्नोत्तरी भी आयोजित की। केरल कृषि विश्व विद्यालय के डा. टी. प्रदीप कुमार, के. वी. यु, के डा. मंजु शशिधरन तथा श्री आर. सुरेश, परियोजना अधिकारी, होर्टीकोर्प ने किसेनों के लिये विशषे व्याख्यान दिये।

मानव संसाधन विकास

- जैवरसायन, जैवप्रौद्योगिकी एवं जैवसूचनाओं विषय पर एक माह का ग्रीष्मकालीन प्रशिक्षण 5 मई से 4 जून 2010 को आयोजित किया गया जिन में 19 छात्रों ने भाग लिया।
- एम एस सी के 13 तथा एम फिल के एक छात्र ने विभिनकन विषयों पर प्रोजेक्ट का कार्य पूरा किया। तीन छात्रों को पी.एच.डी. की उपाधि से सम्मानित किया तथा दो ने पी.एच.डी. की थीसीस जमा की।

EXECUTIVE SUMMARY

BLACK PEPPER

Genetic resources

One hundred and three accessions were collected from the coastal regions of three Taluks in Alleppey district *viz.,* Kathikapally, Ambalapuzha and Cherthala. The altitude of collection sites ranged from -2 m (below sea level) to 7 m MSL. The total number of collections that are being conserved is 2695 which includes 1286 wild pepper, 1400 cultivars and 9 exotic species. About 100 accessions were planted at the alternate germplasm center at CRC Appangala. Two hundred hybrid progenies of the pollu resistant and high caryophyllene cross combination (Subhakara × Coll.816) were planted at Chelavoor for evaluation.

Developing ISSR profiles for identification of released varieties

ISSR profiles were developed for 16 varieties of black pepper with 14 primers, for developing standard profiles and varietal identification. Varietal specific bands were also observed for a few varieties. Identification of varietal specific bands for all released varieties of black pepper is in progress for diagnostics.

Functional annotation of EST sequence data from the transcriptome of *Piper*

Assembly and functional annotation of sequences derived from the transcriptome of *Piper colubrinum* and *P. nigrum* helped in the identification of chalcone isomerase, chalcone synthase, cinnamate 4-hydroxylase, cinnamoyl-CoA reductase, geranyl geranyl pyrophosphate synthase, hmg-CoA reductase, lycopene beta cyclase, phenylalanine ammonia lyase, p-coumaroyl shikimate 3'- hydroxylase and transaldolase genes involved in secondary metabolism.

Cloning of resistance genes

Degenerate primers approach was used to amplify fragments related to R genes in black pepper. Moderately resistant and susceptible black pepper varieties and *Piper* species were amplified using eight pairs of degenerate primers (64 combinations) designed from conserved NBS- LRR regions of six Phytophthora resistance genes from *Capsicum annuum, C. chinense, Nicotiana tabacum, Solanum demissum* and *S. tuberosum*. Cloning and sequencing of 520 bp product showed only 50% similarity to NBS-LRR type disease resistance protein. Moderately resistant varieties of black pepper P24-O-4 had 57% identity to *Solanum trilobatum* NBS-LRR and IISR Shakthi had 48% identity to disease resistance protein *Brassica rapa pekinensis*.

Screening for Phytophthora resistance

Fifty two lines selected as association mapping population were screened using leaf, stem and root inoculation methods. Accession Kumbachola (Acc. No. 1114) was found to be tolerant to Phytophthora infection. This accession was also earlier found to be resistant to Pollu beetle and drought. Seedlings of *P. colubrinum* (178 nos.) on screening with *P. capsici* showed segregation of the resistance character, 21 resistant 2 susceptible and the rest showing moderate resistance.

Effect of light intensity

Studies on the influence of light intensity on black pepper yield revealed that vines that received light intensity of around 500 to 800 µ moles m^{-2} sec^{-1} produced maximum yield (5 kg/vine). Vines which received 200-300 µ moles $m^{-2}Sec^{-1}$ produced 3.4 kg/vine and those which received around 100 µ moles m^{-2} sec^{-1} produced 1.8 kg/vine under Madikeri conditions.

Nutrient requirement for targeted yield

Based on the initial fertility levels of N, P, K the fertilizer doses for obtaining 5, 7.5 and 10 kg/standard yield targets were worked out and applied at Mrigarajendra Estate, Madikeri on Panniyur-1. The recorded yield levels were 7.0, 8.7 and 9.7 kg/standard in the targets of 5, 7.5 and 10 kg/standard, with a deviation of +40.2, +15.6 and -2.9, respectively. Through targeted equation, nutrient requirement for all the yield targets could be predicted with a minimum deviation.

Machine for mixing and vending potting mixture

A machine capable of mixing, pulverizing, sieving, and filling of potting ingredients in poly bags at desired quantity was fabricated in collaboration with CIAE, Coimbatore centre. The unit consists of 3 HP motor, feed hopper, paddles, sieving tray, and electronic vending instrumentation. For spices nursery, the optimized ratio of soil, granite powder and farm yard manure of 2:1:1 (v/v) is used for preparation of potting mixture. Machine can fill around 1600 bags in a day as compared to 600 bags manually by two persons.

Phytophthora characterization

Twenty one new collections of Phytophthora were made during the year, bringing the total collections in National Repository of Phytophthora to 305. Seventy Phytophthora isolates were characterized for their colony morphology, while 42 were characterized for their sporangial morphology, and 37 for their pathogenicity. In black pepper, out of the 137 isolates studied for virulence 110 were highly virulent, whereas 10 were non-virulent. A1 mating type dominated (66.3%) among the 86 collections studied. Metalaxyl-MZ sensitivity of 81 isolates was tested and the EC_{50} and EC_{90} values ranged from 0.0002 to 14.4 ppm and 1.1-68.5 ppm, respectively.

Genetic diversity and fingerprinting of *P. capsici*

Genetic diversity of 126 black pepper isolates of Phytophthora was studied using 20 SSR markers. The dendrogram of diversity indicated high diversity among isolates and there were 5 major groups further divided into 40 minor groups. This is the first study of diversity among black pepper isolates of *P. capsici* using SSR markers.

Genomics

In a bioinformatics mediated approach, a set of three primers were designed and out of the three primers, one set of primer ELICPHYF6 and ELICPHYR6 yielded a product of 250 bp, the sequence of which perfectly matching with alpha elicitin of *P.capsici* from the database. Targeted cloning of WRKY transcription factor genes from *P. colubrinum* yielded a 143 bp gene fragment similar to WRKY sequences already identified in different plant species. A variety of transcription factors, stress induced genes as well as genes related to secondary metabolism with significant similarity to those characterized in other plants were also identified.

Evaluation of biocontrol agents

Forty five isolates of endophytic fungi were isolated from black pepper making the total isolates available to 125. Out of the 45 isolates tested *in vitro* against *P. capsici*, nine showed more than 70% inhibition. Among the three mycological media tested for the isolation of endophytes, Malt Extract Agar (MEA) was the best medium. The Trichoderma isolates (15 nos.) from various locations were tested in vitro against *P. capsici* and all the isolates except PhytoFuRa 7 showed >50% inhibition against the pathogen.

The efficient antagonistic isolates of rhizobacteria obtained from black pepper (BRB 3, BRB 13, and BRB 49) and ginger (GRB 35, GRB 68 and GRB 70) were characterized to decipher its mode(s) of action on *P. capsici*. The suitability of a combination of biocontrol agents and biofertilizers in vermicompost was tested for their effect on plant growth and disease suppression in black pepper in the greenhouse. The results showed that a consortium of IISR 853 (*Pseudomonas aeruginosa*) + *Trichoderma harzianum* + biofertilizers was more promising in increasing the growth of plants. However, the lowest (5.6%) disease incidence was observed with IISR 6 (*P. fluorescens*) + biofertilizers.

Identification of transformants carrying *Piper yellow mottle virus* (PYMoV)

All the hardened plants obtained from both sense and anti-sense constructs were subjected to PCR, dot blot and southern hybridization to confirm the transgene presence. In the case of sense construct, all the 30 plants screened were positive in PCR whereas in anti-sense construct, out of 78 plants screened, 62 plants tested as positive in PCR. In southern hybridization analysis, in the case of sense construct, two plants showed positive signals (out of 10 screened) whereas four out of seven tested were positive in the case of antisense construct.

Identification of transformants carrying *Cucumber mosaic virus* coat protein (CMV-CP)

Out of 109 plants screened, 104 plants were positive in PCR test. Out of 80 plants subjected to dot blot, 43 plants gave positive signals and all the nine plants tested were positive in southern hybridization.

Challenge inoculation of transgenic plants with PYMoV

Transgenic plants obtained both with sense and antisense constructs of PYMoV were challenge inoculated with PYMoV using mealy bug (*Ferrisia virgata*) as vector. After 60 days of inoculation, the plants were screened for the presence of PYMoV through PCR. The results showed that of the 24 plants carrying PYMoV sense construct challenge inoculated, 12 plants showed positive reaction in PCR while 12 plants tested negative in PCR. In PYMoV antisense construct, of the 60 plants challenge inoculated, 45 were positive for virus in PCR while 15 plants were negative in PCR.

Secretome analysis

The presence of α-1, 4 endoglucanase, a major secretory cellulose enzyme in nematodes, was located

in *R. similis* through EST analysis. Docking studies were carried out using 10 phytochemicals and 17 bacterial metabolites against the target protein α-1, 4 endoglucanase and a few chemicals with least dock score were short-listed. An *in vitro* bioassay using five phenolic compounds namely, cinnamic acid, coumaric acid, ferulic acid, caffeic acid and NVA (N-vanillylnonanamide) at four concentrations was conducted with *R. similis* as the test organism. Among these, maximum mortality was observed with the highest concentrations of ferulic acid (70.67%) followed by coumaric acid (65%) and caffeic acid (48%). The mortality of nematodes was directly proportional to the concentration of the compounds.

Evaluation of antagonists

Crude culture filtrates from six bacteria (GRB 35 - *Bacillus amyloliquefaciens*, GRB 68-*Serratia marcescens*, GRB 70-*Enterobacter dissolvens*, BRB 3-*Micrococcus* sp., BRB 13- *Enterobacter* sp. and BRB 49-*Serratia* sp.) were tested *in vitro* for their nematicidal activity. Culture filtrates of BRB 13 at 40 µl/ml caused 100% mortality of *R. similis* within 24 h.

Anthracnose - Characterization

Among the *Colletotrichum gloeosporioides* isolates infecting black pepper, BP 10, BP 15, BP 22, BP 24 and BP 26 were identified as aggressive isolates. The aggressive isolates of *C. gloeosporioides* infecting black pepper were inoculated on 12 cultivars/varieties of black pepper to study the differential reaction and to develop a set of differentials based on the symptomatology. Fig. 8

The existence of fungicide sensitive or resistant isolates among the field populations of *C. gloeosporioides* infecting black pepper was noticed in Pollibetta and the isolate from this locality was tolerant to recommended doses of Bordeaux mixture and carbendazim.

Epidemiology

Daily maximum and minimum temperatures had negative correlation with anthracnose disease incidence while, rainfall and number of rainy days had positive correlation with the disease initiation and subsequent spread. The disease gets initiated during May - June in most of the vines and the incidence attains its maximum during August.

Evaluation of biocontrol agents

Thirty two *Trichoderma* spp. were isolated from soil samples collected from rhizosphere of cardamom and black pepper from Appangala (Karnataka), Idukki, Wayanad (Kerala) and Valparai (Tamil Nadu). Among the isolates WYD T11, the *Trichoderma* sp. obtained from rhizosphere of black pepper was identified as a promising isolate. The isolate was compatible with metalaxyl + mancozeb (at the recommended dose) commonly used in black pepper plantations.

Evaluation of plant extracts

Extracts (2.5%, 5%, 10% and 20%) of 35 locally available plant species were evaluated against *C. gloeosporioides* (cardamom and black pepper), by employing poisoned food technique, in laboratory bioassays among which extracts of *Solanum nigrum, Azadirachta indica* and *S. torvum* were promising. Hyphae of the targeted pathogen also exhibited modifications like abnormal hyphal branching, hyphal tip swelling and vacuolization.

Evaluation of fungicides

Among the nine fungicides evaluated for their efficacy against *C. gloeosporioides* infecting cardamom and black pepper *in vitro*, hexaconazole and carbendazim + mancozeb were promising against the pathogen.

CARDAMOM

Genetic resources

Cardamom field gene bank was enriched with 103 new accessions (73 from KAU, Pampadumpara and 30 from RRS, Mudigere) making the total in the germplasm repository to 550. Morphological characterization has been completed in 50 accessions. Accession IC 547206 and IC 584093 were identified as high yielding with more number of capsules per plant.

Morphological characterization

One hundred and ten genotypes of small cardamom from IISR collections were selected depicting maximum diversity include 12 released varieties, 10 farmer's varieties, 4 related genera and 5 unique varieties. A descriptor was prepared with about 46 taxonomically and agronomically important characters based on IPGRI descriptor and DUS guidelines.

Molecular characterization

Restriction ligation, microsatellite enrichment and cloning was completed. Sequencing of 32 cloned products revealed 8 microsatellites. Primer designing is in progress. EST Data base searches for sequence information containing microsatellites from ginger revealed 94 SSR candidates. 20 Primers were designed.

Of these seven were found to amplify PCR products but only one gave polymorphism between the genotypes.

ISSR profiling of 100 genotypes were developed using 25 ISSR primers. The dendrogram of inter relationships was prepared. Ginger EST SSRs when tested gave a few polymorphic markers.

Evaluation of hybrids

Analysis of 3 successive crop yields of F_1 hybrids of Preliminary Evaluation Trial-I (19 combinations) and PET-II (10 combinations) resulted in identification of three high yielding genotypes such as IC 584097, IC 584098 and IC 54722. These genotypes yielded 20-40 per cent higher yield than corresponding controls (Appangala-1 and Njallani Gold). Among the genotypes shortlisted in the multi location trial, NHY-10 and MA-18 performed better compared to checks.

Among the eight cross combinations of cardamom evaluated for essential oil content, with special reference to moisture stress, Bold×(GG×CCS1) and (GG×CCS 1)×Bold recorded higher oil content under stress conditions. Leaf folding test was undertaken to test drought tolerance of cardamom genotypes and (GG×CCS-1)×Bold and Bold×547219 have taken longer time to fold. Twenty five germplasm accessions of cardamom were evaluated for essential oil content which ranged from 3.5-6.0%. IC 547200 recorded highest oil content followed by IC 547201 with 5.5%.

Studies on Molecular markers linked to *Katte* resistance

Parental polymorphism of Green gold (susceptible parent) and NKE12 (resistant parent) using four SSR primers *viz*., RM01, RM72, RM117, RM 131 failed to detect polymorphism among the parents. Among the 24 markers, two (866, 815) revealed polymorphic band each of 350 bp and 250 bp in the susceptible and resistant parents, respectively. Twenty F_2 mapping population obtained from the cross between GG×NKE 12 was inoculated with aphids for *katte* transmission studies.

Characterization of viral diseases

Based on leaf dip electron microscopy, the causal agent of *kokke kandu* showed a close resemblance with nano virus. Primers were designed to confirm the presence of nano virus in the samples infected with *kokke kandu* disease. Leaf dip electron microscopy of the samples obtained from symptomatic plants affected with chlorotic streak disease revealed the presence of flexuous virions resembling Potyvirus.

Sequencing and BLAST analysis of the sequence generated with the primer pairs targeting the conserved region of Potyvirus (WCIEN) and Poly (A), showed *Banana bract mosaic virus* (BBrMV) as the closest resembling group. Specific primers aimed to amplify coat protein of BBrMV resulted in a product of 950bp size. Sequence analysis of coat protein gene showed an identity of >94% with BBrMV isolates while identity with other distinct potyvirus species were <60%, indicating that causal virus is a strain of BBrMV. A reliable RT-PCR based method was also developed for detection of the virus in plants.

Distribution

Surveys conducted in major cardamom growing regions of South India, revealed that BBrMV infection in cardamom was prevalent in Karnataka, Kerala and Tamil Nadu and the incidence of the disease ranged from 0-15%. The disease was characterized by the appearance of chlorotic streaks along the veins and hence the name 'chlorotic streak' was proposed for the disease.

Characterization of leaf blight

The isolates of *Colletotrichum* spp. obtained from infected samples were characterized based on the colour of the colony and five groups were elucidated namely, gray, white, grayish white, grayish olive and pale pink, of which maximum number of isolates were observed in Group IV namely, grayish olive. Among the *C. gloeosporioides* isolates infecting cardamom, the isolates CD 2, CD 11, CD 25, CD 27 and CD 30 were identified as aggressive.

Resistance

The natural incidence of leaf blight was recorded in 328 germplasm accessions and two accessions were highly resistant (IC 349613, IC 349588), while 103 resistant, 95 moderately resistant, 91 moderately susceptible, 35 susceptible and 2 highly susceptible.

Rhizome rot

Surveys carried out in Wayanad and Idukki districts of Kerala, Valparai in Tamil Nadu and Hassan and Kodagu districts of Karnataka to study the disease incidence revealed that Meppadi Panchayat in Wayanad district as a hot spot. Forty two fungi were

isolated from the 65 samples of rhizome and root rot disease collected from different locations during the survey. The fungi included *Rhizoctonia solani, Fusarium oxysporum, Fusarium solani, Fusarium* spp, *Colletotrichum* spp., *Pythium vexans*, *Botryodiplodia theobromae* and six unidentified cultures.

Bacterial wilt

A new bacterial wilt disease on small cardamom was noticed in Wayanad, Kerala. Phenotypic and genetic characterization revealed that the causative organism is *R. solanacearum* biovar 3 phylotype 1. Multiplex-PCR based phylotyping, 16s rDNA & recN gene sequence based comparison and MLST based comparative genetic analysis further revealed that the strain is 100% similar to the ginger strain of *R. solanacearum.*

Source of resistance to cardamom thrips

Two hundred and forty one accessions available in the germplasm were screened for morphological characters such as plant type, nature (persistence) of bract and leaf sheath (firm or loose) and incidence of thrips (*Sciothrips cardamomi*) infested capsules. The mean percentage of infested capsules was 15.0%, 23.4% and 32.5% in Malabar, Vazhuka and Mysore types, respectively. The mean percentage of infested capsules was 28.5% and 15.3% in accessions with persistent and non-persistent bracts, and 27.7% and 14.4% in accessions that had firm and loose leaf sheaths, respectively.

TURMERIC

Genetic resources

One thousand and twenty six accessions of *Curcuma* spp are being maintained in the repository. Two hundred and forty four accessions received from NBPGR - Shillong and Thrissur were also planted for maintenance.

Evaluation of seedling progenies

Out of 60 seedling progenies with higher multiplication rate during previous year, 25 lines showed higher multiplication rate (above 15 times) in the field. Rhizomes of 232 seedling progenies showed high variability for the quality parameters, curcumin, oil and oleoresin. Curcumin content ranged from 0.02 (354/3) to 4.92% (389/1) and 23 progenies showed above 3% curcumin. Forty nine progenies showed dry recovery above 20%.

Organic farming

Among different systems of management organic and integrated systems recorded comparable yields (30.2 and 30.6 t/ha). The var. Alleppey Supreme has recorded higher yield (17%) under organic system than Prathibha compared to inorganic system. The soil organic carbon, N, P, K, Ca, Mg and Zn were higher under integrated system. The enzymes like acid phosphatase and dehydrogenase were also higher under integrated system. Among combination of organic manures, treatment with farm yard manure (FYM) + Neem cake (NC) + Vermicompost (VC) recorded highest yield (32 t/ha), followed by FYM+ Biodynamic formulation (BD501)+ Panchagavya (PG) (26.6 t/ha) compared to control (17.4 t/ha).

Micronutrients on yield and quality

The effect of Zn and B on the yield and quality of turmeric var. Prathibha was studied. Soil application of Zn @ 5 kg/ha and 0.25% Zn as two foliar sprays along with application of recommended dose of P recorded higher rhizome yield of 17.4 and 18.5 kg/3 m^2, respectively. In the absence of P application, soil Zn application up to 10 kg/ha yielded higher (20.8 kg/ 3 m^2) compared to other treatments. Similarly, without liming, application of B up to 1 kg/ha increased the rhizome yield (15.7 kg/3 m^2) which was 39% higher compared to control. But when lime was applied, similar increase in yield was observed even without application of B, indicating the benefits of correcting the soil pH in increasing the B availability. One foliar spray of B (0.2%) also recorded higher yield (16.7 kg/3 m^2) on par with lime application alone. Curcumin content was significantly higher (5.11%) in two foliar sprays of B @ 0.2%.

Improved processing

Experiments on curing of turmeric (var. Prathibha) by improved steam boiling and conventional water boiling methods, showed that turmeric cured by traditional water boiling method for 40, 60, 90 min, took 11 days for drying while turmeric cured in improved boiler for 30, 45 and 60 min took 12, 23 and 24 days. Maximum retention of curcumin (5.91%) and essential oil (3.6%) was obtained in rhizomes cured by traditional boiling method for 40 min. Increase in curing time resulted in significant reduction in curcumin, starch, essential oil and oleoresin content. Slicing of rhizomes to 5 mm thickness and drying without curing, significantly

reduced the drying time (9 days). However, there was significant reduction in quality in terms of curcumin (5.71%) and essential oil (3.07%) contents.

Bionomics of shoot borer

The life cycle of shoot borer was studied on four resistant and four susceptible accessions of turmeric. The average adult longevity was 3.8 and 4.0 days, on susceptible and resistant accessions, respectively. The fourth and fifth larval instar and pupal weights were 0.144, 0.114 and 0.087 g, respectively, on resistant accessions and 0.136, 0.123 and 0.085 g, respectively, on susceptible accessions. However, the differences were not statistically significant.

Adoption of varieties

Turmeric variety IISR Prathibha performed well in farmers' plots at Guntur, Andra Pradesh and Gundlupet, Karnataka under different systems of planting. The variety was observed to be with less incidence of rhizome rot under field conditions and tolerant to water logging compared to the local types (Tekurpet and Salem). The average yield obtained at Guntur was 38.4 t/ha and the yield estimate projection was 40 t/ha at Gundlupet.

Impact assessment

The survey was conducted in Erode and Bhavani Taluks of Erode District in Tamil Nadu, a traditional turmeric tract and 25 farmers from each of the taluks were selected randomly to assess the level of adoption of scientific cultivation practices, high yielding released varieties and its impact on yield and returns to the farmers. The survey revealed that, Suvarana (PCT-8), an improved variety released by IISR in 1987, has now spread over a period of 15 years, to an extent of about 80% of total area under the crop in Bhavani Taluk) followed by Roma, variety released from High Altitude Research Station, Pottangi to an extent of about 40 % in Erode Taluk. The short duration of the crop (compared to local Erode and Salem varieties with around 10 months), suitability for early planting in places with assured irrigation, high curcumin content, relative disease tolerance compared to local cultivars and stable yield over seasons are the reasons reported by the farmers for the adoption of IISR Suvarna. The farmers reported an yield of 35-40 t/ha from the improved varieties in Bhavani Taluk.

GINGER

Genetic resources

Five hundred and ninety five accessions of ginger are being maintained, besides 64 accessions received from NBPGR were also planted for maintenance. Among five shortlisted nematode tolerant accessions evaluated for morphological and yield characters, Acc. 219 was found to be promising with high yield and nematode tolerance.

Cytology

An exotic collection from China supplied by a farmer from Quilon, Kerala showed vigorous plant morphology, variation in flower colour pattern, high pollen fertility and bold rhizomes. Pollen fertility assessed by staining was found to be 58% and *in vitro* germination was 50.58%. Pollen germination and pollen tube growth was observed on stigmatic surface and rarely in style also. However, no fruit set was observed. Cytological analysis of root tip cells showed that the collection is a tetraploid with 2n=44.

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/5 m^2 bed yield targets in ginger were worked out and applied in 3-5 splits at Madikeri. Nutrient requirement for realizing all the three targeted yield levels could be predicted successfully with a positive deviation of 15.7 – 70.0%. The realized yield levels were 42.5, 47.8 and 52.0 kg/ 5 m^2 for the yield targets of 25, 35 and 45 kg/5 m^2, respectively.

Organic farming

Among the different management systems, highest yield was recorded under organic system (20 t/ha). In general var. Mahima and Varada performed well under organic management compared to Rejatha with 17-19% yield increased compared to inorganic system. Soil enzyme activities was higher under organic system. Among combination of organic manures, treatment FYM+VC+NC+PG+BD recorded highest yield (25.6 t/ha) compared to control (9.7 t/ha). The availability of major nutrients and acid and alkaline phosphatases and dehydrogenase activity were higher under FYM+NC+VC+PG and BD application. Varada recorded higher oleoresin content under organic system (3.4%) whereas other varieties under integrated system.

Characterization of bacterial wilt

Five new isolates of *Ralstonia solanacearum* biovar 3 from Calicut and Wayanad were added to the repository and were found to cause wilt in ginger plants in 10-14 days. Multiplex-PCR based phylotyping of R. solanacearum revealed predominance of Phylotype I in India. An isolate from potato obtained from West Bengal tested positive for Phylotype II indicating its American origin. Multi-locus Sequence typing (MLST) of 21 strains of *R. solanacearum* was carried out by PCR amplification and sequencing of housekeeping genes (ppsA, adk, gapA, gdhA, gyrB) & virulence genes (hrpB, fliC and egl). Real time PCR based detection of *R. solanacearum* in soil was standardized.

Host resistance

Fifty four ginger accessions irradiated with gamma ray were challenge inoculated with *R. solanacearum* and two accessions showed resistant reaction even after three repeated inoculations.

Disease management

Trials on management of bacterial wilt of ginger with 11 treatments, including two antagonistic plants (*Tagetes* sp. and *Ocimum sanctum*) and biopriming of rhizomes with six endophytic / rhizobacteria and an actinomycetes indicated that pre-planting with *Tagetes* sp. reduced the disease incidence and enhanced ginger yield. Nine actinomycete isolates from ginger soil were found to be antagonistic to *R. solanacearum*.

Evaluation of biocontrol agents against rhizome rot

The efficient antagonistic isolates of rhizobacteria obtained from black pepper (BRB 3, BRB 13, and BRB 49) and ginger (GRB 35, GRB 68 and GRB 70) were characterized to decipher its mode(s) of action on the pathogens *Pythium myriotylum* and *R. solanacearum*. Acetone + EtoAc extractions were obtained and evaluated against the pathogens among which the antibiotic obtained from GRB 68 was promising in inhibiting *P. myriotylum*, and *R. solanacearum in vitro*.

Field experiments indicated that *Bacillus amyloliquefaciens* (GRB 35) and *Serratia marcescens* (GRB68) were promising for disease control and plant growth promotion. The strains GRB 68 (*S. marcescens*) and GRB 35 (*B. amyloliquefaciens*) were found to enhance the sprouting of rhizomes besides reducing soft rot and bacterial wilt in ginger.

Bionomics of shoot borer

The life cycle of shoot borer (*Conogethes punctiferalis*) was studied on six resistant and six susceptible accessions of ginger. The mean adult longevity was 4.4 and 4.9 days, on resistant and susceptible accessions, respectively. The fourth and fifth larval instar and pupal weights were 0.104, 0.104 and 0.07g, respectively, in resistant and 0.127, 0.112 and 0.073 g, respectively, in susceptible accessions. However, the differences were not statistically significant.

Evaluation of EPNs

The infectivity of EPNs strains IISR-EPN 01 to 08 was tested against shoot borer larvae under *in vitro* conditions. Among these, IISR-EPN 01, IISR-EPN 02, IISR-EPN 07 and IISR-EPN 08 were more pathogenic to the larvae causing 100% mortality within 72 h, whereas IISR-EPN 03, IISR-EPN 04 and IISR-EPN 06 killed all the larvae within 96 h.

NUTMEG

Genetic resources

The Plant Germplasm Registration Committee (NBPGR, New Delhi) approved the registration of the nutmeg germplasm A9-71 (IC 537220, INGR10142) as a source of high sabinene (45.0% sabinene in nutmeg oil and 41.9% sabinene in mace oil). It has low levels of myristicin (1.9% and 1.1%), elemicin (0.8% and 1%) and safrole (0.1% and 3.2%).

Budding

Green chip budding with orthotropic buds was successful in nutmeg on *Myristica fragrans* rootstock with 90-100% success. The ideal time for budding was August to November.

CASSIA

Essential oil and oleoresin contents in scraped and unscraped dried bark from different portions of the shoot indicated that the oil content is high in scraped bark compared to the unscraped bark, where as oleoresin content was high in unscraped bark.

VANILLA

Interspecific hybridization

Fifty interspecific hybrids each of *V. planifolia* × *V. tahitensis*, *V. tahitensis* × *V. planifolia* and selfed progenies of *V. tahitensis* were established *ex vitro*. One of the inter-specific hybrids between *Vanilla* sp.

(A&N islands)-White flowered × *V. aphylla*, has flowered after 8 years of maintenance. The flowers were smaller than that of *Vanilla sp* (A&N), but larger than that of *V. aphylla*. There were 6-8 flowers per inflorescence. Flowers had the general appearance and colour of that of *V. aphylla*, but the frill of the labellum was more similar to that of *Vanilla* sp. (A&N). The plant was without any leaves in early years of growth but, later produced leaves smaller than that of *Vanilla* sp. (A&N). The results indicate a strong influence of *V. aphylla* which was used as male parent.

ANTIOXIDANT PROPERTY OF SPICE EXTRACTS

The antioxidant property of extracts of *Garcinia indica, G. gummi-gutta*, tamarind and curry leaves were compared at different time periods, immediately after extraction, up until one year after extraction, at three month intervals 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 and quantifying the total phenols. Drastic decrease in the antioxidant parameters has been reported after six months of extraction. Chemoprofiling of curry leaf essential oil revealed that, t-caryophyllene which was up to 26% after six months of extraction was reduced to negligible amounts (0.5%) by nine months due to oxidation to t-caryophyllene oxide.

A comparison of the essential oil of mature and tender curry leaves revealed 33% and 35% of t-caryophyllene and 11% and 9% of β-phellandrene and α-selinene in mature and tender leaves, respectively. The essential oil yield and total phenol content of tender and mature curry leaves were at par. The DPPH radical scavenging ability of essential oil and water extract of tender leaf was significantly higher than the mature leaves (78% and 52% respectively), while the Fe(III) to Fe(II) reducing activity of essential oil and ethanol extract of tender leaf were significantly higher than that of mature leaves (83% and 45% respectively).

BIOINFORMATICS

Secretome analysis of *P. capsici* and *R. similis* was carried out. On exploring the ESTs of *R. similis*, 214 secretory proteins were identified and their functional annotation was carried out. About 45% of these secretory proteins showed similarity to nematodes. The mode of interaction of Glucanase Inhibitor Protein (GIP) from *P. capsici* with plant endo- β -1, 3-glucanases was studied through structural and docking studies.

Geoinformatics

Using Eco-Crop model of DIVA GIS, availability of garcinia in the North Eastern Himalayan states was predicted and six species endemic to NE States were collected. Hydroxy citric acid (HCA) content was compared for species from both Western Ghats and Himalayan foot hill ecosystems and Western Ghat species were found to have higher HCA content.

Database development

New databases on ginger and turmeric germplasm accessions were developed and hosted on the Institute server. The scope of Phytolib, the literature database, was further widened to include articles on Ralstonia and Fusarium. PhytoPD, a repository of Polymerase Chain Reaction primer sets, useful for the identification and detection of Phytophthora species, was developed and uploaded. It includes all the universal primers and species-specific primers for more than 30 species of Phytophthora published in literature.

National Consultative Meet

Hortinformatics 2010, the National Consultative Meet on Bioinformatics in Horticulture was organized 11-12 October 2010. About 90 delegates from more than 30 research institutes and universities participated in the event. Sixteen invited talks and 23 posters were presented by various scientists in four technical sessions during the meet.

EXTENSION AND TRAINING

The extension and training services of the institute is coordinated through the ATIC, a single window system of delivery of technology services, inputs and products to the end users. During the year, 2769 farmers availed farm advisory services from the centre; 1175 students visited the centre for study purpose. An income of ₹ 246,725 was generated through the sale of planting material, bioagents, spice produce and publications.

The institute conducted three on-campus training programmes sponsored by CPCRI, Kasaragod, Department of Horticulture, Maharashtra and Department of Agriculture, Punjab, in which 35 scientists, officials and progressive farmers participated. One off-campus training was organized

under the Horticulture Mission for North East and Himalayan States at Guwahati, Assam in which 23 SMSs from various KVKs and 27 progressive farmers participated. The institute participated in three exhibitions/farmers fairs at the national level and three at the regional/state level. Two video conferencing sessions with village resource centers in Wayanad district were organized through VSAT facility in which 105 farmers participated.

Mobilising mass media support for sharing agro-information

- Media visits were organized to farmers plots in Gundlupet (turmeric), Appangala (black pepper) and Kayamkulam (coconut)
- More than 30 Success Stories and 75 news items have been given through print media (on coverage of media meet, Kissan mela, success stories, media visits, technologies released etc.)
- Four Radio news based programmes and six TV news clippings and four episodes of programmes on medicinal values of ginger, turmeric, black pepper and cardamom for regional TV channel were provided
- Produced and broadcasted 15 audio capsules through AIR Calicut.
- Three video films on Augmenting Black Pepper Production – A Success Story (Malayalam, English, Hindi), Success Story of a 'Prathiba' grower – Post production stage and Success of broiler goat technology - Post production stage were produced.

KRISHI VIGYAN KENDRA

Trainings

Nine on-farm trials and eight front line demonstrations in horticulture, fisheries, poultry, livestock and food technology are in progress. One hundred and sixty six training programmes were conducted during the year in various subjects in which 4026 farmers, unemployed youth and women participated. Participatory seed production was undertaken in two ginger and three turmeric farmers' plots and the seed rhizomes obtained were sold to 42 and 69 farmers, respectively. The KVK also participated in five exhibitions and six study tours were arranged for farmers.

Karshika Sankethika Darshanam

Karshika Sankethika Darshanam 2011, Kissan Mela & Technology Expo was organized from January 27-29, 2011 at IISR, Chelavoor Campus. Mr. K K Raghavan, Joint Rubber Production Commissioner, Rubber Board, Calicut, inaugurated the mela. Dr. V A Parthasarathy, Director of IISR chaired the inaugural session. Dr. I John Kutty, Associate Director of Research, Kerala Agricultural University, Pattambi, Corporation Councilor Mr. M P Hameed and Dr. C V Sairam, Principal Scientist, Agri Economics, Zonal Director Unit, KVK Bangalore offered felicitations. Fifteen exhibition stalls of different organizations displayed their technologies/ products. Over 200 farmers and 500 students attended the three days programme. A quiz programme on Agriculture for school students was also organized.

HUMAN RESOURCE DEVELOPMENT

- One month summer training on Biochemistry, Biotechnology and Bioinformatics was conducted for 19 M.Sc. students during 5th May - 4th June 2010.
- Thirteen M.Sc. and one M. Phil students carried out project work in various disciplines. Three students were awarded and two have submitted for Ph.D degree.

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

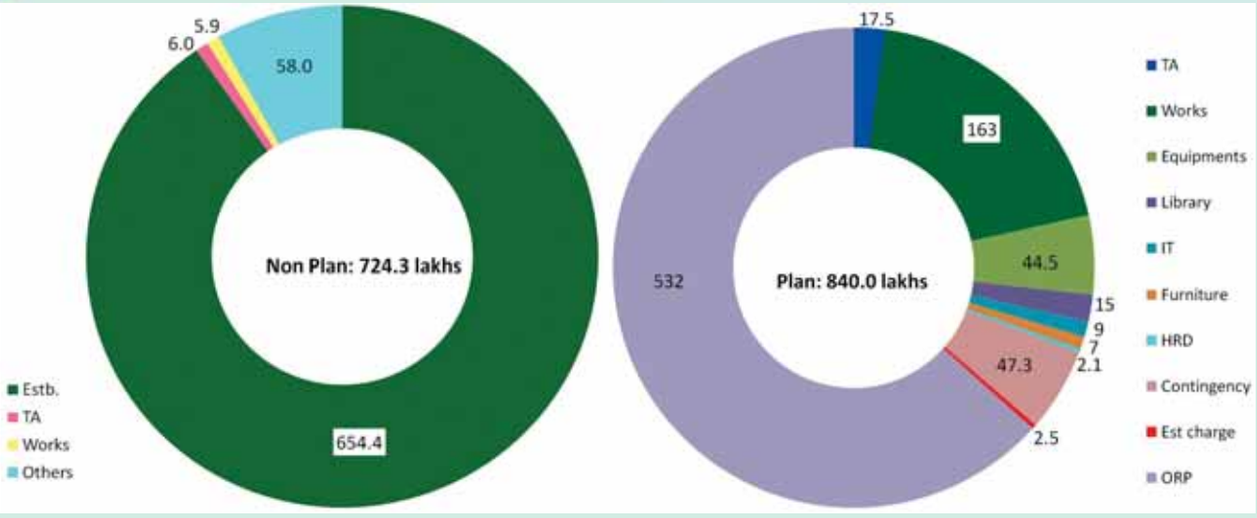
- To extend services and technologies to conserve genetic resources of spices as well as soil, water and air of spices agroecosystems.
- To develop high yielding and high quality spice varieties and sustainable production and protection systems using traditional and non-traditional techniques and novel 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. 1564.3 akhs during the year, which included Rs. 840.0 lakhs under Plan and Rs. 724.3 lakhs under Non Plan



Resource generation: Institute earned a total of Rs. 32.0 lakhs through sale of planting materials, biocontrol agents, training, publications and consultancy services.

Staff: The institute has a sanctioned strength of 43 scientific, 24 administrative, 31 technical and 59 supporting staff, of which 34, 14, 28 and 44 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

Administrative block

A new administrative block was established at Chelavoor campus with an area of 512 m^2 having facilities for hosting office automation server.

Instrument facilities improved

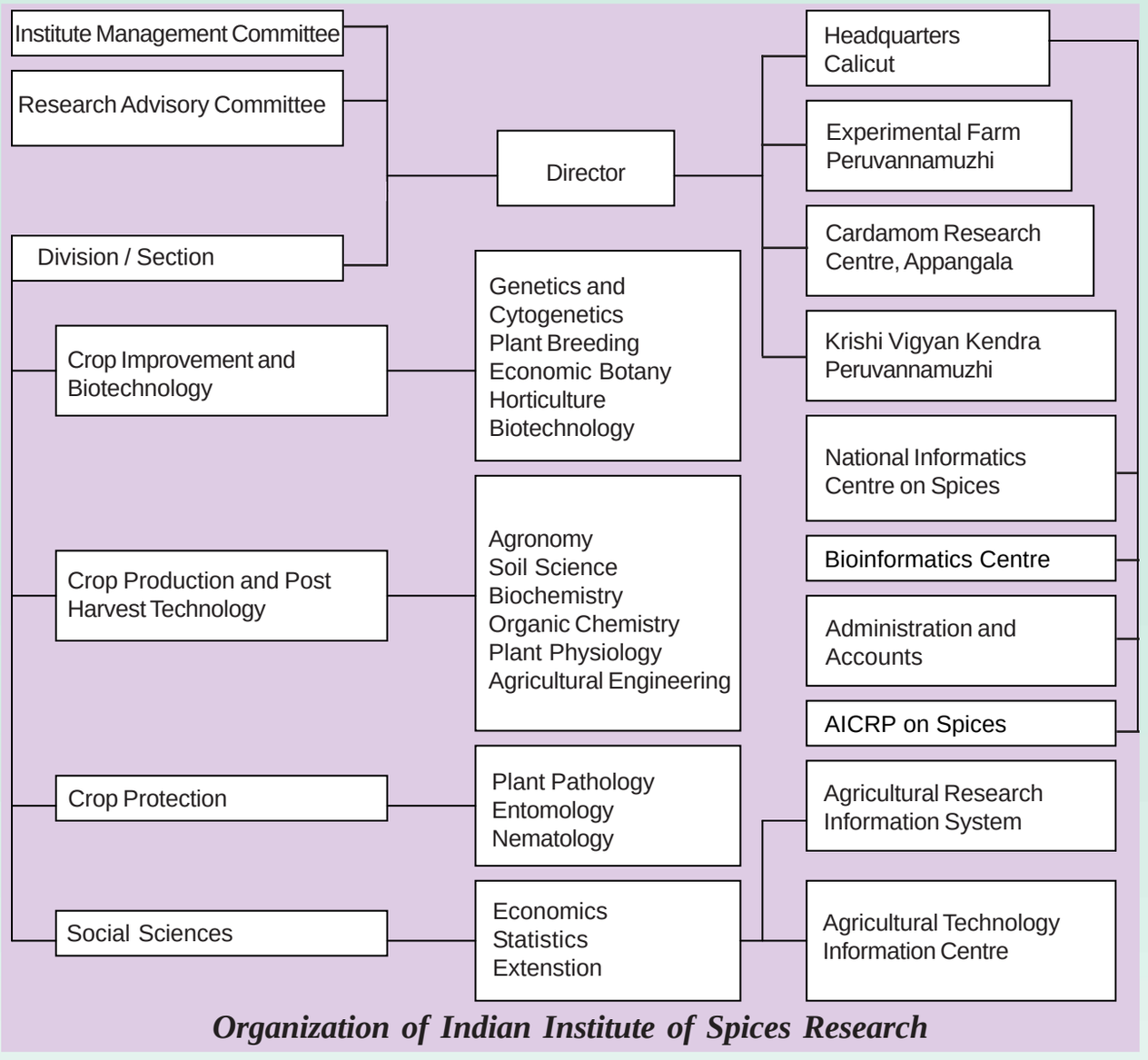
During this year equipments like Real time PCR, CN analyser were added to the central instrumentation facility. A 250 KVA generator facility was also installed at the institute.

Staff position of the institute

Category	Sanctioned	Position			Total	Vacant
		Calicut	Peruvannamuzhi	Appangala		
Scientist	43	29	1	4	34	9
Technical	31	14	12	2	28	3
Administration	24	13	-	1	14	10
Supporting	59	17	10	17	44	15
Total	157	73	23	24	120	37

Staff position of KVK

Category	Sanctioned	Position			Total	Vacant
		Calicut	Peruvannamuzhi	Appangala		
Technical	12	-	12	-	12	-
Administration	2	-	1	-	1	1
Supporting	2	-	2	-	2	-
Total	16	2	15	-	15	1



Organization of Indian Institute of Spices Research

Newly inagurated Administrative block

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*., Appangala and Kidu of Karnataka 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 with NBPGR for their unique characters. Microsattelites developed for Piper species were successfully used to detect polymorphism in black pepper cultivars.

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 *P. capsici* was isolated by targeted gene amplification using degenerate primers from *P. 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 at the rate of 50 litres/vine enhanced yield 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. Intercropping medicinal plants (*Vetiveria zizanoids* and *Alpinia calcarata*) in juvenile black pepper garden was found to be profitable with a B:C ratio of 2.3. 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. The open pollinated progeny of IISR Shakthi 04-P24-1 continued to be resistant to root infection by *P. capsici* even after 4 years after planting in the field. 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 *P. 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. Among the new chemicals tested in vitro against *P. capsici*, Acrobat 50 showed 100% inhibition at 50 ppm concentration. 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.

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. PhytoWeb, a comprehensive portal on Phytophthora diseases of horticultural crops in India was developed. Phytolib, an electronic database of research publications on Phytophthora has also been developed and launched.

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. Karshika Sankethika Darshanam and Media Meet were organized to mobilize mass media support for sharing Agro-Information.

Cardamom: IC numbers have been obtained for all the available germplasm. Meanwhile, germplasm bearing unique characters have been registered with NBPGR, New Delhi. The improved varieties such as IISR Vijetha, IISR Avinash and Appangala 1 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 genotypes such as APG 293, 398, 416 and 250 are found to be promising. Accessions IC 547146 and IC 349630 were short listed for high yield with more number of capsules per plant. 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. 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. 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×RR1, GG×RR1, CCS1×GG, GG×893 and CCS1×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% α- terpinyl acetate) cardamom such as NHY 14, MB 3, NHY 18 and OP 28 have been identified. 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. 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. Surveys conducted in major cardamom growing areas of Karnataka and Kerala, revealed the prevalence of Banana bract mosaic virus (BBrMV) infection.

Ginger: Germplasm repository at IISR is the largest collections 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. Cross specific amplification of rice microsatellites was successfully done in ginger. Ginger Acc. No. 195, a tetraploid having 2n=44, 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, *R. 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 and 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. Open pollinated 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 ISSR technique revealed high degree of polymorphism among the accessions. A total of 140 microsatellites containing genomic DNA fragments were isolated from turmeric adopting the selective hybridization method with di and trinucleotide biotinylated probes. Two synonymous Curcuma species viz., *C. zedoria* and *C. malabarica* showed identical SSR profiles for 40 microsatellite loci. 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. 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. 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. Lamda cyhalothrin 0.0125% was more promising in reducing the percentage of shoots infested by the shoot borer. 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 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 *C. sulphuratum, C. glaucescens, C. glanduliferum, C. macrocarpum* and *C. perrottetti* revealed that the major chemical constituents in these oils were α-phellandrene, β-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. With the help of BIO CLIM models (Altitude and Rainfall) of DIVA GIS, the existence of Garcinia in the N E 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, Assam and Nagaland.

Vanilla: Vanilla germplasm are being maintained in the repository, which includes a flower colour variant collected from Andaman and Nicobar islands. Comparative anatomical analysis of different vanilla species was carried out. Interspecific hybridization was made between *Vanilla planifolia* and *V. aphylla*. Reciprocal crosses were conducted between *V. planifolia* and *V. tahitensis* (species reported as resistant to root rot disease) and high percent of fruit set was observed in both the crosses. 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 black pepper germplasm assembled at the conservatory are maintained in the nursery and field genebank. The present status is 2695 accessions (wild pepper- 1286, cultivars- 1400 and exotic species- 9). The germplasm accessions at CRC, Appangala are conserved at the field genebank. Two hundred and thirty accessions of wild germplasm are conserved at the field genebank and hundred more accessions were planted during the period under report. Two hundred and thirty accessions were characterized for eight morphological characters. Herbarium specimens (100 nos.) were prepared and preserved in the herbarium facility. Three coastal Taluks in Alleppey district of Kerala *viz*., Karthikapally, Ambalpuzha and Cherthala were surveyed and 103 accessions were collected. The altitude of collection sites ranged from (-) 2 MSL to 7 MSL. In addition, four black pepper accessions were collected from Wayanad district (Fig 1.1).

Pollu resistant bush pepper lines were raised from the female parent (Subhakara) as well as the male parents (tolerant lines which included Coll. 816, 841, 1084 and 1114.) Inter cultivar hybrids (Subhakara×Coll. 816, Subhakara×Coll. 841, Subhakara×Coll. 1084 and Subhakara×Coll. 1114) were developed. More than 650 hybrid progenies were raised, established and maintained in the nursery. Two hundred hybrid progenies developed from the cross combination Subhakara×Coll. 816 were planted in the field for screening them against pollu beetle infestation. Fifty seedlings from Subhakara×Acc 1495 were screened for drought tolerance. Two relatively tolerant, 18 moderate and 5 susceptible lines were identified based on relative water content (RWC) and membrane stability.

Breeding for resistance to Phytophthora

A mapping population of 140 lines of P1×Subhakara was maintained in the field and data on segregating

Fig 1.1. Germplasm collections made from Wayanad (a) Konni local (b) Wayanadan bolt

Improvement

One hundred progenies of the cross Subhakara × Coll.809 (high yield and high caryophyllene) were planted at Chelavoor. In the yield trial planted in 2002 (10 entries) maximum fresh yield per vine was recorded in HP1411 (2.4 kg/vine) followed by HP 780 (2.02 kg/vine). The controls Subhakara and Sreekara recorded 1.85 and 1.36 kg berries per vine, respectively.

characters like shoot tip colour, leaf shape and size, length of laterals, spike and fruit characters were recorded. For raising another mapping population of Subhakara×P24, 20 progenies of the cross were germinated. 57 lines from association mapping population and 60 progenies from mapping population were multiplied for screening. DNA was isolated from 57 genotypes of association mapping population.

Developing ISSR profiles for identification of released varieties

ISSR profiles were developed for 16 varieties of black pepper with 14 primers, for developing standard profiles and varietal identification. Varietal specific bands were also observed for a few varieties. Identification of varietal specific bands for all released varieties is in progress for diagnostics.

Screening mapping populations against Phytophthora

Twenty seven lines selected as association mapping population were screened using leaf, stem and root inoculation methods. In leaf and stem inoculation, the size of lesion was scored as an index for disease resistance on a 0-4 scale. The plants were rated as resistant, moderately resistant and susceptible in both leaf and stem inoculation methods separately and the average rating was taken as Disease Susceptibility Index and those with DSI < 30% were rated as resistant, 31 - 40% as moderately resistant and > 40% as susceptible. Most of the genotypes were grouped as either susceptible or moderately resistant. None of the genotypes were found to give resistant reaction. Accessions 1386 and 1389 (both named *Kattanadan local*) gave most tolerant reaction along with HP 750 (Table 1.1).

Agrobacterium mediated genetic transformation

The Chitinase construct was multiplied and mobilized into super virulent strain of Agrobacterium EHA 105. Experiments on transformation are in progress.

Generation of ESTs

In order to generate large number of bases of cDNA sequence for plant transcriptome analysis, RNA sequencing of Piper colubrinum challenged with P. capcisi was undertaken using Illumina technology. Preliminary analysis was done with the available data and sequence annotation of the contigs and singletons were done through blast- sequence comparison to the available crop gene databases. Gene functional categories associated with metabolic process were highly represented in the transcriptome. Another most highly represented category are those genes involved in resistance to stress and response to biotic and abiotic stimuli. A number of transcription factor genes and genes involved in signaling, like the mitogen activated protein were found in the transcriptome. SNPs were also identified in a few selected genes. The experiment is being repeated for recovery of longer contigs for sequence comparison and other studies.

Expression analysis of specific genes in Piper colubrinum transcriptome

Pattern of gene expression under stress was studied based on the number of copies of specific sequences recovered from the trancriptome. Good representation of defense genes (eg. Osmotin), transcription factors and already identified R gene was found (Table 1.2).

Cloning of resistance genes

Degenerate primers approach was used to amplify fragments related to *R* genes. Moderately resistant and susceptible black pepper varieties and *Piper* species were amplified using eight pairs of degenerate primers (64 combinations) designed from conserved NBS-LRR regions of six *Phytophthora* resistance genes from *Capsicum annuum, C. chinense, Nicotiana tabacum, Solanum demissum* and *S. tuberosum*. Cloning and sequencing of 520 bp product showed only

Table 1.1. The list of moderately resistant genotypes and hybrids selected after leaf and stem screening

Acc. No	Genotype	Avg. leaf lesion (mm)	DSI (%)	Avg.Stem lesion (mm)	DSI (%)	Avg. DSI (%)
1386	Kattanadu Local	5.0	25.0	4.0	37.5	31.2
1389	Kattanadu Local	7.0	37.5	3.0	25.0	31.2
1605	Mullenkolly	8.0	35.0	6.0	35.0	35.0
HP 130	Neelamundi × Karimunda	4.0	25.0	10.0	43.8	34.4
HP 442	Perambramunda × Panniyur 1	3.3	25.0	11.3	50.0	37.5
HP 581	Panniyur1 × Balankotta	7.3	41.6	7.3	25.0	33.3
HP 750	Perambramunba × Karimunda	5.0	37.5	3.0	25.0	31.2
HP 780	Panniyur1 × Karimunda	7.6	33.3	6.2	31.3	32.3

Table 1.2. Pattern of specific gene expression in *Piper colubrinum* upon challenge inoculation with *Phytophthora*

Genes	Read length (bp)	No. of reads	Maximum coverage depth (bp)
Osmotin	315	916	516
β-1,3-glucanase	549	472	198
Betaine aldehyde dehydrogenase	97	2	2
Superoxide dismutase	127	26	26
Peroxidase	156	17	17
Aquaporin	266	107	83
Hydroxyproline-rich glycoprotein	176	23	23
WRKY gene	72	36	20
R gene fragment	237	68	46

50% similarity to NBS-LRR type disease resistance protein. Moderately resistant varieties of black pepper P24-O-4 had 57% identity to *Solanum trilobatum* NBS-LRR and IISR Shakthi had 48% identity to disease resistance protein *Brassica rapa* subsp. *pekinensis*.

Rootstock intervention to manage Phytophthora and nematodes infection

The wild *Piper* species *viz*., *P. magnificum*, *P. hamiltoni, P. thomsoni* and *Piper* Acc. 6046 were screened for *P. capsici* and nematodes infecting pepper. The resistance of *P. hamiltoni* and *P. magnificum* against *P. capsici* was confirmed. However, *P. hamiltoni* was found susceptible to the nematodes, *R. similis* and *Meloidogyne incognita.* Acc. 6046 was also found susceptible to *R. similis*. Screening black pepper grafts of Sreekara using Coll. 1090, a *Phytophthora* tolerant line, as rootstock indicated that root rot can be controlled to as low as 15.9% with the use of phorate alone to control nematodes without fungicidal application. However, Coll. 1090 was observed to be highly susceptible to anthracnose disease.

Black pepper variety IISR Sreekara grafted on *P. ornatum,* a resistant species identified earlier, did not sprout even after one and half years indicating that it cannot be used directly as rootstock. Therefore, 12 *Piper* species were tried as potential interstocks and eight species were found compatible. *P. colubrinum* and *P. betel* as scions showed incompatibility by putting out aerial roots and lack of thickening of the stock. The species found promising are *P. attenuatum, P. hymenophyllum, P. hamiltoni, P. argyrophyllum, P. longum, P. sermantosum, P. chaba* and Acc. 6046. Grafting of Sreekara variety on *P. hamiltoni* was successful (80%) and the growth was normal up to nine months. Grafting laterals of 10 varieties of pepper on *P. colubrinum* in large numbers gave an overall success of 46.91%. Seedlings were raised from Panniyur 1 lateral grafted on *P. colubrinum*, a resistant species, termed as mentor grafting and these seedlings expressed transfer of *P. colubrinum* characters.

Nutrient requirement for targeted production

Based on the initial fertility levels of N, P, K the fertilizer doses for obtaining 5, 7.5 and 10 kg/standard yield targets were worked out and applied at Mrigarajendra estate, Madikeri on Panniyur-1. The recorded yield levels were 7.0, 8.7 and 9.7 kg/vine in the targets of 5, 7.5 and 10 kg/vine, with a deviation of +40.2, +15.6 and -2.9 respectively. Through targeted equation, nutrient requirement for all the yield targets could be predicted with a minimum deviation. Through targeted nutrient supply 6.3-47.3% yield increase as compared to the normal recommendation was realized.

Targeted yield kg/standard	N	P_2O_5 (g/std)	K_2O	Realized yield (kg/std)	Deviation %
5	7	60	5	7.0	+ 40.2
7.5	55	100	160	8.7	+ 15.6
10	105	140	315	9.7	- 2.90

Studies on allelopathy in tree species-black pepper interactions

The major objectives of the study are to analyze the rhizosphere soils for various physico-chemical, biochemical and microbial parameters and their inter-relationships associated with allelopathic interferences of various standards and to study the effects of various tree species (standards) on growth of black pepper. TLC analysis of water extracts of tree species commonly employed as standards for black pepper viz., ailanthus (*Ailanthus triphysa* Dennst.), garuga (*Garuga pinnata* Roxb.), gliricidia (*Gliricidia sepium* (Jacq.) Steud.), erythrina (*Erythrina variegate* L.), jack (*Artocarpus heterophyllus* Lam.) and silver oak (*Grevellia robusta* A. Cunn. Ex R. Br.) revealed that ailanthus and silver oak had alkaloids and flavones as the major constituents, gliricidia and erythrina had flavones, jack had sterols and flavonols and garuga had flavones and triterpenes as the major constituents.

In the green house study, the leaf and stem extracts of these standards were applied at varying rates (0, 12.5%, 25%, 50%, and 100% conc.) to three-month old rooted black pepper cuttings (IISR Thevam). The extracts were applied at monthly intervals. Results at 150 DAP revealed that irrespective of the tree standards plant height increased up to 25% concentration and then decreased markedly at higher concentrations of 50 and 100%. Results on number of leaves, root length and fresh weight also followed an identical trend. Results on soil analyses revealed minimum variations in soil pH due to tree extracts across dilutions). Soil mineral N, Bray P and exchangeable K decreased markedly with increasing concentrations of tree extracts, irrespective of the tree species.

Machine for mixing and vending potting mixture

One aspect of nursery operation that need tremendous labor is potting mixture preparation and filling. With this background a machine for mixing and vending potting mixture was fabricated in collaboration with CIAE, Coimbatore. This power operated continuous type potting machine is capable of mixing, pulverizing, sieving, and filling of potting ingredients in poly bags at desired quantity. The unit consists of 3 hp motor, feed hopper, paddles, sieving tray, and electronic vending instrumentation (Fig 1.2). For spices nursery, the optimized ratio of soil, granite powder, and FYM is 2:1:1 (v/v) is used for preparation of potting mixture. One person can fill around 1600 bags in a day using this machine whereas manually only 600 bags can be filled by two persons.

Fig 1.2. Potting mixture vending machine

Nutrient spray to regulate alternate bearing

To investigate if spiking can be regulated by providing nutrients during spike initiation period, three rounds of sprays (April 2nd week, May 1st week and May 4th week) of 19:19:19 NPK complex fertilizer (@ 0.5, 1.0, 1.5 and 2.0% foliar sprays along with a control – water spray) were given. Among the nutrient sprays, 1.0 % spray recorded the maximum berry yield (24.4 kg fresh yield/vine) followed by 0.5 % spray (23.8 kg/vine). Control recorded the least (18.8 kg/vine) followed by 2 % spray (20.4 kg/vine) indicating that yield levels can be enhanced during the poor bearing year through nutrient sprays at spike initiation period.

Black pepper powder and chemical quality

Chemical quality and medicinal property of black pepper powder samples (using hammer mill) stored in laminated polyester packs for five months was analysed at monthly intervals. 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 cause any change in medicinal

activity. Gradual reduction of oil, oleoresin and piperine was observed during the 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 was stored in 90% N_2 and 10% CO_2 in three layered laminated polyethylene packing and analysed for oil, oleoresin and piperine. The data was compared with samples of Panniyur-1 harvested in this season. The sample had a moisture content of 8.7%, 2.0% oil, 7.0% oleoresin and 2.2% piperine. Except for the mild reduction in moisture content after 480 days of storage it retained the chemical quality equivalent to that of current season sample.

Phytophthora foot rot / slow decline

Twenty one new collections of *Phytophthora* spp. were made during the year, bringing the total collections in the National Repository of *Phytophthora* to 305 (Table 1.3). Seventy *Phytophthora* isolates were characterized for their colony morphology, 42 for their sporangial morphology, and 37 for their pathogenicity. In black pepper, out of the 137 isolates studied for virulence, 110 were highly virulent whereas 10 were non-virulent. A1 mating type dominated (66.3%) among the 86 collections studied. The metalaxyl-mz sensitivity of 81 isolates was tested and the EC_{50} and EC_{90} values ranged from 0.0002 to 14.4000 ppm and 1.1 to 68.5 ppm, respectively. Genetic diversity studies using 20 SSR markers indicated high diversity among 126 black pepper isolates of *Phytophthora* sp.

Host resistance

Fifty two germplasm accessions were screened against *P. capsici* by leaf, stem and root inoculation methods. Cv. Kumbachola (Acc. 1114), resistant to 'pollu' beetle and tolerant to drought, was tolerant to *Phytophthora*

Table 1.3. Isolates maintained in the National Repository of *Phytophthora* sp.

Host plant	Collected during 2010-11	No. of isolates available	Host plant	Collected during 2010-11	No. of isolates available
Black pepper	7	165	Tapioca	-	3
Colocasia	1	10	Bauhinia	-	2
Tomato	-	09	Potato	-	1
Vanilla	-	03	Papaya	-	1
Coconut	1	09	Clove	-	1
Strawberry	-	03	Carnation	-	1
Crossandra	-	02	Vigna	-	2
Gerbera	-	02	*Trichosanthes* sp.	-	1
Periwinkle (*Vinca* sp.)	-	03	Brinjal	-	1
Betelvine	-	24	Sesamum	-	1
Cardamom	5	12	Clove	-	1
Cocoa	1	09	Avocado	1	1
Rubber	-	08	Yam	1	1
Capsicum	-	03	*Diffenbachia* sp.	-	1
Nutmeg	-	03	Pineapple	-	1
Citrus	2	12	Apple	-	1
Arecanut	1	02	Geranium	-	1
Piper longum	-	01			
Plectranthus sp.	-	01			
Piper chaba	1	03			

infection also. Seedlings of *P. colubrinum* (178 nos.) on screening with *P. capsici* showed segregation of the resistance character, 21 plants being resistant to *Phytophthora,* two plants susceptible and the rest showing moderate resistance.

Genomics

Using bioinformatics, a set of three primers were designed, out of which, one set of primer ELICPHYF6 and ELICPHYR6 yielded a product of 250 bp, the sequence of which perfectly matched with alpha elicitin of *P. capsici* from the database. R genes in moderately resistant and susceptible black pepper varieties and *Piper* species were amplified using eight pairs of degenerate primers (64 combinations) designed from conserved NBS- LRR regions of six *Phytophthora* resistant genes from other plants. However, cloning and sequencing of the 520 bp product showed only 50% similarity to NBS-LRR type disease resistance protein. Targeted cloning of *WRKY* transcription factor genes from *P. colubrinum* yielded a 143 bp gene fragment similar to *WRKY* sequences already identified in different plant species.

In vitro evaluation of antagonists

Forty five isolates of endophytic fungi were isolated making the total isolates available to 125. Out of the 45 isolates tested *in vitro* against *P. capsici*, nine isolates showed more than 70% inhibition. Among the three mycological media tested for the isolation of endophytes, malt extract agar (MEA) was the best medium. The promising *Trichoderma* isolates (15 nos.) received from various locations were tested against *P. capsici* and *Pythium aphanidermatum* (causing rhizome rot of turmeric) under *in vitro* conditions. All the isolates except PhytoFuRa 7 showed >50% inhibition against both the pathogens (Table 1.4).

Evaluation of biocontrol agents in the field

Evaluation of endophytic and rhizosphere biocontrol agents for the management of *Phytophthora* foot rot and slow decline diseases initiated during 2008 was continued in the field at Peruvannamuzhi. The candidate organisms were BP 35 (*Pseudomonas aeruginosa*), BP 25 (*P. putida*), BP 17 (*Bacillus megaterium*), TC 10 (*Curtobacterium luteum*) (endophytic bacteria) and IISR 853 (*Pseudomonas fluorescens*) and IISR 6 (*Pseudomonas aeruginosa).*

The experiment was designed in such a way that the nematicide phorate was integrated with bioagents *viz*., BP 35, BP 25 and IISR 6 which are antagonists to *P. capsici* and the fungicide Metalaxyl-Mz was integrated with BP 17, TC 10 and IISR 853 which are antagonists to *R. similis*. The treatments were imposed twice during monsoon and post monsoon seasons. No inorganic fertilizers were applied to the plant base. Farmyard manure was applied twice during May and

Table 1.4. *In vitro* inhibition of Trichoderma isolates against *P. capsici* and *P. aphanidermatum*

Trichoderma isolates	Inhibition against *P. capsici* (%)	Inhibition against *P. aphanidermatum* (%)
PhytoFuRa 1	63.3 d	67.1 ab
PhytoFuRa 2	58.7 e	68.6 a
PhytoFuRa 3	59.1 e	66.5 ab
PhytoFuRa 4	64.4 cd	65.3 bcd
PhytoFuRa 5	50.9 g	63.3 cde
PhytoFuRa 6	66.1 bc	62.5 de
PhytoFuRa 7	52.7 fg	46.2 g
PhytoFuRa 8	59.9 e	62.3 e
PhytoFuRa 9	57.8 e	58.2 f
PhytoFuRa 10	68.7 b	66.3 ab
PhytoFuRa 11	54.6 f	66.0 abc
PhytoFuRa 12	53.0 fg	64.5 bcde
PhytoFuRa 13	67.1 bc	62.9 de
PhytoFuRa 14	67.8 b	66.7 ab
PhytoFuRa 15	74.6 a	61.9 e

September and sprayed with $ZnSO_4$ (0.25%) during May and DAP (0.5%) during September. TC10 + Metalaxyl-Mz recorded significantly higher yield followed by BP 17 + phorate. No incidence of Phytophthora or slow wilt could be noticed in any of the treatments during the period (Fig 1.3).

Fig. 1.3. View of the biocontrol agents evaluation plot

Evaluation of biocontrol agents and biofertilisers

The suitability of a combination of biocontrol agents and biofertilizers in vermicompost was tested for their effect on plant growth and disease suppression in the greenhouse. The biocontrol agents *P. fluorescens* (IISR 6), *P. aeruginosa* (IISR 853), *C. luteum* (TC 10), *Trichoderma harzianum, Pochonia chlamydosporia* and biofertilizer organisms *Azospirillum lipoferum* (N_2 fixer), *P. fluorescens (*P-solubilizers) and *Paenibacillus glucanolyticus* (potash mobilizer) were used in the study. The results showed that a consortium of IISR 853 (*P. aeruginosa*) + *T. harzianum* + biofertilizers was more promising in increasing the growth of plants.

Evaluation of resistant lines and biocontrol agents

Evaluation of biocontrol agents for the management of *Phytophthora* and slow decline diseases, was continued in the field at Peruvannamuzhi with three promising disease/nematode resistant lines namely, HP 39, IISR Shakti, C 1090 and biocontrol agents such as *T. harzianum, P. fluorescens* (IISR 6 and ISR 853) and *P. chlamydosporia* in comparison with the susceptible line Sreekara. The incidence of the disease was negligible during the year.

Evaluation of soil amendments for growth of resistant line

04-P24, the *Phytophthora* resistant black pepper line is a slow growing OP progeny. Seven different organic amendments including biofertilizers, *Azosprillum lipoferum* (N fixer), *P. fluorescens* (P solubilizer), *P. glucanolyticus* (K solubilizer), neemcake, groundnut cake, vermicompost, farmyard manure and NPK (recommended doze) were evaluated for their effect on growth of 04-P24. The result showed that biofertilizers and NPK were promising in increasing the biomass when compared to other treatments including control. However, there was no difference in the height and number of leaves among various treatments.

Nematode diversity

Single nematode cultures of 13 new *R. similis* isolates and 17 populations of root knot nematodes were made from different parts of Kerala, Tamil Nadu and Karnataka. Out of the six root-knot nematode populations tested using SCAR primers, five (two each from Kozhikode and Kodagu, and one from Coimbatore) belonged to *M. incognita*. On testing three primers out of the 50 SSR primers designed from EST sequences of *R. similis*, one set of primers (EY193167, Forward primer: GCCCACGCTACTAC TCGTTC; Reverse primer: CTGGAGACCCCAAAT GATTG) showed polymorphism. Out of the 24 RAPD primers tested, eight primers resulted in differential amplification of genomic DNA of *R. similis*. The ITS region and D2-D3 of 28S region of nine isolates of *R. similis* were amplified with 18-26S and D2A-D3B primers, respectively. The products obtained were sequenced and genetic variations in these populations are being critically examined.

Phenyl propanoids in black pepper - nematode interactions

An EST based secretome analysis was carried out to identify the excretory-secretory (ES) proteins of *R. similis*. Out of the 214 secretory proteins identified, about 45% showed similarity to proteins from other nematodes. Functional annotation of these proteins revealed the presence of some of the major secretory and cell wall degrading enzymes like transthyretin (*Contig1094*), GHF5 endo1, 4 β glucanase (*GW 395922*), glutathione-S-transferase1 (*GST*) (*Contig 931*), glutamate dehydrogenase (*Contig 395*) and 3-hydroxyacyl-CoA dehydrogenase (*EY193427*). Total homogenates of *R. similis* showed clear cellulase activity in the CMC plate assay, and was compared with cellulase activity of *Bacillus amyloliquefaciens*.

In silico screening of phenyl propanoids

Eight compounds in the phenyl propanoid pathway were selected and screened for their nematicidal activity using PASS server and GHF5 endo 1, 4 β glucanase, the cell wall- degrading enzyme present in *R. similis*, as the target for docking studies. The docking studies identified four compounds *viz*., caffeic acid, ferulic acid, coumaric acid and alpha cubebin to have the highest potential to inhibit the target enzyme.

Bioassay of phenolic compounds for nematode inhibition

Nematode inhibition by five phenolic compounds *viz*., cinnamic acid, coumaric acid, ferulic acid, caffeic acid and (*N-vanillylnonanamide*) NVA at four different concentrations was evaluated *in vitro* on *R. similis*. Among the five compounds, maximum mortality was observed with the highest concentrations of ferulic acid (70.7%) followed by coumaric acid (65.0%) and caffeic acid (48.0%) (Table 1.5). The mortality of nematodes was directly proportional to the concentration of the compounds. Using Probit analysis, LD_{50} values were calculated for coumaric acid (144.08 µg ml^{-1}), ferulic acid (123 .69 µg ml^{-1}) and caffeic acid (288. 91 µg ml^{-1}).

Extraction of antibiotics from endophytes

Strains of plant associated *P. aeruginosa* isolated from black pepper (IISR 6, IISR 13 and BP 35), ginger (IISR 51 and GEB 9) and *Chromolaena odorata* (IISR 853) were characterized for the presence of gene(s) coding for surfactant and phenazine antibiotics (rhamnolipid production in *P. aeruginosa* has been reported to require both the *rhl* system and *rhlA* and *rhlC*). *rhlA* (1100bp) and *rhlC* (1200bp) could be detected in all six strains as well as in the reference strain, PAO1 (Fig. 1.4). Similarly, specific amplification of *rhlI*

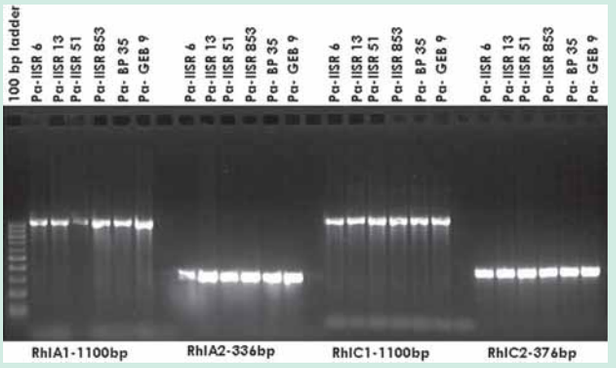


Fig. 1.4. Amplification of *rhlA* and *rhlC* genes for rhamnolipid production in six strains of *Pseudomonas aeruginosa*

(377bp) and *rhlR* (266bp) gene fragments, the regulatory genes for rhamnolipid biosynthesis in *P. aeruginosa*, was obtained in a PCR assay in all the six strains as well as the reference strain, PAO1. Role of phenazines was also confirmed by the amplification of the gene encoding phenazine biosynthesis enzyme (*phzF*) using specific primers (Ps-up1 5-ATC TTC ACC CCG GTC AAC G-3, Ps-low1 5-CCR TAG GCC GGT GAG AAC-3).

Comparative genomics of Pseudomonas aeruginosa

Six isolates of *P. aeruginosa* of plant origin were compared by phenotypic and genotypic methods. Phenotypic characters such as antibiotic resistance, swarming motility and surfactant production were documented. All the six plant associated *P. aeruginosa* exhibited a characteristic round, 'moving away from middle' like growth pattern with remarkable accumulation of biomass within 12-16 h of incubation at 37°C on soft modified King's medium B (KMB)

Table 1.5. Mortality (after 72 h) of *Radopholus similis* exposed to different concentrations of phenyl propanoids

Compound	20*	50	100	200
Cinnamic acid	5.7 (13.6)	6.6 (14.9)	9.0 (17.4)	14.3 (22.2)
Coumaric acid	9.6 (18.1)	12.9 (21.1)	38.0 (38.0)	65.0 (53.7)
Ferulic acid	9.5 (18.0)	19.0 (25.8)	37.6 (37.8)	70.9 (57.4)
Caffeic acid	17.7 (24.8)	22.3 (28.2)	30.7 (33.6)	48.0 (43.8)
N-vanillylnonanamide	9.3 (17.8)	11.3 (19.6)	19.3 (26.1)	27.6 (31.7)
CD (5%)	Across columns – 1.8; Across rows – 1.6			
CV%	7.88			
Figures in parentheses are arc sine transformed values; * µg ml^{-1}				

agar (0.6%). Besides they showed intrinsic antibiotic resistance against kanamycin.

PCR amplification with primers specific for gene encoding DNA repair protein (*recN*) in *P. aeruginosa* yielded partial *recN* gene sequences (937bp) from all the six strains which had 99% similarity with three of the fully sequenced strains such as PAO1, PA14 and LESB58. Based on the multiple alignments of sequences, a phylogenetic tree was constructed by UPGMA which was subjected to 1000 bootstrap trials. The analysis indicated that *P. aeruginosa* isolated from plants formed two non-overlapping clusters. The cluster I consist of IISR6, IISR13, & IISR51 and isolates IISR853, IISRBP35 and IISRGEB9 into the other cluster. PCR amplification and sequencing of seven housekeeping genes (*acsA, aroE, guaA, mutL, nuoD, ppsA,* and *trpE*) were performed and compared to the data available in the MLST database for *P. aeruginosa* (http://pubmlst.org/paeruginosa). The allelic profiles served as input data to analyze the strain relatedness using eBurst, a novel clustering algorithm designed for MLST data (Table 1.6). The *P. aeruginosa* isolates obtained from plants were grouped into two lineages as in the previous analysis. Allelic profiles of the strains Pa-IISR6, Pa-IISR13 and Pa-IISR51 matched with sequence type 760, a strain documented from human sputum in China. The strain Pa-BP35, Pa-IISR853, Pa-GEB9 are single locus variant of ST575, it does not have any double locus variants and has 15 other three locus variants in the population. Sequence Type 575 is a strain documented from disease (human) habitat from Utrecht Medical Center, Utrecht, The Netherlands.

In silico and in vitro screening of bacterial metabolites

Seventeen compounds produced by *Bacillus megaterium* were docked against GHF5 endo 1, 4 beta glucanase of *R. similis* out of which eight compounds (2-nonanone, 2-pentylfuran, 2-undecacone, 2, 6, 10-trimethyl-dodecane, benzene acetaldehyde, benzene ethanol, decanal and hexadecane) showed promising results.

Culture filtrates of six bacteria *viz*., GRB 35 (*Bacillus amyloliquefaciens*), GRB 68 (*Serratia marcescens*), GRB 70 (*Enterobacter dissolvens*), BRB 3 (*Micrococcus* sp.), BRB 13 (Unidentified) and BRB 49 (*Serratia* sp.) were tested for their efficacy to kill *R. similis*. Except BRB 13, none of the isolates showed any nematicidal activity.

Maintenance of virus-free mother vines

PCR based method was used for indexing black pepper plants of improved varieties against *Piper yellow mottle virus* (PYMoV). The identified virus-free material was maintained and multiplied under insect-proof conditions. Besides, black pepper samples received from different organizations were also indexed for viruses and results communicated.

Identification of transformants carrying PYMoV sense and antisense constructs

All hardened plants obtained from both sense and antisense constructs were subjected to PCR to confirm the presence of transgene. PCR was performed using two sets of primers; one set of primer was specific for kanamycin region while the other set was specific for the transgene. Kanamycin specific primers gave an amplicon of approximately 940 bp (Fig 1.5) in positive plants whereas the other set of primers gave an amplicon of 539bp in case of both sense and antisense constructs. In the case of sense construct all the 30 plants screened were positive in PCR whereas in antisense construct, out of 78 plants screened, 62 plants tested as positive in PCR.

Table 1.6. Allelic profiles of plant associated *Pseudomonas aeruginosa* strains based on sequence comparison of seven housekeeping genes

Strain	*Acs*	*Aro*	*Gua*	*Mut*	*Nuo*	*Pps*	*Trp*
IISR 13	15	121	36	5	4	15	8
IISR 6	15	121	36	5	4	15	8
IISR 51	15	121	36	5	4	15	8
IISR 853	22	5	83	2	4	13	7
BP 35	22	5	83	2	4	13	7
GEB 9	22	5	83	2	4	13	7
PAO 1	7	5	12	3	4	1	7

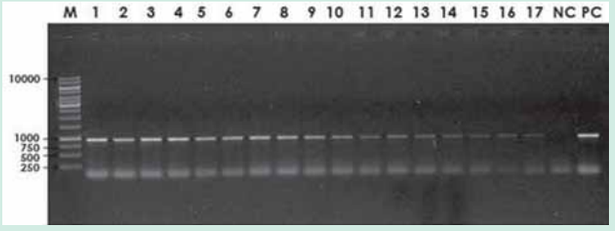


Fig. 1.5. Screening of putative transformants using npt-II specific primers

Lane M: 1 Kb ladder, Lane 1-17: transformed plantlets, Lane NC: Negative control, Lane PC: Positive control

The selected PCR positive plants were subjected to dot blot assay. In dot blot of plants obtained with sense construct out of 30 plants subjected to dot blot, 24 plants gave positive signal whereas out of 44 plants in antisense construct screened, 38 were positive. Plants that gave intense spots in dot blot assay were taken for southern hybridization. In the case of sense construct, two plants showed positive signals out of 10 screened whereas four out of seven were positive in the case of antisense construct.

Identification of transformants carrying CMV-CP sense construct

Out of 109 plants screened for identification of transformants carrying *Cucumber mosaic virus* coat protein (CMV-CP) sense construct, 104 plants were positive in PCR. Kanamycin specific primers gave an amplicon of around 940bp in positive plants whereas the other set of primers gave an amplicon at 780bp. Out of 80 plants subjected to dot blot, 43 plants gave positive signals and all the nine plants tested were positive in southern hybridization

Challenge inoculation of transgenic plants with PYMoV

Transgenic plants obtained both with sense and antisense constructs of PYMoV were challenge inoculated with PYMoV using mealybug, *Ferrisia virgata*. After a 24 h acquisition access period, 15 mealybugs each was transferred on to test transgenic plants and allowed an inoculation access period of 24 h. Thereafter, the plants were sprayed with insecticide and kept for observation in insect-proof glasshouse (Fig. 1.6). After 60 days of incubation, the plants were subjected to PCR to check for presence or absence of virus. PCR test involved isolation of total DNA from 50 mg leaf tissue to be used as template in the PCR. Primers designed for the amplification of 450bp region of ORF I of PYMoV was used. The results showed

Fig. 1.6. Transgenic plants of black pepper challenge inoculated with PYMoV

that of the 24 plants carrying PYMoV sense construct challenge inoculated, 12 plants showed positive reaction in PCR while 12 plants tested negative. In PYMoV antisense construct, of the 60 plants challenge inoculated, 45 were positive for virus in PCR while 15 plants were negative.

Screening of Piper spp against PYMoV

Four hundred and thirty four 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, *F. 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 434 accessions were susceptible to PYMoV.

Characterization of Colletotrichum isolates

The *Colletotrichum gloeosporioides* isolates infecting black pepper, was inoculated to determine the aggressiveness and the isolates BP 10, BP 15, BP 22, BP 24 and BP 26 were identified as aggressive isolates. The aggressive isolates were inoculated on 12 different varieties of black pepper to study the differential reaction and to develop a set of differentials based on the symptomatology, Variability in the symptoms was characterized based on the prominence of the yellow halo around the spot (Fig1.7) and the diameter of the spot was also recorded to study the response of the varieties against different aggressive isolates.

Epidemiology

Daily maximum and minimum temperatures had negative correlation with disease incidence while, rainfall and number of rainy days had positive

Fig 1.7. Prominent (a) and non prominent (b) yellow halo caused by *Colletotrichum gloeosporioides* infection on black pepper

correlation with disease initiation and subsequent spread (Fig1.8). The disease was initiated during May - June in most of the vines and the incidence attained its maximum during August. The disease was initiated as small round necrotic lesions on the young leaves of the runner shoots from which it advanced to the leaves of orthotrophs (climbing shoots) and plagiotrophs (side branches) as well as to spikes which resulted in shedding of leaves and spikes.

Evaluation of antagonists

Thirty two *Trichoderma* spp. were isolated from soil samples collected from rhizosphere of cardamom and black pepper from Appangala (Karnataka), Idukki (Kerala), Wayanad (Kerala) and Valparai (Tamil Nadu). Among the isolates WYD T11, the *Trichoderma* sp. obtained from rhizosphere of black pepper was identified as a promising isolate. The culture filtrate obtained from the isolate adversely affected conidial germination, appressorial formation and melanization of *C. gloeosporioides*. The isolate was compatible with metalaxyl + mancozeb (at the recommended dose) commonly used in black pepper plantations.

Evaluation of plant extracts

Extracts (2.5%, 5%, 10% and 20%) of 35 locally available plant species were evaluated against *C. gloeosporioides* (from cardamom and black pepper), by employing poisoned food technique, in laboratory bioassays among which extracts of *Solanum nigrum*, *Azadirachta indica* and *S. torvum* were promising. Hyphae of the targeted pathogen also exhibited modifications like abnormal hyphal branching, hyphal tip swelling and vacuolization.

In vitro evaluation of fungicides

Nine fungicides were evaluated (at six concentrations) for their efficacy against *C. gloeosporioides* infecting cardamom and black pepper by employing poisoned food technique, among which, hexaconazole and carbendazim + mancozeb were promising against the targeted pathogen infecting cardamom and black pepper.

Isolation of sources of resistance for pollu beetle

Fifty one accessions from the germplasm collection were screened against *pollu* beetle (*Lanka ramakrishnae*) for locating sources of resistance to the pest. Among the cultivars, Acc. 1423 was free from pollu beetle attack during the year. The highest berry damage (51.6%) was recorded on Acc. 1627. Among the hybrids, Accs. 1054 and 1505 remained free from pollu beetle damage during the year. The highest berry damage (33.1%) was recorded on Acc. 1550.

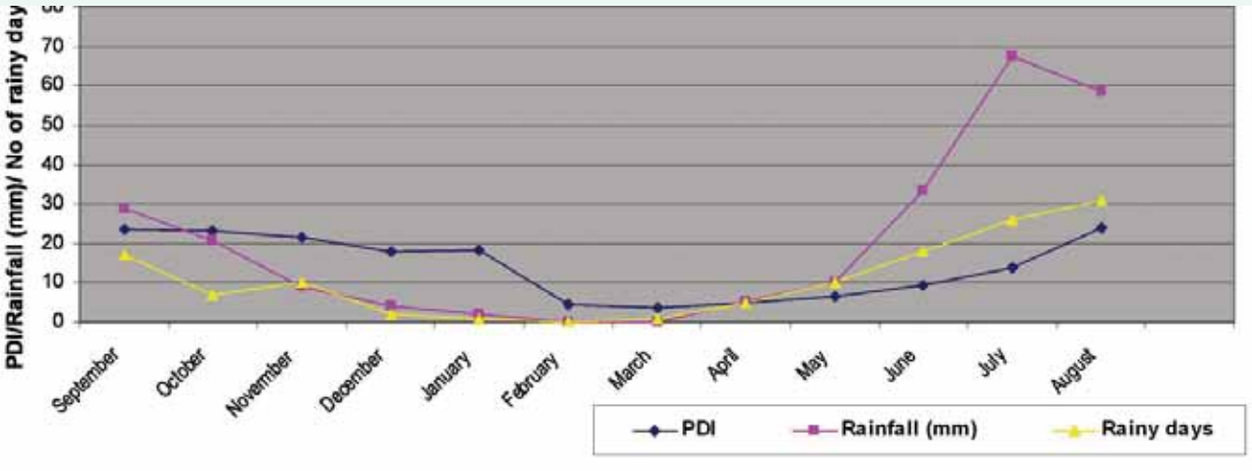


Fig 1.8. Relationship between rainfall and incidence of anthracnose in black pepper

CARDAMOM

Characterization of germplasm

Four hundred and forty two accessions have been maintained in the field gene bank, which includes 278 Malabar, 73 Mysore, 63 Vazhukka and 28 others. Cardamom field gene bank was enriched with 103 new accessions (73 from Pampadumpara, KAU and 30 from RRS, Mudigere) during this year. Morphological characterization was done in 50 accessions. Acc. IC 547206 and IC 540892 were short listed for high yield and maximum number of capsules per plant (Table 2.1). Accession IC 584058 (APG 474) was identified for early uniform setting with bold capsules (Fig 2.1).

Sixty seven accessions were screened under natural field conditions to identify resistant sources against leaf blight disease. Natural incidence of leaf blight was recorded during 2011 and none of the accessions exhibited resistant reaction against leaf blight disease. Thirty accessions were screened for drought tolerance under field condition. Leaf folding due to light and moisture stress was recorded in the field for 30 genotypes. Few genotypes recorded partial folding of leaf and were green even after 3 hours exposure to

Fig. 2.1. IC 584058 identified for uniform fruit setting

Table 2.1. Morphological characters of promising genotypes

Characters	Range	Mean	CV (%)	Promising genotype
Plant height (cm)	87.80-251.06	161.77	23.95	IC 540893
Total tillers	06.20-46.60	21.23	46.89	IC 540892
Bearing tillers	01.00-17.00	05.88	71.66	IC 547213
Leaf length (cm)	21.00-64.20	48.26	15.24	IC 547206
Leaf width (cm)	06.50-34.75	09.91	46.79	IC 547189
No. of panicles	01.00-34.00	10.26	78.64	IC 540892
Panicle length	24.50-56.20	36.28	19.17	IC 547144
Inter node length (cm)	02.00-05.48	03.56	21.96	IC 547146
Capsule length (cm)	01.10-02.18	01.49	13.34	IC 584096
Capsule width (cm)	00.73-01.48	01.12	11.21	IC 584096
No. of seeds	09.40-27.40	15.47	27.97	IC 584096
No. of capsules/plant	14.50-3516	585.00	84.99	IC 547206
Capsules wet weight (g)	25.00-3456	540.00	92.31	IC 547206

direct sunlight. Specific leaf weight and relative water content was also recorded.

Analysis of three successive crop yields of F_1 hybrids in Preliminary Evaluation Trial-I (19 combinations) and PET-II (10 combinations) resulted in identifying three high yielding selections such as IC 584097, IC 584098 and IC 54722. These selections yielded 20-40 per cent higher yield than corresponding controls (Appangala 1 and Njallani Gold).

Among the materials short listed for multi location trial, IC 547142 (NHY-10) and IC 547203 (MA-18) (Fig 2.2) performed better compared to others during 2010-11.

Fig. 2.2. MA-18 with maximum fresh capsules/ plant

Molecular profiling using ISSR and SSR Primers

Ninety five selected core collections of cardamom germplasm were profiled using about 25 ISSR and microsatellite markers. Cluster analysis was done based upon on distance matrices by using the unweighted group method analysis (UPGMA) in NTSYS software. The relationships between varieties were represented in the form of dendrogram (Fig 2.3). The molecular diversity detected was less in comparison with morphological variability.

Cross generic SSR profiling of small cardamom with rice SSR primers

Cross generic SSR profiling of small cardamom was done with rice SSR primers. Of the 12 primers tested, two primers gave excellent polymorphic profiles (Fig 2.4)

Developing microsatellites from EST databases

EST Data base searches for sequence information containing micro satellites from ginger revealed 94 SSR

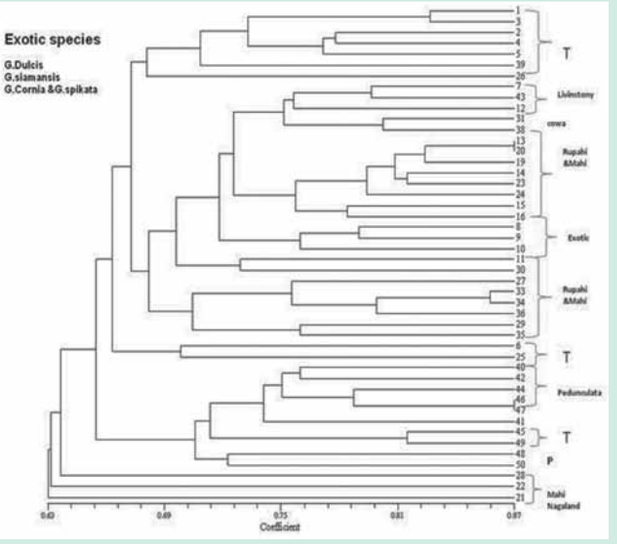


Fig. 2.3. Dendrogram of diversity derived from an UPGMA analysis using ISSR markers in 95 selected core collections of cardamom

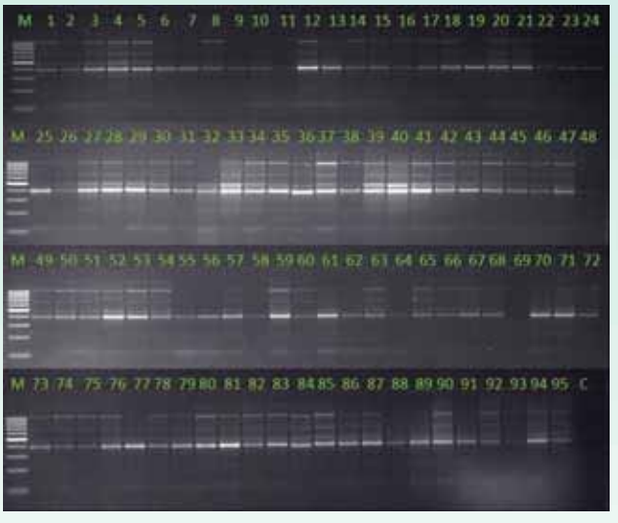


Fig. 2.4. Cross generic SSR amplification of 95 accessions of small cardamom with rice SSR Primer SSR 0I

candidates. Twenty two Primers were designed. Of these, seven were found to amplify PCR products in cardamom. One of them showed good polymorphism and hence can be used to detect molecular diversity in cardamom.

One hundred and ten small cardamom genotypes from IISR collections were selected depicting maximum diversity for morphological characterization. They included 12 released varieties, 10 farmer's varieties, four related genera and five unique varieties. A

descriptor was prepared with about 46 taxonomically and ergonomically important characters based on IPGRI descriptor (IPGRI, 1994) and DUS guidelines (PPV & FRA 2009). Data on 40 morphological and floral characters were recorded.

Development of microsatellite markers from cardamom genomic DNA

Selective hybridization method was used to capture microsatellite DNA Loci from small cardamom. Genomic DNA was digested with RSa1 into small fragments approximately in the range of 300 bp to 2 Kb. DNA fragments with microsatellite sequences complementary to the biotinylated microsatellite oligos (probes) were captured using steptavidin coated magnetic beads (Streptavidin M-280 Dynabeads ; Dynal, Oslo, Norway). The enriched DNA (pure Gold) was incorporated into TOPO XL cloning vector [TOPO XL Cloning@Kit from Invitrogen (Carlsbad, CA) and transformed into TOP10 Cells (Invitrogen) using the TOPO XL Cloning@Kit from Invitrogen (Carlsbad, CA). A total of 32 white colonies were screened using colony PCR. Colonies which gave an amplicon of above 300bp in size were selected and plasmids were isolated and sequenced at Xcelris Labs Ltd, Ahmedabad. Out of the total 32 plasmids sequenced, 29 gave good quality sequences which were used for designing of primers. A total of 11 primers were designed from the sequences obtained.

Cardamom elite lines for yield and quality under moisture stress

Three genotypes (RR1, CL-893, green gold) relatively tolerant to moisture stress and CCS -1 a susceptible genotype were crossed to develop a drought tolerant variety with good yield and quality characters. Crosses were evaluated for growth and yield parameters withholding two irrigations compared to control. Soil moisture content was recorded gravimetrically. Growth parameters and yield parameters were recorded. Plant height, number of shoots per clump, number of bearing shoots, number of panicle per clump, number of capsules per panicle and dry capsule yield recorded significant variation and was reduced under moisture stress. Cross GG×CCS1 recorded maximum yield (896.5 kg/ha) under irrigation followed by CCS1 OP (890 kg/ha). Under stress, 893×GG recorded maximum yield (288.2 kg/ha), followed by RR1×GG (248.7 kg/ha) and CCS1 Self (227.7 kg/ha).

Evaluation of cross/hybrids with special characters

Field experiment with crosses Bold×Green gold; Green gold×Bold; Bold×(GG×CCS1); (GG×CCS1)×Bold; IC 547219×Bold; Bold×IC 547219; (GG×NKE-19)×Bold; Bold×(GG×NKE 19) with control and stress treatments were established in the field for two years. Plant height, number of panicles per clump, panicle length, number of capsules per panicle and dry yield were found to be significantly reduced under moisture stress. GG×(CCS1×Bold) recorded higher panicle number in control and in stress Bold×(GG×NKE19) recorded maximum panicle number in stress. Panicle length was maximum in Bold×(GG×NKE 19) (Fig 2.5) both in control and stress. Number of capsule per panicle was maximum in Bold×(GG×CCS1) followed by Bold×IC 547219. Dry yield was maximum in (GG×CCS1)×Bold both in control and stress.

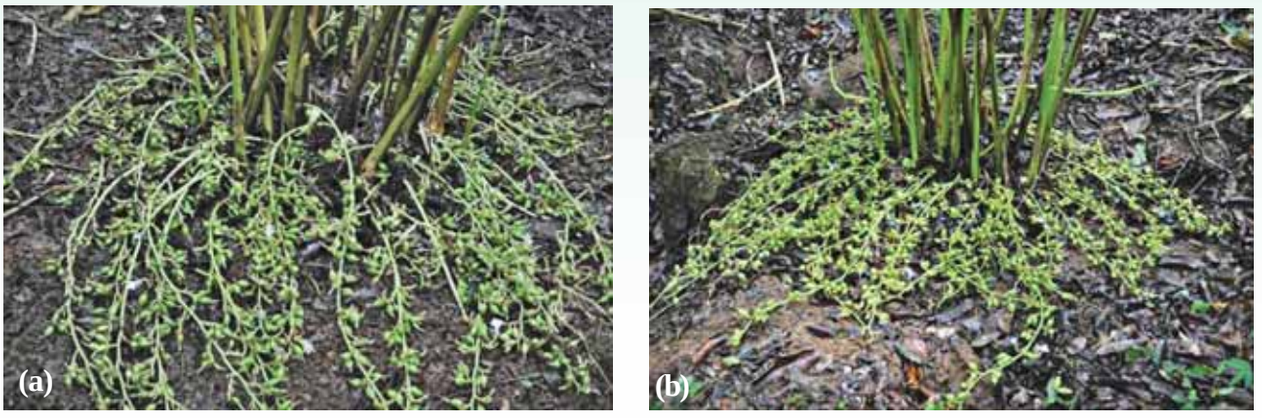


Fig. 2.5. Hybrids with with long panicles, long bold green capsules (a) Bold×(GG×NKE19), (b) (GG×CCS1)×Bold

Drought tolerance in cardamom

Leaf folding test was undertaken to test drought tolerance of cardamom genotypes. When leaves were exposed to sunlight on concrete floor, (GG×CCS-1)×Bold and Bold×IC 547219 took longer time to fold and even green after 3 hours in open sunlight. Specific leaf weight was also recorded. Peroxidase, catalase and SOD activities were assessed in irrigated and stress situations. All the enzymes activities were increased under stress (Table 2.3)

Twelve short listed and three checks of cardamom genotypes were planted with control and stress treatments. Moisture stress was imposed by withholding irrigation. All the genotypes started producing panicle. IC 584058 (APG 474) recorded early yield with good setting and bold capsule. Growth data was recorded at the initiation of stress. Leaf rolling test under open sunlight and specific leaf weight and soil moisture content was recorded in different treatments. Enzyme such as peroxidase, catalase and SOD were assayed. Peroxidase, catalase and SOD activities were increased under stress in all the genotypes.

Quality evaluation

Twenty five germplasm accessions of cardamom were evaluated for seed weight and essential oil content and these ranged from 63-73% and 3.5-6% respectively. The capsules of IC 547200 contained 73% seeds and 6% essential oil which was followed by IC 547201 with 69.6% seeds and 5.5% essential oil. Among the accessions evaluated, IC 547200 was superior in quality with regard to essential oil content and its components. The essential oil of Acc. No. 547200 contained 25.6% 1,8-cineole and 49.4% α-terpinyl acetate.

Eight hybrid combinations of cardamom were evaluated for seed weight, essential oil content and oil composition, with special reference to drought tolerance. The seed weight varied from 66.98-72.18% in control and 59.65-72.4% under stress and essential oil content ranged between 4.2-5.5% and 4-5.5%, respectively. The hybrid, (GG×CCS1)×Bold was found to be superior with regard to the quality of essential oil, followed by Bold×(GG×CCS1). The capsules of (GG×CCS1)×Bold contained 5.25-5.5% essential oil with 29-33% 1,8- cineole and 41-45% α- terpinyl acetate.

VIRAL DISEASES

Development of diagnostics for viruses

Based on leaf dip electron microscopy the causal agent of *kokke kandu* showed a close resemblance with nano virus. Primers were designed to confirm the presence of Nano virus in the samples infected with *kokke kandu* disease. Surveys conducted in major cardamom growing regions of South India, revealed that *Banana bract mosaic virus* (BBrMV) infection in cardamom was prevalent in Karnataka and Kerala. The disease was characterized by the appearance of

Table 2.3. Enzyme activities under moisture stress conditions

Crosses	Peroxidase activity (da/min)		Catalase activity (da/min)		SOD activity (da/min)	
	Control	Stress	Control	Stress	Control	Stress
Bold×GG	0.129	0.140	0.0013	0.005	5.17	6.54
GG×Bold	0.154	0.171	0.0016	0.001	5.29	5.98
Bold×(GG×CCS1)	0.115	0.152	0.0060	0.004	6.31	7.05
GG×(CCS1×Bold)	0.151	0.100	0.0095	0.005	6.08	7.44
IC 547219×Bold	0.102	0.095	0.0002	0.001	7.33	7.08
Bold×IC 547219	0.080	0.160	0.0037	0.002	8.25	8.64
GG×(NKE 19×Bold)	0.137	0.121	0.0085	0.003	4.69	8.42
Bold×(GG×NKE 19)	0.110	0.122	0.0145	0.003	6.54	6.54
Mean	0.122	0.133	0.0057	0.003	6.21	7.21

chlorotic streaks along the veins and hence the name 'chlorotic streak' was proposed for the disease. Subsequent, surveys conducted in 77 cardamom plantations in 49 locations of Kerala, Karnataka and Tamil Nadu revealed that, incidence of the disease ranged from 0% to 15%. Leaf dip electron microscopy of the samples obtained from symptomatic plants revealed the presence of flexuous virions resembling *Potyvirus* (Fig 2.6).

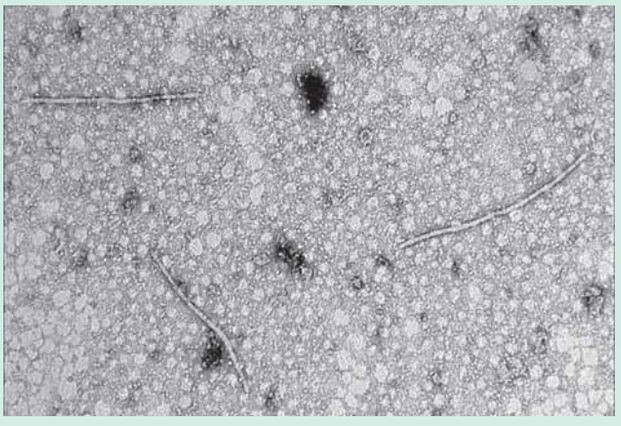


Fig. 2.6. Electron micrograph of BBrMV of cardamom

Sequencing and BLAST analysis of the sequence generated with the primer pairs targeting the conserved region of *Potyvirus* (WCIEN) and Poly (A), showed *Banana bract mosaic virus* (BBrMV) as the closest virus. Specific primers aimed to amplify coat protein of BBrMV resulted in a product of 950bp size (Fig 2.7). Sequence analysis of coat protein gene showed an identity of >94% with BBrMV isolates while identity with other distinct potyvirus species were <60%, indicating that causal virus is a strain of BBrMV. A reliable RT-PCR based method was also developed for detection of the virus in plants.

Validation of RT-PCR method

The result of validation of RT-PCR method using 40 field samples showed successful detection of BBrMV in 31 samples. All symptomatic samples (22) collected from different geographical regions tested positive for the virus. Of the eight asymptomatic tillers collected from different infected clumps of cardamom, all the samples tested positive indicating BBrMV infection in these tillers. Of the 10 apparently healthy plants collected from adjacent infected plants, one tested positive for BBrMV infection.

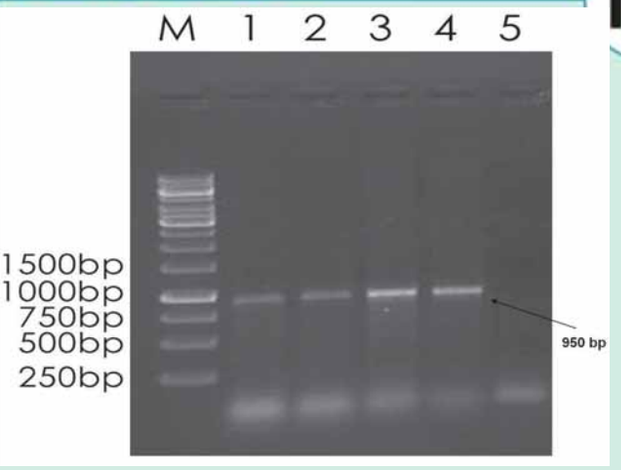


Fig. 2.7. Amplification of BBrMV from cardamom using specific primer

M: Marker (1 Kb ladder); Lane 1: Sirsi isolate; Lane 2: Idukki isolate; Lane 3: Wayanad isolate; Lane 4: Positive control (BBrMV infected banana); Lane 5: Negative control (Healthy Banana).

Rhizome and root rot distribution

Thirty five locations were surveyed in Wayanad and Idukki districts of Kerala, Valparai in Tamil Nadu and Hassan and Kodagu districts of Karnataka to study the distribution of pathogens associated with rhizome root rot of cardamom. Meppadi Panchayat in Wayanad District was identified as a hot spot of the disease. Sixty fungi were isolated from the 75 samples of rhizome and root rot diseases from different locations during the survey (Fig 2.8). The fungi isolated from the samples included *Rhizoctonia solani*, *Fusarium oxysporum*, *Fusarium solani*, *Fusarium* spp., *Colletotrichum* sp., *Pythium vexans*, *Botryodiplodia theobromae* and unidentified cultures (Fig 2.9). Soil samples were collected from the rhizosphere of healthy cardamom plants from all the locations surveyed and 45 isolates of *Trichoderma* sp. were isolated from the samples.

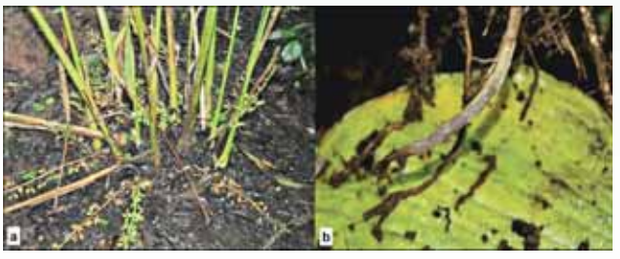


Fig. 2.8. Symptoms of (a) rhizome rot and (b) root rot in cardamom

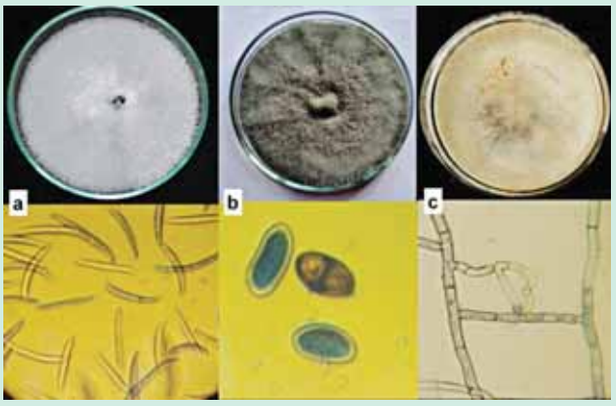


Fig. 2.9. Fungi isolated from rhizome rot and root rot affected samples in cardamom

(a) *Fusarium* sp. (b) *Botryodiplodia* sp. (c) *Rhizoctonia* sp.

Leaf spot pathogen diversity

Out of 150 samples collected from various crops, 100 were infected with *Colletotrichum* spp. The cultures were identified by comparing the colony and conidial morphology and were subsequently pure cultured and maintained for further studies. Among the 100 isolates of *Colletotrichum* spp., 40 were isolated from black pepper, 30 from cardamom and 30 from other hosts such as turmeric, ginger, arecanut, chilli, betelvine, mile-a-minute (*Persicaria perfoliata* (L.) H. Gross), coffee, clove, yam, oil palm, bell pepper and tea.

Colony characteristics such as diameter at 10 days after inoculation, colour of the colony, shape and size of the conidia, and shape, size and number of lobes of appressoria were studied to characterize the isolates. The colony, conidial and appressorial characteristics of *Colletotrichum* spp. isolated from cardamom, black pepper and other hosts were diverse. Five groups were elucidated based on colour *viz*., gray, white, grayish white, grayish olive and pale pink and maximum number of isolates were accommodated in Group IV (grayish olive).

Pathogenicity

To ascertain the pathogenicity of the *C. gloeosporioides* isolates infecting cardamom, the isolates were cultured on PDA medium and aggressive isolates were identified by recording the radial growth of the fungal colony after seven days of inoculation. The isolates CD 2, CD 11, CD 25, CD 27 and CD 30 were identified as aggressive isolates.

Sources of resistance for thrips

Two hundred and forty one accessions obtained from the germplasm were screened against cardamom thrips (*Sciothrips cardamomi*). The total number of capsules damaged, numbers of capsules with low (<25%), medium (>25% to <50%) and heavy (>50%) attack were recorded on each accession. Morphological characters such as plant type, nature (persistence) of bract and leaf sheath (firm or loose) and incidence of thrips infested capsules were also recorded. Two Malabar types, IC 349392 and IC 547159 and one Vazhuka type, IC 49542 remained free from capsule damage by thrips. The highest capsule damage (62.5%) by thrips was recorded on IC 349536 followed by IC 349384 (58.67%), both being Mysore types. The mean percentage of infested capsules was 15.0%, 23.4% and 32.5% in Malabar, Vazhuka and Mysore types, respectively. The mean percentage of infested capsules was 28.5% and 15.3% in accessions with persistent and non-persistent bracts, and 27.7% and 14.4% in accessions that had firm and loose leaf sheaths, respectively.

GINGER

Genetic resources

Five hundred and ninety five accessions of ginger are being maintained in addition to 64 accessions received from NBPGR (Thrissur).

Evaluation of nematode tolerant accessions

A trial was laid out with four ginger accessions along with check, IISR Varada. Morphological and yield characters were recorded. Among the four accessions tolerant to root knot nematode (*M. incognita*), yield per bed ranged from 6.67 to 11.00 kg. Maximum yield was recorded in Acc. 219, followed by IISR Varada (Table 3.1).

Pollination studies

In vivo pollination was done in high pollen fertile line collected from farmer's field at Quilon. *In vitro* self pollination was performed using a high pollen fertile line from Quilon and moderately fertile line Acc. No. 12. No seed set was observed so far. Pollination studies with Acc. No.195 was not possible as none of the plants flowered this year.

Pollen fertility studies in mutants

One hundred and twenty MC5 and 191 MC4 generation of plants derived from irradiated buds were maintained in bags. Pollen fertility analysis by staining of two mutants showed improvement in stainability. Pollen fertility in two mutants was HP 0.5/10: 35.29% and S 1.0/6: 37.3 %.

Cytological and embryological studies

Chromosome number analysis of 10 mutants (MC5) showed normal number of 2n=22. High pollen fertile collection from Quilon was found to be a tetraploid with 2n=44 on analysis of mitotic chromosome number. Microtome sections of ovules, which showed development during *in vitro* pollination were prepared. No embryo formation was observed on staining and microscopic analysis.

Organic Farming

Highest yield was recorded under organic system (10 kg/bed of 3 m^2) and there was no significant difference in yield among the varieties under organic treatments. In general var. Mahima and Varada performed well under organic management compared to Rejatha with 17-19% yield increase compared to inorganic system. The soil pH and magnesium were higher under organic system. The soil N, K and Ca levels were higher under integrated systems.

Among combination of organic manures, treatment FYM+VC+NC+PG+BD recorded highest yield (12.8 kg/bed) compared to control (4.85 kg/bed). Highest soil N was recorded in the same treatment, followed

Table 3.1. Evaluation of nematode tolerant accessions for yield and yield contributing characters

Entries	Plant height (cm)	No. of tillers	Leaves/ main tiller	No. of leaves	Leaf length (cm)	Leaf breadth (cm)	Yield (kg/3m^2)
Acc. 372	64.11	10.89	24.56	176.78	28.85	2.61	6.67
Acc. 65	66.67	8.44	23.44	140.33	28.07	2.60	7.33
Acc. 219	66.89	10.11	25.11	164.44	27.56	2.52	11.00
Acc. 251	68.72	8.89	24.33	132.00	29.81	2.77	8.67
IISR Varada	81.67	13.67	27.67	159.67	27.11	2.63	10.63
Mean	67.93	11.17	24.69	155.09	27.77	2.58	8.59
CD (0.05)	5.14	2.45	2.47	NS	1.45	NS	1.33

by PG+BD application. The P, K, Ca, Mg and Zn status were higher under NC+VC+PG and BD. This treatment also showed higher acid and alkaline phosphatase and dehydrogenase activity. The organic system recorded higher oleoresin content in Varada (3.4%) and integrated system in other varieties. The integrated system of Rejatha and Mahima recorded highest fiber content (3.7 and 3.6%). Among PGPR treatments, GEB 17 application showed highest yield (10.2 kg/ bed) compared to control (8.85 kg/bed). Rhizome rot incidence was minimal among treatments. GEB 17 application also recorded highest dehydrogenase activity.

Nutrient requirement for targeted production

Based on the initial soil availability of major nutrients, the fertilizer doses to obtain yield targets of 25, 35 and 45 kg/5 m^2 were calculated and applied at a farmer's plot in Madikeri. Nutrient requirement for realizing all the three targeted yield levels could be predicted successfully with a positive deviation of 15.7–70.0%. The realized yield levels were 42.5, 47.8 and 52.0 kg/ 5 m^2 for the yield targets of 25, 35 and 45 kg/5 m^2, respectively.

Storage studies

Studies on storage of ginger seed rhizomes was performed in a multi tier storage structure of capacity 2.7 tonnes provided with 27 nos. of removable storage trays of size 1 x 1 x 0.45 m. The trays had a wooden base with welded mesh side walls for proper aeration. Freshly harvested and fungicide treated ginger rhizomes (var Varada) were used for storage. The trays were filled with 100 kg seed rhizomes and covered with various materials like *Glycosmis pentaphylla, Strychnos nux-vomica* leaves, pesticides, sawdust, sand and granite powder. A control treatment with no covering material was also adopted. The results of the study indicated that ginger rhizomes stored for four months with granite powder as covering material recorded maximum healthy rhizomes (75.30 kg) followed by sawdust (68.0 kg). Lowest recovery of healthy rhizomes was recorded by the control treatment (38 kg).

Essential oil profiles

Seven varieties (Himgiri, Mahima, Rejatha, Rio-de-Janeiro, Suprabha, Suravi and Varada) of ginger grown at Appangala were evaluated for volatile and non volatile constituents. Essential oil and oleoresin contents in these varieties ranged from 0.9-1.2% and 2.8-3.6%, respectively. The composition of 11 chief components representing 80-85% of essential oil was evaluated. Among the genotypes, not much change in composition of essential oil was observed. However, the contents of zingiberene and farnesene showed variations between 28.6-37.7% and 5.5-19.9% respectively, and bisabolene was present in the oil of Mahima, Rejatha and Suravi only.

Nonvolatiles

The gingerol and shogaol contents of these varieties were analysed by HPLC. The pungent compounds *viz.*, 6-gingerol, 8-gingerol and 10-gingerol ranged from 1.0-1.4%, 0.09-0.29% and 0.01-0.3% respectively, contributing 1.3-1.7% of total gingerols. 10-Shogaol was not present at detectable levels, where as 6-shogaol and 8-shogaol were in the range 0.18-0.24% and 0.002-0.45% respectively. Suravi was superior among the treatments, with 1.7% total gingerols and 0.67% total shogaols.

Effect of micronutrients on flavour

In the variety Mahima application of Zn resulted in increase of oleoresin content from 2.9% to 5.5%. But no change was observed in the essential oil and its constituents.

Bacterial wilt - Diversity

Five new isolates of *R. solanacearum* biovar 3 from Kozhikode and Wayanad were added to the repository and were found to wilt ginger plants in 10-14 days. A new bacterial wilt disease was noticed in Wayanad on cardamom. Phenotypic and genetic characterization revealed that the causative organism is *R. solanacearum* biovar 3 and phylotype 1. Multiplex-PCR based phylotyping, 16s rDNA and recN gene sequence based comparison and MLST based comparative genetic analysis further revealed that the strain is 100% similar to the ginger strain of *R. solanacearum* (Fig 3.1).

Multi-locus Sequence typing (MLST) of 21 strains of *R. solanacearum* was carried out by PCR amplification and sequencing of housekeeping genes ppsA, adk, gapA, gdhA, gyrB and virulence genes (hrpB, fliC and egl). Several novel alleles could be found in ginger strain of *R. solanacearum* on comparing with the alleles documented in the database www.pamdb.org. Real time PCR based detection of R. solanacearum in soil was standardized (Fig 3.2).

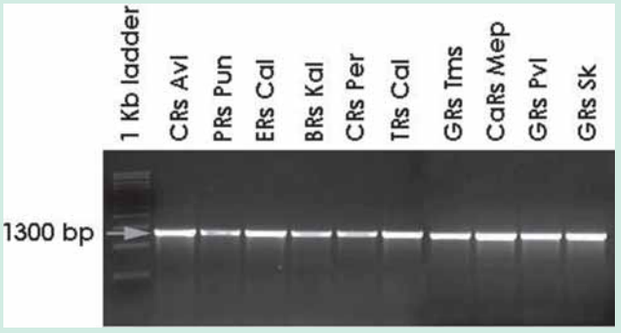


Fig. 3.1. recN gene sequence based comparision of *R. solanacearum*

Host resistance

Fifty four ginger accessions irradiated with gamma rays were challenge inoculated with *R. solanacearum* and two accessions showed resistance even after three repeated inoculations whereas the soil was tested sick by Real Time PCR.

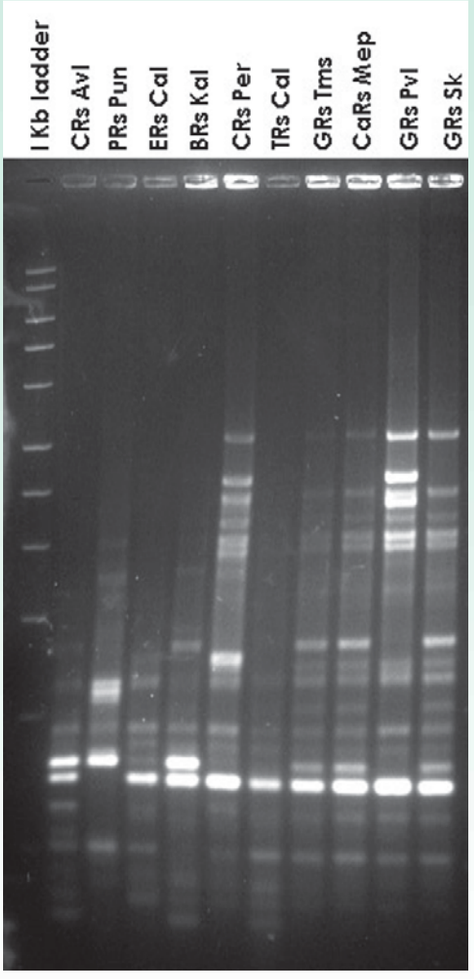


Fig. 3.2. Box PCR based DNA profiling of ginger strains of *Ralstonia solanacearum*

(M1 Marker 100bp ladder, 1-CRs Av1, 2-PRs Pun, 3-ERs Ca1,4-BRs Mnp, 5-CRs Per, 6TRs CaI, 7-GRs-Tms, 8 CaRs Per, 9-GRs 09-01, 10- 09-17

Management

In a trial on management of bacterial wilt of ginger with 11 treatments, including two antagonistic plants (*Tagetes* sp. and *Ocimum sanctum*) and biopriming of rhizomes with six endophytic/rhizobacteria and one actinomycetes, pre-planting with *Tagetes* sp. reduced the disease incidence and enhanced ginger yield (Table 3.2). Actinomycetes isolated from ginger soil were evaluated against *R. solanacearum* under *in vitro* conditions and nine isolates showed antagonistic activity.

Table 3.2. Evaluation of bacterial antagonists and antagonistic plants against bacterial wilt

Treatment	Disease incidence (%)
Tagetes sp.	31.2
Ocimum sanctum	65.7
SBW *P. aeruginosa*	90.4
Pf5 *P. aeruginosa*	84.2
Phz *P. aeruginosa*	60.2
IISR 51	76.5
GEB 13	59.9
GEB 19	77.0
VC 11 (Actinomycetes)	82.0
Streptomycin sulphate (200ppm)	70.9
Control	76.6
CD 0.5%	18.7

Bionomics of shoot borer

The life cycle of shoot borer (*Conogethes punctiferalis*) was studied on six resistant and six susceptible accessions of ginger. The mean adult longevity was 4.4 and 4.9 days, on resistant and susceptible accessions, respectively. The fourth and fifth larval instar and pupal weights were 0.104, 0.104 and 0.07g, respectively, in resistant accessions and 0.127, 0.112 and 0.073 g, respectively, in susceptible accessions. However, the differences were not statistically significant.

Formulation of artificial diet

A semi-synthetic artificial diet was formulated for maintenance of shoot borer culture in the laboratory. The major dietary components included in the diet were, chickpea flour, dried ginger leaf powder, yeast, casein, agar, formaldehyde, salt and amino acids. Egg-laying was also successfully induced in the insect under laboratory conditions.

Isolation of EPNs

Twenty one soil samples were collected from ginger rhizosphere from various locations in Vythiri, Mananthavady and Sulthanbathery Taluk of Wayanad. Out of these only two strains of EPNs were found.

Identification of EPNs

Out of eight species of EPNs isolated from rhizosphere of ginger and turmeric, two species belonged to *Steinernema* sp., one to *Heterorhabditis* sp. and five to *Oscheius* sp. Among the *Steinernema* sp, one species has been tentatively identified as new species on the basis of morphometric analysis and scanning electron microscopy (SEM).

Infectivity of EPNs against shoot borer

The infectivity of eight EPN strains was tested against shoot borer larvae *in vitro*. Among these, IISR-EPN 01 (*Oscheius* sp.), IISR-EPN 02 (*Heterorhabditis* sp.), IISR-EPN 07 (*Oscheius* sp.) and IISR-EPN 08 (*Oscheius* sp.) were more pathogenic to shoot borer larvae and they brought about 100% mortality within 72 h, whereas IISR-EPN 03 (*Steinernema* sp.), IISR-EPN 04 (*Oscheius* sp.) and IISR-EPN 06 (*Oscheius* sp.) killed the larvae within 96 h.

TURMERIC

Conservation of germplasm

In *Curcuma*, 1026 accessions are being maintained. Two hundred and forty four accessions of turmeric received from NBPGR (Shillong and Thrissur) were also planted for maintenance.

Developing ISSR/ EST SSR profiles for identification of released varieties

ISSR profiles (Fig 4.1) were developed for seven varieties of turmeric for developing standard profiles and varietal identification with eight ISSR primers.

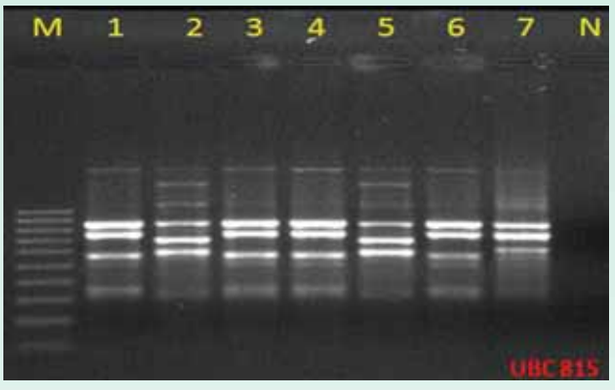


Fig. 4.1 ISSR profiling of released varieties of Turmeric using the primer 815 (5'-CTC TCT CTC TCT CTC TG-3')

Lane one to seven represents IISR Suvarna, IISR Suguna, IISR Sudharsana, IISR Prabha, IISR Prathiba, Alleppey Supreme and IISR Kedaram.

Varietal specific bands were also observed for a few varieties.

Primer	Variety	Base pair
UBC 834a	IISR Suvarna	600 bp
UBC 835a	IISR Suvarna	400 bp
UBC 811	IISR Suguna, IISR Sudharsana	390 bp

Cloning of *pal* gene

PCR conditions were optimized using *pal* gene specific primers, designed based on plant transcript assembly database at TIGR. A 1300 bp PCR amplified product was obtained and sent for sequencing.

Evaluation of nematode (*M. incognita*) tolerant accessions

The experimental materials consisted of seven accessions and released variety IISR Prathibha, as check. Various yield and yield contributing characters *viz.*, plant height, tillers/plant, leaves/plant, leaf length, leaf breadth and yield/3m^2 were recorded. Maximum yield of 14.0 kg/3m^2 was recorded in Acc. 79 and Acc. 48 (Table 4.1), which was at par with IISR Prathibha (15.2 kg/3m^2).

Evaluation of seedling progenies

Two hundred and fifty six seedling progenies and 23 mother plants were planted in three replications. High variability with respect to yield was observed. Twenty five progenies showed multiplication rate above 15 times. Thirty five progenies showed dry recovery above 25%. Seed material from all the progenies and mother plants were preserved for next year's trial.

Sixty seedling progenies which showed higher multiplication rate in previous years trial were planted in the field to confirm the performance and also to multiply the material for further evaluation. Of these, 27 progenies showed more than 15 times yield per seed material in 2011 and most of them showed dry recovery of above 20%.

Cytological analysis of seedling progenies

Chromosome number analysis was completed in 20 progenies. All of them showed deviation from normal number of 2n=63. Most frequently occurring number was 2n=84 (Table 4.2).

Quality analysis in seedling progenies and mother plants

Processed rhizomes of 232 seedling progenies and 16 mother plants were analyzed for curcumin, oil and oleoresin. Variability was observed for all the three quality parameters. Curcumin content ranged from 0.02 (354/3) to 4.92% (389/1). Forty nine progenies showed

Table 4.1. Evaluation of nematode tolerant accessions for yield and yield contributing characters

Entries	Plant height (cm)	No. of tillers	No. of leaves	Leaf length (cm)	Leaf breadth (cm)	Yield (kg/3m^2)
Acc. 200	119.00	2.50	13.50	55.63	20.15	10.50
Acc. 142	116.63	5.75	28.50	54.00	16.75	9.75
Acc. 79	92.50	2.00	11.50	46.75	13.00	14.00
Acc. 35	149.50	3.75	15.50	64.75	17.15	12.00
Acc. 48	94.75	2.50	13.75	45.75	15.00	14.00
Acc. 146	122.75	2.00	11.75	59.00	14.00	10.25
Acc. 130	133.50	1.00	9.00	56.50	19.00	9.75
Acc. 376	142.50	2.25	11.00	68.25	14.25	10.25
Prathibha	164.75	2.25	14.25	76.00	18.25	15.23
CD (0.05)	21.01	1.25	4.81	10.34	3.67	1.82

Table 4.2. Chromosome number variation among seedling progenies of turmeric

Chromosome number (2n)	Seedling Number
82	20/9
83	18/19
84	18/15, 18/16, 18/24, 18/27, 20/8, 69/2, 69/9, 69/10, 138/25, 138/54, 138/60, 399/4, 415/12
86	18/8, 69/4
88	18/20
89	138/2
90	18/9

dry recovery above 20%. Seedling progenies showed > 3% curcumin content.

Organic farming

Turmeric was grown organically by applying FYM, vermicompost, ash and rock phosphate, azospirillum, phosphobacteria, *Trichoderma* and *Pseudomonas* sp. (IISR-6 & 853) as bio control agents. Organic and integrated systems showed comparable yield (15.1 and 15.3 kg/3m^2). The var. Alleppey Supreme recorded higher yield (17%) under organic system than Prathibha compared to inorganic system. The soil organic carbon, N, P, K, Ca, Mg and Zn were higher under integrated system. The enzymes like acid phosphatase and dehydrogenase were also higher under integrated system. Among organic manure combinations, treatment FYM+NC+VC recorded highest yield (16 kg/3m^2), followed by FYM+BD+PG (13.3 kg/3m^2) compared to control (8.7 kg/3m^2). The soil OC, N, P, Ca, Mg and Zn were also higher under NC+VC+PG and BD. Among the systems, curcumin (6.6%) and starch (47%) content was highest in organic management in Alleppey supreme. Prathibha also recorded higher oleoresin and starch contents under organic system, on par with integrated and inorganic systems.

Nutrient requirement for targeted production

Based on the initial soil availability of major nutrients, contribution of nutrient from soil (CS), from FYM (CFym) and from fertilizer (CF) were calculated for turmeric and fertilizer doses to obtain yield targets of 15, 20 and 25 kg/3m^2 was calculated and applied. In var. Prathibha and Alleppey Supreme, the highest yield up to 18.8 kg/3m^2 was obtained for the target levels 25 kg/3m^2. Through targeted equation, nutrient requirement for 15 and 20 kg/3m^2 yield could be predicted successfully with a minimum deviation of -6.0 and -8.0 %, respectively. At higher target levels the realized yield showed a deviation of -25.0%. But through targeted nutrient supply 43-92% yield increase as compared to the normal recommendation was realized.

Yield kg/bed	N	P_2O_5 (g/bed)	K_2O	Realized yield (kg/bed)	Deviation %
15	45	40	-	14.0	-6.67
20	75	55	50	18.4	-8.0
25	105	70	125	18.8	-24.9
RDF*	30	25	60	9.75	-

**RDF- Recommended dose of fertilizer*

Micronutrients on yield and quality

The effect of Zn and B on the yield and quality of turmeric var. Prathibha was studied. Soil application of zinc @ 5 kg/ha and 0.25% Zn as two foliar sprays along with application of recommended dose of P recorded higher rhizome yield of 17.4 and 18.5 kg/3 m^2, respectively. In the absence of P application, soil Zn application up to 10 kg/ha yielded higher (20.8 kg/ 3 m^2) compared to other treatments (Table 4.3). Similarly, without liming, application of B up to 1 kg/ha increased the rhizome yield (15.7 kg/3 m^2) which was 39% higher compared to control. But when lime was applied, similar increase in yield was observed even without application of B, indicating the benefits of correcting the soil pH in increasing the B availability. One foliar spray of B (0.2%) also recorded higher yield (16.7 kg/3 m^2) on par with lime application alone. Curcumin content was significantly high (5.11%) in two foliar sprays of B @ 0.2%.

Table 4.3.Effect of zinc levels on yield of turmeric var. Prathibha

Treat	Soil Zn (120 DAP)			Yield(kg/ 3 m^2 bed)		
(kg/ha)	-P	+P	M	-P	+P	M
Zn-0	1.2	1.2	1.2	14.03	13.20	13.62
Zn-5	3.6	2.4	3.0*	15.20	17.37	16.28*
Zn-10	5.1	7.4	6.2*	20.77	14.53	17.65*
Zn-15	9.2	9.8	9.5*	14.87	14.03	14.45
FS-1	1.3	1.4	1.3	16.37	14.70	15.54
FS-2	1.7	1.6	1.6	14.37	18.53	16.45*
CD (p=0.05)		1.1				1.5

Zn – Zinc; FS- Foliar spray (@ 0.25%); * - Sig. at p=0.05

Curing of turmeric

Studies on curing were conducted in TNAU model improved turmeric boiler and drying was done between 9 AM to 3 PM. Initial moisture content of turmeric rhizomes (*cv* Prathibha) was 78.89% and dried to 10% after various initial pretreatment like traditional water cooking, improved steam boiling, slicing and dipping in boiling water. Through improved boiler, steaming was done for 30, 45 and 60 min and cooking of rhizomes was sufficient only after 60 min of steaming. Another batch was cooked by water boiling method in the traditional method for 40, 60, 90 min. One batch was dipped in boiling water and dried and another batch was sliced to 3 mm thick and dried. The

Table 4.4. Biochemical qualities of cured turmeric rhizomes by different pre treatments

Treatments	Drying time h (days)	Curcumin %	Essential Oil %	Oleoresin %	Starch %
Water boiling- 40 min	66.33 (11)	5.91	3.60	13.03	66.96
Water boiling- 60 min	65.83 (11)	5.85	3.60	13.30	60.32
Water boiling- 90 min	65.33 (11)	5.12	3.33	13.08	62.44
Steam cooking-30 min	144.5 (24)	6.00	3.33	13.96	63.33
Steam cooking-45 min	137.5 (23)	5.76	3.20	12.60	72.18
Steam cooking-60 min	71.5 (12)	5.12	2.93	12.22	61.38
Dip in boiling water -10 min	77.5 (13)	5.18	3.20	11.54	66.86
Slicing -3 mm	53.5 (9)	5.71	3.07	12.76	50.53
CD (0.05)	1.10	0.21	0.37	1.18	5.10

cooked rhizomes were dried in open cemented yard. The dried rhizomes were tested for their biochemical qualities and results of the study (Table 4.4) indicated that, slicing significantly reduces the drying time (9 days). Turmeric cured in improved boiler for 60 min took 12 days for drying whereas for 30 min curing drying time increased to 24 days and by traditional water boiling for 40, 60, 90 min, took 11 days for drying. The reduction in curcumin, starch and drying time with increased curing time is highly significant by both methods.

Cryogenic grinding for retention of quality

Dry turmeric rhizome was powdered in pin mill and exposed to 40°C for ten days. About 15% reduction in oil was observed while total oleoresin, curcumin and total phenol did not show any variation at high temperature. But when rhizomes were cured in boiling water for about 90 minutes prior to drying, many oil constituents with lower temperature stability would have been lost, which is the reason for poor impact of pin mill grinding on oil content at high temperature. Antioxidant oxidant activity was also assayed for 10 days by the three established methods which did not show any change due to high temperature.

Influence of biochemical factors on curcuminoid levels

Out of 300 turmeric accessions examined, higher content of curcuminoids (> 4 %) was noticed in 40 accessions. Curcumin-1 varied from 22.14% to 51% among the accessions analysed; while curcumin-2 ranged from 25.5% to 61.1%. Curcumin-3 showed wider variation ranging from 6.88% to 30.43%. Majority of these accessions also had higher content of oleoresin. Accessions with lower percentage of starch (less than 30%) had higher curcumin levels. Activity of the major downstream enzyme, curcumin synthase (CS) was either on par or increased slightly in high curcumin accessions, while in the low curcumin accessions, the CS activity decreased from 5th to 6th month, indicating a positive correlation.

Shoot borer - Bionomics

The life cycle of shoot borer was studied on four resistant and four susceptible accessions of turmeric. The average adult longevity was 3.8 and 4.0 days, on susceptible and resistant accessions, respectively. The fourth and fifth larval instar and pupal weights were 0.144, 0.114 and 0.087 g, respectively, on resistant accessions and 0.136, 0.123 and 0.085 g, respectively, on susceptible accessions. However, the differences were not statistically significant.

VANILLA

Maintenance of germplasm collections, seedlings/mutants/interspecific hybrids

Ninety three germplasm collections and more than 500 seedlings/mutants/interspecific hybrids were maintained.

Ex vitro establishment of seedlings/mutants/ interspecific hybrids

Fifty seedlings, 100 mutants and 80 interspecific hybrids were established *ex vitro* in plastic cups filled with potting mixture. 60 mutants, and 30 interspecific hybrids were transferred to pots for further growth.

Recording of morphological characters from germplasm collections

Morphological characters namely leaf length, leaf breadth, internode length and stem girth were recorded from five collections, 4733, 4757, 4766, 4719 and 4716.

Screening interspecific hybrids of *V. planifolia* × *V. tahitensis* for root rot disease

Ten plants of interspecific hybrids between *V. planifolia* and *V. tahitensis* were treated with cultures of *Fusarium oxysporum*, the causal organism for root rot and stem rot in vanilla. Untreated plants formed the control. The treated plants are under observation.

Additionally, 10 plants each derived from the irradiated protocorms of *V. planifolia* with 0.5 kr and 1.0 kr of gamma rays were also treated with cultures of *Fusarium oxysporum* and untreated plants formed the control.

Chromosome number analysis in interspecific hybrids of *V. planifolia* × *V. tahitensis* in comparison to the parents

Chromosome number analysis was performed in four interspecific hybrids between *V. planifolia* ×*V. tahitensis* in comparion to the parents. *Vanilla planifolia* was found to have 2n=28 as frequent chromosome number while *V. tahitensis* had 2n=32. Among the interspecific hybrids analyzed three showed 2n=30 as predominant chromosome number while in one hybrid, cells with 2n=28 were observed very frequently.

NUTMEG

Evaluation of germplasm

The Plant Germplasm Registration Committee (NBPGR, New Delhi) in its XXII meeting approved the registration of the nutmeg germplasm *viz*., A9-71 (IC 537220) proposed by IISR, as a source of high sabinene (45.0% sabinene in nutmeg oil and 41.9% sabinene in mace oil). It has low levels of myristicin (1.9% and 1.1%), elemicin (0.8% and 1%) and safrole (0.1% and 3.2%) It has been provided with a registration number INGR10142.

In the trial on clonal evaluation of high yielding nutmeg lines, A9/185 was found to have significantly more height (675 cm), canopy (580 cm), girth (61.6 cm) and number of primary branches (83.6). In the trial on clonal evaluation of nutmeg lines having high myristicin and elemicin, A4/20 recorded significantly higher height (57.4 cm), canopy (52.2 cm) while A9/4(3) recorded significantly higher number of primary branches per plant.

In the trial on clonal evaluation of nutmeg lines having low myristicin and elemicin and high sabinene, A9/95 recorded more plant height (70.8 cm), canopy (47.3 cm) and girth (1.05 cm) while A9/69 recorded the maximum number of primary branches per plant (3.3).

Production of orthotropic shoots from plagiotropic grafts

Fifteen different treatments in various combinations, which include pruning, bending, ringing the bend portion, spraying of three different hormones *viz*., 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 a large number of shoots were induced in the treated grafts, none of them were orthotropic.

Budding for production of orthotropic grafts

Modified patch budding (with orthotropic brown buds) on 2 year old rootstock gave 20-40% success. However, green chip budding with leaf retained on the bud wood gave 90 to 100% success during July to October when budded on to 6 to 12 month old rootstock. Advantage of budding over grafting is that more orthotropic plants could be produced from the available orthotropic scions.

Manipulation in trees and orthotropic shoots

Various treatments like detopping of trees and detopping 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. Large number of orthotropic shoots (up to 44) were produced on trees and 4-5 orthotropic shoots were produced from grafts. These shoots would further produce orthotropic shoots on pruning.

CINNAMON

Cryogenic grinding for retention of Quality

Cinnamon bark was powdered in pin mill and was exposed to 40°C and analysed for oil, oleoresin, total phenol and antioxidant activity. Except for about 15% reduction in oil content no profound change was noted in total phenol and antioxidant activity.

GARCINIA

Germplasm survey and collection

The survey conducted in the North Eastern India revealed that the population density of many species is dangerously low and is reduced to one or two trees in a given location making survival of these species very difficult (Fig 6.1). This is further aggravated by the fact that seeds fail to produce seedlings due to various physiological and environmental factors making natural multiplication and maintenance of these species impossible.

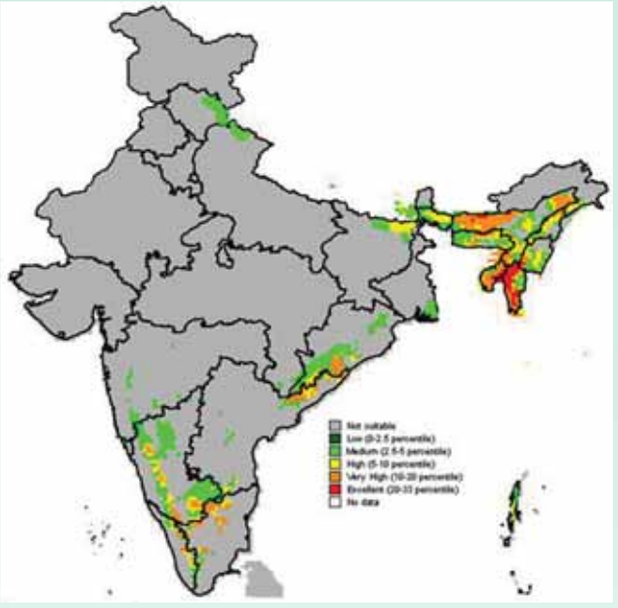


Fig. 6.1. The 'BIOCLIM' prediction map showing the domains for Garcinia species in India

Micropropagation of Garcinia Species

An efficient method of propagation of three endemic species of garcinia - *G. indica, G. tinctoria,* and *G. gummigutta* was developed to produce plantlets with high level of shoot multiplication and root formation since the traditional methods of propagation of garcinia has some limitations. Micropropagation studies showed that MS medium supplemented with 2.5 mg L^{-1} 6 benzyl amino purine (BAP) gave best response and induced multiple shoot initiation (Fig 6.2). Root initiation took place in MS medium with or without α Naphthalene Acetic Acid (NAA) but root elongation was faster in MS medium supplemented with 2 mg L^{-1} of NAA. Species wise differences in *in vitro* response were observed (Fig 6.3). *In vivo* seed germination studies were conducted to understand the seed germination pattern in the three species.

Fig. 6.2. Seed germination of *Garcinia indica* on germination paper.

(a) Whole seed growth after 2 months AR-adventitious root, PR-primary root. (b) Seed cut into three fragments A, B and C and Fragment A is the proximal end, Fragment B is the middle fragment and Fragment C is the distal end.

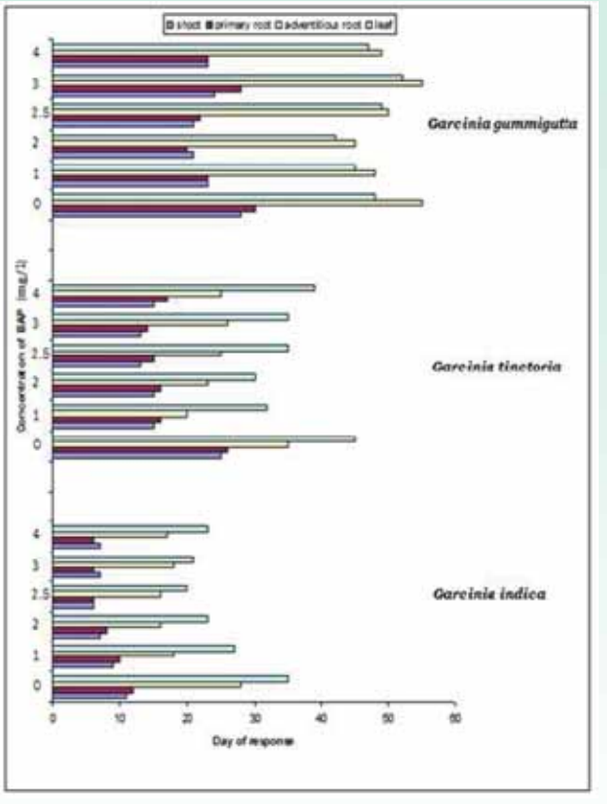


Fig. 6.3. Effect of BAP concentration in (mg L^{-1}) on initiation of shoot, root and leaves in three species of *Garcinia.*

RAPD – PCR profiling of 50 accessions of *Garcinia* species collected from different regions of NE States was done with 12 primers. Species studied

were *G. tinctoria, G. xanthochymus* (Tepor tengo), G. *livingstoni* (exotic), *G. dulcis* (exotic), *G. cowa* (Kuji thekara), *G. pedunculata* (Bor thekara), *G. lancifolia* (Rupohi thekara) and unidentified (Mahi thekara) (Fig 6.4). The dendrogram showed that species wise distinction is clear, but intra species variability is high. The species specific band found in Western Ghats is 480 bp while in NE region it is 450 bp (Fig 6.5).

The percentage of HCA (Hydroxycitric acid) was estimated from leaf and fruit rind tissue of garcinia from Western Ghats and from NE States through HPLC. The result indicated that Western Ghat's species like *G. gummi-gutta* and *G. indica* had higher percentage of HCA than NE species. *G. xanthochymus* which was present in both the eco-systems, showed absence of HCA (Table 6.1).

Volatile oil composition indicated that *G. cowa* has seven compounds, *G. indica* 12 compounds, *G. tinctoria* nine compounds and *G. gummi-gutta* eight volatile compounds with more than 1% concentration in oil. *t*-Caryophyllene and γ-Muurolene were found in all at high concentrations and α-Humulene, γ-Gurjunene and γ-Cadinene were also common in all the three species except *G. cowa*. The volatile oil obtained by hydro distillation of garcinia leaves did not show any characteristic piquant aroma, though the constituents are exactly same as that of other spice

Fig. 6.4. Exotic species of garcinia (a) *Garcinia dulcis* (b) *Garcinia livingstoni*

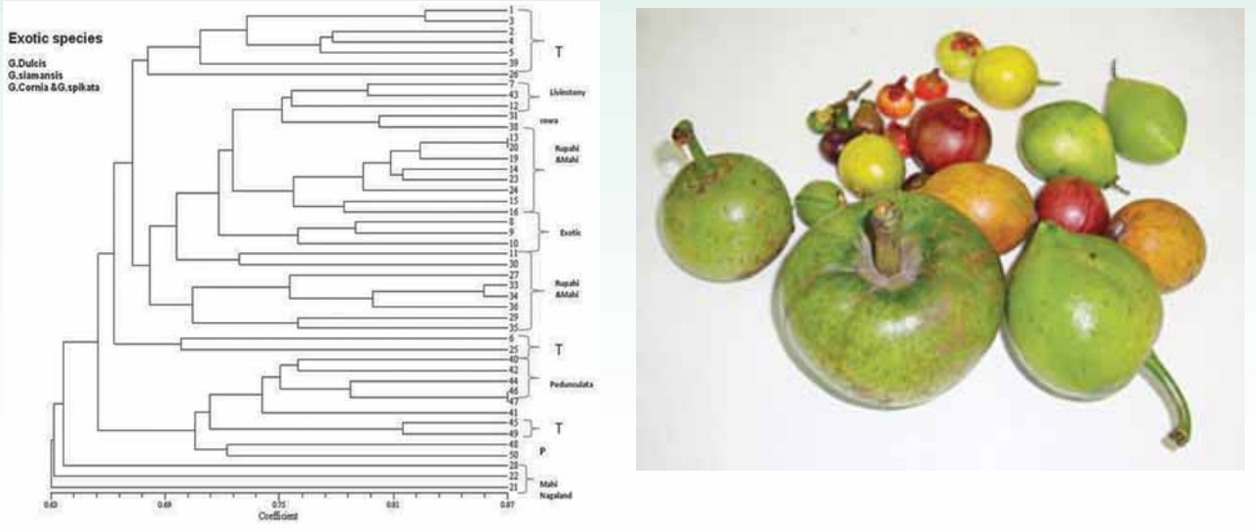


Fig. 6.5. (a) The dendrogram showing variability among the *Garcinia* species; (b) Diversity of Garcinia from upper Assam and Nagaland

Table 6.1. HCA content in different parts of Garcinia species

Species	HCA content (%)		
	Leaf	Fresh fruit	Dry fruit
G. cowa (Kuji thekara)	1.5	4.2	4.2-5.5
G. pedunculata (Bor thekara)	1.08	2.1	3.8
G. lancifolia (Rupohi thekara)	2.45	3.0-4.5	4.0 -5.8
G. sp (Mahi thekara)	0.06	0.01-.25	0.01-1
G. xanthochymus (Tepor tenga)	Nil	Nil	Nil
G. gummi-gutta	3.95	5.43	5.5
G. indica	3.53	4.83	5.0

oils. Stearic acid was present in a very high percentage in garcinia seed butter. A limited number of tree species, have been reported to accumulate more than 30% stearate in their seed oil which has high anti-plasma cholesterol property (Table 6.2).

Table 6.2. Fatty acid (%) profiling in seeds of *Garcinia sp.* by GC-FID

Fatty acid	*G. indica*(%)	*G. gummi-gutta* (%)
Palmitic acid	15	12
Stearic acid	40	28
Arachidic acid	9	8

STUDIES ON MYCOTOXINS, NUTRACEUTICALS AND BIOACTIVE COMPOUNDS

Exploration of spices for natural food colours and pigments

Eighteen plant species were evaluated for total anthocyanin, total carotenoids, lycopene and phenol content. *Tithonia diversifolia*, *Baugainvillea* (orange), *Baugainvillea* (red) and beet root gave high carotenoid content. Total carotenoid ranged from 0.07 mg to 0.73 mg/g tissue.

Mycotoxins

In vitro inhibition studies using bacterial antagonists, *viz*., IISR 853, Bp 35, Bp 25, Bp 17, IISR 6, TC revealed IISR 6 as the most potent species in preventing aflatoxin production to the extent of 60%. In continuation of these studies, simultaneous and deferred antagonistic assays were conducted against *Aspergillus flavus*. In both cases, no aflatoxin production was seen in treatments, whereas the total production in control was 485.85 ppb. The results confirm that the inhibitory activity of *P. aeruginosa* is due to extra cellular metabolites produced by the bacteria in culture.

Nutraceutical properties of bioactive compounds

The antioxidant property of water and ethanol extracts of *Garcinia indica, G. gummi-gutta*, tamarind (*Tamarindus indica* L.) and curry leaves (*Murraya koenigii* (L.) Sprengel, and essential oil of curry leaves were compared at different time periods – immediately after extraction (I quarter), after three months (II quarter), six months (III quarter), nine months (IV quarter) and one year (V 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. Cell culture studies on the effect of spice extracts on human colon carcinoma cell lines, Caco-2 cells, have also been initiated.

Garcinia indica

The total phenol content of water and ethanol extracts were stable for up to six months after extraction, after which it decreased. The DPPH radical scavenging activity was greater in the ethanol extract and decreased marginally in both water and ethanol extracts, in a year of storage. Fe(III) to Fe(II) reducing activity was greater in the ethanol extract and reduced significantly in both extracts with time.

G. gummi-gutta

The total phenol content of water and ethanol extracts were stable for three months after extraction; and decreased significantly thereafter. The DPPH radical scavenging activity decreased only marginally in the ethanol extract, but significantly in the water extract in a year of storage. Fe(III) to Fe(II) reducing activity was greater in the ethanol extract and reduced marginally in both extracts with time.

Tamarind

The total phenol content of water and ethanol extracts were stable for three months after extraction; after which it decreased gradually. The DPPH radical scavenging ability of tamarind water and ethanol extracts decreased gradually on storage to almost 1/ 3rd the original values. Fe(III) to Fe(II) reducing activity was greater in the ethanol extract and reduced in both extracts with time.

Curry leaves

The total phenol content significantly reduced in one year after extraction, in the essential oil, water and ethanol extracts, the decrease was more rapid in the essential oil (2.97 to 0.019 mg ml^{-1}). The DPPH radical scavenging activity of the essential oil decreased significantly, while the water and ethanol extracts did not decrease even after one year of storage. *t*-Caryophyllene, the main component in curry leaf essential oil, was present to ~26% up to the 3rd month after extraction, but was reduced to negligible amounts (0.5%) by the 9th month, almost all of which was oxidized to *t*-caryophyllene oxide. The minor components in the essential oil were a-pinene, a-humulene, a-guaiene and epiglobulol. All the above spice extracts were either on par or superior to the synthetic phenols BHA and BHT, in their antioxidant potential, especially on storage. The decrease in total antioxidant potential was marginal in the extracts.

Antioxidant property of curry leaves of different maturity

The essential oil yield and total phenol content of tender and mature curry leaves were at par. The DPPH radical scavenging ability of essential oil and water extract of tender leaf was significantly higher than the mature leaves (78 and 52% respectively); while the Fe(III) to Fe(II) reducing activity of essential oil and ethanol extract of tender leaf was significantly higher than the mature leaves (83 and 45% respectively). A comparison of the essential oil of mature and tender curry leaves revealed that *t*-caryophyllene in mature leaves was 33% and tender leaves 35%; b-phellandrene and a-selinene: 11% in mature and 9% in tender.

Cell culture studies

Effectiveness of curcumin as a nutraceutical can be optimized by using it along with an adjuvant like piperine to increase its bioavailability. From studies on the cell viability of Caco-2 cells, the most effective dosage combinations of curcumin and piperine are 25 µm of curcumin/10 µm of piperine and 25 µm of curcumin /1 µm of piperine. On transport across Caco-2 cells both curcumin and piperine were rapidly converted to their metabolites, the m/z values (obtained by MALDI-TOFTOF) of which are similar to: β-D-curcumin-mono-glucoside, piperilate, cinnamic acid ester, piperidine derivative, cinnamoyl derivatives.

EXTENSION AND IMPACT ASSESSMENT

A survey was conducted to study the adoption, spread and impact of scientific technologies developed by the institute in farmers' fields including improved varieties of spices released in Erode district of Tamil Nadu. The methodology adopted was ex-post impact assessment-disaggregate economic rate of return assessments on adoption of scientific technologies followed by cost of cultivation estimates based on primary data.

Tamil Nadu contributes to about 15% of the total area (40,000 ha) under turmeric in the country and Erode district accounts for around 15000 ha. The survey was carried out in two turmeric growing taluks in Erode district namely, Erode and Bhanvani taluks. A sample of 30 randomly selected farms was used for primary data collection. Secondary data was collected form Spices Board and government operated regulated market in the district.

The major varieties of turmeric cultivated in the area are Erode local, IISR Suvrana, Roma and Salem. Since last 10 years improved varieties like IISR Suvarana (PCT-8, from IISR, Calicut) and Roma (from HARS, Pottangi) have been adopted by farmers in the region. Based on the data of market arrivals in the regulated markets, it was estimated that IISR Suvarna contributes to about 20 % of total production and Roma contributes to about 10% of total production in the area; the local cultivar Erode local contributes to about 60% and Salem 10% to the total production. IISR Suvarna is adopted more in Bhavani taluk endowed with relatively fertile sandy loam soil with assured irrigation water from Bhavani river. Roma is cultivated in red loam soil and the source of irrigation is canals of the Lower Bhavani Project. The adoption index worked out on the basis of eight recommended scientific cultivation practices was 0.76. The reported average yield was 30 t/ha for improved varieties and 25 t/ha for local cultivars. The highest yield reported was 40 t/ha. The dry recovery of improved varieties was reported to be 20-22% compared to 16-18% for the local cultivars. The reasons for the adoption of the IISR Suvarna in the region as reported by the sample farmers are the short duration of the crop compared to local varieties, suitability for early planting in places with river water irrigation, early arrivals in market, high curcumin content, relative disease tolerance compared to local cultivars and stable yield.

The cost of cultivation worked out on per hectare basis are as follows: Input cost is Rs 156,500 (63% as seed cost); and labour cost is Rs 125,000 (36% for harvesting and processing). Whole sale price analysis revealed that the average whole sale price during 2005-09 was Rs 35 per kg. However the average price during last two years was as high as Rs 150 per kg. The estimated B:C ratio taking in to consideration an average whole sale price of Rs 35 was 3.73.

Yield stability of IISR Prathibha

IISR Prathibha turmeric variety released in the year 1996 has been spreading to different states in the country. Success stories have come from Guntur (Andhra Pradesh) and Gundlupet (Karnataka) this year. Mr.Chandrasekhar, Guntur District, who has been growing the variety since 2004, recorded the yield of 16 t/acre and the variety is found to be free from rhizome rot incidence as compared to Salem and Tekurpet. The genotype is also found to be tolerant to water logging in the area. Mr. Abdul Nabeel, Kozhikode is another farmer who cultivates Prathibha. He obtained an yield of 40 t/ha from his farm at Gundlupet (Karnataka). At this location too, the variety is found tolerant to rhizome rot incidence as compared to the local variety. The average release yield of Prathibha at research farm was 39.5 t/ha. The nearly similar yield levels obtained at farmer's plot from two states under different package of practices attest the yield stability of the genotype over varying environments.

Mass contact / Outreach extension

The institute participated in following exhibitions and kisan melas:

- HORTI EXPO 2010 (Swadesh Praem Jagrih Sangosh 2010) sponsored by National Conference on Biodiversity for Livelihood Economic Development and Healthcare, at Bangalore from 28th to 30th May, 2010.
- International Coconut Bio Diversity Fair 2010 at CPCRI, Kasaragod from 25th to 28th October, 2010.
- Kissan Mela at IISR, Calicut from 27th to 29th January, 2011.
- Calicut Flower Show held from 10th 15th February 2011 at Calicut.

Video Conferencing/Video films

Under the Satellite Technology based Village Resource Centre (VRC) Scheme sponsored by the Kerala State Planning Board, three conferencing lessons were broadcast to the four Village Resource Centers in Wayanad district of Kerala in which 129 farmers participated.

Multi-enterprise farming models to the address agrarian crisis of Wayanad District of Kerala

The NAIP project was initiated on a consortium mode and IISR has the major objective of production and supply of nuclear planting materials of black pepper and ginger. The consortium leader of the project is RARS (KAU), Ambalavayal and the consortium partners include IISR, Calicut; Regional Coffee Research Station, (Coffee Board), Chundale, Wayanad District; Vegetable and Fruit Promotion Council Kerala (VFPCK), Kakkanad, Ernakulam District, Kerala and Wayanad Social Service Society, Mananthavady, Wayanad District, Kerala.

For three clusters of Wayanad, 828 beneficiaries have been identified of which 187 have been identified for Vythiri cluster. Around 15,000 cuttings of our varieties of black pepper have been supplied to RARS, Ambalavayal for further multiplication and distribution to the farmers of Wayanad. Fertilizer inputs including rock phosphate, neem cake, zinc sulphate and magnesium sulphate were also distributed though RARS, Ambalavayal. Eight booklets have been brought out in Malayalam for distribution to the farmers *viz*., production of organic black pepper/ organic ginger; postharvest handling of black pepper/ ginger; value-added products from black pepper/ ginger; calendar of operations for black pepper/ ginger. A training program on 'Modern agricultural practices and techniques on black pepper' was organized at MS Swaminathan Research Foundation, Kalpetta. The topics covered were foot rot and slow decline, IPM and IDM, black pepper production technologies, white pepper production technologies, nursery management, good agricultural practices and hygienic post-harvest management.

Mobilising mass media support for sharing agro-information

i) Media visits were organized to farmers plots in Gundlupet (turmeric), Appangala (black pepper) and Kayamkulam (coconut)

ii) More than 30 Success Stories and 75 news items have been given through print media (on coverage of media meet, Kissan mela, success stories, media visits, technologies released etc.)

iii) Four Radio news based programmes and 6 TV news clippings and four episodes of programmes on medicinal values of ginger, turmeric, black pepper and cardamom for regional TV channel were provided

iv) Produced and broadcasted 15 audio capsules through AIR, Calicut.

v) Three video films on Augmenting Black Pepper Production – A Success Story (Malayalam, English, Hindi), Success Story of a 'Prathibha' grower – Post production stage and Success of broiler goat technology - Post production stage were produced.

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 13 spice crops namely, black pepper, cardamom, cassia, cinnamon, clove, coriander, cumin, fennel, fenugreek, ginger, large cardamom, nutmeg and turmeric, with its 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 (SAU/CAUs)/Research Institutes. The XI Plan budget of AICRPS is Rs. 1400.00 lakhs with Rs 250.00 lakhs (ICAR share) during 2010-11.

Black pepper

The germplasm of black pepper was collected and conserved in all the black pepper centres. An alternate repository of black pepper germplasm is being established at RARS, Ambalavayal. Among the various accessions of black pepper germplasm evaluated at Panniyur, Chalakudy, ICP- 48 and P-5 were found to be promising during 2010. The intervarietal hybrid P6 × P 5 developed at Panniyur is promising with a green berry yield of 5 kg/vine. Dapoli centre has standardized a technology for rooting of orthotropic shoots in black pepper by treating the two node orthotropic cuttings without leaves in *Pseudomonas fluorescence* (10^8 cfu) powder formulation or by dipping in common sugar (2%) solution for one minute. Application of potassium phosphonate @ 0.3% as spray and soil application of *Trichoderma harzianum* @ 50 g/vine with one kg of neem cake to the root zone and application of Bordeaux mixture 1% as spray and copper oxychloride @ 0.1% as drench is recommended for effective and economical management of foot rot disease of black pepper in the Konkan region. In black pepper growing tracts of Malnad region, three major species of Erythrina *viz*., *Erythrina indica*, *E. fusca* and *E. subumbrans* are being used as black pepper standards. The incidence of gall wasp, a serious pest attacking black pepper standards was recorded in two species, namely, *E. indica* and *E. fusca* and no incidence was reported on *Erythrina subumbrans*.

Cardamom

The open pollinated progenies $21C_8$ recorded highest dry capsule yield (195 kg/ha) followed by $23C_8$ (190.2 kg/ha) and $22C_8$ (189.6 kg/ha) at Mudigere. In CVT at Pampadumpara, PS-27 recorded highest yield (386 g/plant). At Mudigere, CL-722 (292.0 kg/ha) and PS-27 (262.00 kg/ha) were found promising for dry capsule yield. Spraying six rounds of quinalphos (0.05%) was most effective for the management of cardamom shoot and capsule borer and cardamom thrips at Pampadumpara.

Large cardamom

Survey was conducted at Sukhia Pokhri and Rang Bhang of Darjeeling, Dentam and Hee-Gaon of West Sikkim, Ravangla and Namchi of South Sikkim, Dzongu area of North Sikkim and Assam lingzey, Pakyong of East Sikkim and nine germplasm *viz*., SCC 218 (Hario Ramsey), SCC 219 (Rato Varlangey), SCC 220 (Ramsey), SCC 221 (Varlangey), SCC 222 (Asarey), SCC 223 (Ramsey), SCC 224 (Chivesey), SCC 225 (Allied Genera), SCC 226 (Hario Varlangey) were collected and planted at Kabi farm. Characterization of the collected germplasm was made as per the descriptor. IC numbers for 48 accessions of large cardamom were received from NBPGR, New Delhi.

Ginger

Accessions NDG-55 (Kumarganj), GCP-32, GCP-14, GCP-33, GCP-54, GCP-01 (Pundibari) SG-26/04, SG-40/04, SG-8/04, SG-1029, SG-823 (Solan) and RG-43, RG-18 (Dholi) were identified as high yielders. Study on the performance of ginger varieties in various agro climatic zones of the country revealed that the average yield of rhizome per plot was highest (5.68 kg) in Suprabha followed by Varada (4.61 kg) and Gorubathan (4.31 kg) at Kalyani. At Phasighat, (Arunachal Pradesh) varieties Surabhi and Nadia were found to be suitable where as at Solan, variety Himigiri recorded maximum yield. Suprabha and Mahima were found suitable for Ranchi. At Dholi, under organic management, fully organic treatment gave maximum yield as compared to integrated management and fully inorganic. Application of organic nutrients produced highest clump weight of 387.51 g and highest yield of 6.26 kg per plot at Pundibari. At Kumarganj, application

of 50% recommended dose of fertilizer (60:40:40 kg NPK kg/ha) + 50% FYM (10 t/ha) + *Azosporillum* (5 kg/ha) + seed treatment and soil application of *Pseudomonas flourscence* + *Trichoderma* (50 g/3 m^2) gave maximum fresh rhizome yield of 62.37 q/ha. At Chintapalle, high yield with less incidence of soft rot was reported when rhizomes were treated with rhizobacterial antagonist followed by rhizome treatment with Metalaxyl-Mancozeb 72 % WP (1.25 g/l).

Turmeric

Among the 29 early maturing genotypes evaluated at Kumarganj, NDH-79 (362.10 q/ha of fresh rhizome yield) and NDH-74 (352.47 q/ha) were found to be promising. Out of the 74 medium maturing types, NDH-98 (421.60 q/ha) and NDH-18 (Narendra Haldi –1) (335.20 q/ha) were found to be superior for yield. Among the 36 late maturing genotypes, NDH-8 gave maximum fresh yield of 375.0 q/ha followed by 357.15 q/ha in NDH-7. At Kalyani, varieties Duggirala and Suranjana performed well whereas, Narendra Haldi-1 performed well at Pundibari. At Calicut, maximum fresh yield was recorded in Rajendra Sonia followed by Narendra Haldi. Variety Suranjana was found to be the best at Raigarh. Application of 100% reccommended dose of fertilizer (NPK @ 150:60:108 kg/ha) through drip, once in a week recorded highest rhizome yield at Kammarpally and Coimbatore. Soil application of micro nutrients on turmeric produced highest yield of 9.24 kg per plot whereas, foliar spray of micro nutrients produced a yield of 8.98 kg per plot at Pundibari. At Coimbatore, foliar spray of Propiconazole (0.1%) on 45 and 90 days, was the best treatment in reducing the leaf spot intensity to 19.33 PDI and leaf blotch intensity to 13.34 as compared to untreated control and also recorded the highest yield of 38.92 t/ha with C:B ratio of 1:4.60. At Kumarganj, rhizome treated with Hexaconazole (0.1%) + foliar spray with Hexaconazole (0.1%) on 45 and 90 DAS was effective against the control of the leaf blotch disease (17.84% PDI). Minimum incidence of leaf spot was observed in rhizome treatment with propaconazole (0.1%) and foliar spray of propaconazole (0.1%) at 45 and 90 DAS.

Tree spices

The germplasm of tree spices including nutmeg, cinnamon, cassia and clove were collected, maintained, characterized and catalogued at Dapoli and Yercaud/ Pechiparai. In nutmeg, accession Sel. 4 recorded highest yield of 1005 fruits per tree and an oleoresin content of 8.67%, at Pechiparai. Among the cinnamon accessions, Sel. 65 performed well and attained a plant height of 3.90 m, stem girth of 29.35 cm, leaf yield of 7.83 kg/tree with a dry bark yield of 620 g/tree. In clove, Sel. 13 was found to be promising with a dry yield of 3.70 kg/tree.

Cumin

Mean performance of the entries evaluated in CVT for two years at Jobner revealed superior performance of CUM-13 (677.61 kg/ha) followed by CUM-12 (595.14 kg/ha). UC-339 (726.74 kg/ha) and UC-336 (671.88 kg/ha) were found to be promising in an IET at Jobner. The genotypes UC-331, UC-274 and UC-225 were identified as high yielders under irrigated conditions, while, UC-239, UC-274 and UC-225 were the best genotypes under limited moisture conditions, at Jobner. Application of *Trichoderma harzianium* @ 20 kg/ha + FYM @ 6 t/ha (BCR 1: 2.42) or *Trichoderma harzianium* @ 20 kg/ha + FYM @ 3 t/ha (BCR 1: 2.16) at the time of sowing is recommended for the effective and economic management of cumin wilt at Jagudan.

Coriander

Among the 275 accessions evaluated at Coimbatore, CS-251 was found to be promising for yield. At Dholi, RD-420 and RD-395 were identified as high yielders. COR-32 was found to be promising at Jabalpur and Udaipur. The other best performers at various centres were COR-25 at Kumarganj, COR-31 at Raigarh, COR-30 at Guntur, COR-27 at Jobner and COR-29 at Ajmer. At Guntur, application of 100% N+ *Azospirillum* + 5 t/ha FYM recorded maximum yield (954 kg/ha). Application of copper as copper sulphate (soil application) 25 kg/ha gave an yield of 900 kg/ha followed by foliar spray of zinc sulphate 0.5 % (2 sprays, 45 and 60 days of sowing) (894.33 kg/ha) at Coimbatore. Three methods of irrigation and four schedules of irrigation were evaluated in coriander at Guntur. Though there are no significant differences among the methods of irrigation, providing irrigation at 30 and 60 DAS recorded highest yields (995 kg/ha) followed by irrigation at 30 and 45 DAS (883 kg/ha). Application of rhizobacteria FK 14 + FL 18 (seed treatment- 600 g/ha+soil application–2 kg/ha) and application of rhizobacteria FL 18 (seed treatment + soil application) was found to increase yield. Technology for production of leafy coriander under 50% shade during offseason was developed at Coimbatore.

Fennel

At Dholi, the germplasm accessions RF-14 and RF-20 were reported as high yielders and FNL-43 and FNL-41 were found to be promising. Two entries *viz*., UF-157 (2166.82 kg/ha) and UF-278 (2137.63 kg/ha) were found to be high yielders at Jobner. FNL-43 (1904.22 kg/ha) and FNL-46 (1901.33 kg/ha) were also found to be promising based on the yield performance.

Fenugreek

Out of 105 fenugreek germplasm screened at Kumarganj, NDM-37 gave maximum seed yield of 23.70 q/ha followed by NDM-25 and NDM-48 (22.50 q/ha). At Guntur, LFC-122 recorded highest yield (1270 kg/ha) followed by LFC-78 (1145 kg/ha). FGK-31, FGK- 30, FGK-33 and FGK-37 performed well at Kumarganj, Coimbatore and Guntur, Udaipur and Jobner, respectively. Large scale demonstration of the role of rhizobacteria in growth promotion was taken up in farmers fields. Seed treatment and soil application with FK-14 and seed treatment and soil application with FL-18 were found to increase leaf yields (1.54 and 1.51 t/ha, respectively) at Guntur. RMt-1, UM-29, UM-13 were found to perform well with high yield in irrigated conditions whereas, in drought conditions, UM-36, UM-26, UM-10 were the high yielders.

BIOINFORMATICS CENTRE

Secretome analysis

Secretome analyses of *Phytophthora capsici* and *Radopholus similis* were carried out. On exploring the ESTs of *R. similis*, 214 secretory proteins were identified and their functional annotation was carried out. About 45% of these secretory proteins showed similarity to nematodes. The mode of interaction of Glucanase Inhibitor Protein (GIP) from *P. capsici* with plant endo- β -1, 3-glucanases was studied through structural and docking studies.

PhytoPD, a new database

PhytoPD, a repository of Polymerase Chain Reaction primer sets, useful for the identification and detection of *Phytophthora* species, was developed and uploaded. It includes all the universal primers and species-specific primers for more than 30 species of *Phytophthora* published in literature

Databases redesigned

Spice Genes, the spice germplasm database, was thoroughly modified with advanced graphical tools and data on turmeric and ginger germplasm were added (Fig. 9.1). PLASBID database was updated and the data redundancy in the existing database was minimized. The PASSCOM database was updated with additional information on turmeric, ginger and cardamom compounds and pathways.

Fig. 9.1. Home page of Spice Genes, the redesigned database on spice germplasm

Hortinformatics 2010

A National Consultative Meet on Bioinformatics in Horticulture (Hortinformatics 2010) was organized from 11-12 October 2010 (Fig. 9.2). About 90 delegates from more than 30 research institutes and universities participated in the event. Sixteen invited talks and 23 posters were presented by eminent scientists in four technical sessions spread over two days.

Fig. 9.2. Dr. H.P. Singh, DDG (Horticulture) inaugurating Hortinformatics 2010

Training programmes

A short-term training on 'Application of Genomics and Bioinformatics in *Phytophthora*/*Ralstonia* Research' has been organized exclusively for the project staff of PhytoFuRa at Indian Institute of Spices Research, Calicut from 08-17 February 2011 (Fig 9.3). Eighteen participants from different centers have undergone this training.

Fig. 9.3. Participants of the PhytoFuRa training programme

ARIS CELL

As per mandate, ARIS cell, undertakes the routine maintenece of Local Area Network of the Institute and audio visual support to the various institute activities. During the period new mailing software has been installed with unlimited user space. VAST connectivity has been established in the IISR Experimental Farm, Peruvannamuzhi and Cardamom Research Centre, Appangala for getting better internet connectivity. VPN connectivity was also established for linking the CRC, Appangala, Experimental Farm, Peruvannamuzhi, KVK, Peruvannamuzhi with the headquarters. The IISR website was modified using the open source software Joomla and was re-launched in August 2010. The farmers' corner in the website was enriched with details of planting material availability, information about released varieties, package of practices in various languages and other pamphlets. New menus like Media Corner, Education, Video Library, Publications etc. were incorporated apart from the already existing features. The IISR library portal 'spiceE-Library has been modified with additional features (Fig 10.1). The institutional repository 'DSpice' was registered with DSPACE and is now available online. The office automation software (ARISoft) was upgraded as a web-based model from the existing partially client.

Fig. 10.1. Newly launched IISR website

LIBRARY

The library resources at IISR were further improved by procuring additional books, databases and journals. To facilitate this, a book exhibition was organized during 9-10 March 2011. The library continued to be a part of CeRA, the e-journal consortium of ICAR, and catered to the requests from different CeRA members. It subscribed the agricultural database CAB abstracts online. A new website was developed for the library (SpicE-library) with links to the new databases and digital resources (Fig. 11.1). The scope of digital institutional repository, DSpice, was widened with institute publications like annual reports, research highlights, Spices news etc. The open source software 'Greenstone' was installed in connection with digitization of books and five important books were scanned and hosted. 'Journal finder' a tool for journal paper submission, hosted in the library website was popularized. Mendeley, an open source tool to manage scientific literature & documents was introduced and in order to familiarize the software a demonstration was arranged. Twelve issues of the Agrititbits, the agricultural news service, were brought out. Forty new members registered through the biometric access control system. Library procured 140 books and added 35 books, 38 technical reports, five theses and 12 project reports on *gratis* basis during the period.

Fig. 11.1. Spice E - Library portal

AGRICULTURAL TECHNOLOGY INFORMATION CENTRE

The Agricultural Technology Information Centre (ATIC) of the institute is involved in technology dissemination functions through a single window system.

Technology Inputs

The technology inputs distributed from ATIC include planting material of improved varieties of spices, biocontrol agents, vermicompost, spice products and extension literature. During this year, planting materials worth ₹ 163,777/- was distributed which was an increase of 63% over the previous year. The proceeds from sale of publications amounted to ₹ 64,270/- indicating a fourfold increase compared to previous year. The sale of bio agents showed a marginal decrease over the previous year and only ₹ 11,012/- worth of biocontrol agents were sold during the year. The total income generated during the year in ATIC was ₹ 246,725/-.

Farmers visit and advisory services

The ATIC was visited by 1274 farmers from Calicut district, 474 farmers from outside Calicut district, but within the state and 1021 farmers from outside state for advisory services (Fig 12.1). One thousand one hundred and seventy five students from educational institutions spread across the country visited the centre on study tour. The total visit recorded to the centre was 2934. The total visit to ATIC by various stakeholders including dignitaries was 4108, which indicated a fourfold increase over the previous year and highest compared to all the years since the inception of ATIC. The pattern of information seeking behavior of farmers showed the following trend: Direct visits – 4108; Phone calls – 589; Letters – 280; E mail – 144.

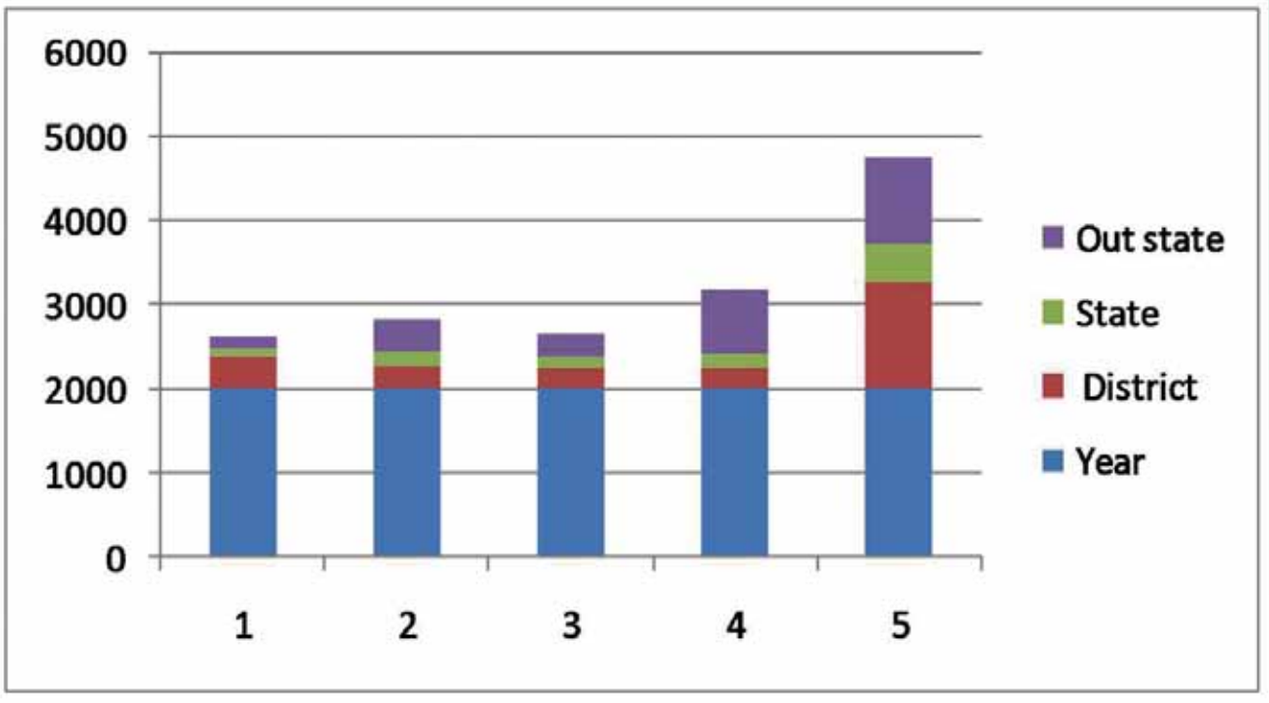


Fig. 12.1. Visit pattern by farmers to ATIC (last five years)

KRISHI VIGYAN KENDRA

Training programmes

KVK has conducted 166 training programmes for farmers, farm women, rural youth and extension functionaries in the disciplines of agronomy, horticulture, animal sciences, home science, fisheries, plant protection and allied fields. A total of 4026 trainees were benefited by the programmes.

FLD Programmes

This is a new concept of field demonstration and the main objective is to demonstrate newly released crop production and protection technologies and its management practices in farmers' fields under different agro-climatic regions and farming situations. Nine FLD programmes were undertaken during the period as detailed below.

1. Demonstration of HYVs of black pepper with high intrinsic qualities
2. Demonstration of bush pepper production technology using Karimunda variety
3. Demonstration of seed production of HYVs of turmeric
4. Integrated disease management of Phytophthora foot rot of black pepper
5. Post AI administration of sterile ceftriaxone sodium on conception rate in milch cows
6. Use of leaves of *Annona squamosa* for wound healing in cattle
7. Popularization of Tiger Shark (*Pangasius sutchi*) for freshwater aquaculture
8. Induced breeding of fresh water fishes
9. Demonstration of value added product from pepper- bottled green pepper

OFT Programmes

These programmes aim at testing the new technologies developed at research stations in the field of crop husbandry, horticulture, animal husbandry, fisheries etc. to ensure their suitability and sustainability to the specific locations and to suggest or modify or refine the technology accordingly. This is done by testing a released technology in real farm situation with the participation of farmer. The major OFT programmes carried out during the period are listed below (Fig 13.1 – 13.3).

1. Induction of flowering in Olour mango through paclobutrazol application combined with INM and IPM
2. Assessment of bacterial fermentation technique for white pepper production
3. Performance evaluation of mixed cropping of nutmeg variety Viswasree grafts in coconut garden
4. GnRH treatment and double AI for management of repeat breeding cows.
5. Bio seed assay for pregnancy testing in dairy cattle
6. Use of live feed in rearing of ornamental fishes
7. Culture of fresh water fishes using low cost feed
8. Testing of value added product of nutmeg

Fig. 13.1. Broiler goat rearing

Fig. 13.2. Bush pepper production

Fig. 13.3. Training on fabric painting

Revolving Fund Programme

The Kendra has a strong revolving fund programme to generate income for productive uses. Under this programme, quality planting materials of various crops are produced and made available to public at affordable rates. Income also was generated by way of sale of layer chicks, goats, heifers and bulls and consultation and doorstep services through the clinic. During the period, an amount of ₹ 9.56 lakh has been realised through sale of planting materials, ornamental fishes, bioproducts, bioagents and the activities of Plant and Animal Health Centre.

Plant and animal health centre

The Kendra operates a plant and animal clinic offering various services to the farmers. An artificial insemination facility is also available at the centre to upgrade the genetic stock of livestock. The centre offers consultation, treatment and doorstep services with a nominal fee. In addition to the various treatments, the centre also provides vaccination facility and organizes animal health camps in association with the state animal husbandry department. The various activities taken up by the Clinic during the period are furnished below:

Consultancy/advisory/home services	671
Artificial inseminations	285
No. of Animal health campaigns/infertility camps	4
Vaccination of poultry birds and animals	23630
Block *Ksheeroltsavam*	2
District *Ksheeroltsavam*	1

Soil testing campaigns and issue of Soil Health Cards

Soil testing campaigns were conducted in all the eleven wards of Chakkittapara panchayat and soil health cards were issued to forty two farmers. A total of 14 soil health campaigns were conducted so far and altogether 167 soil samples were analysed.

Farmers' Field School

A Farmers' Field School on Integrated Pest Management of vegetables was conducted at Thalakkalathur involving 15 farmers. Training programmes, method demonstrations, field visits, farmers' group meetings and field day were organised as part of the programme.

Other extension activities

KVK conducted three seminars, participated in eight Kissan Mela cum exhibitions, broadcasted seven radio talks and conducted two study tours for farmers to various research institutions during the period. An extension literature on "Broiler goat rearing" was published.

Participatory seed production in ginger and turmeric

In order to enhance the production of quality planting materials, a farmer participatory seed production programme was taken up in ginger and turmeric with the assistance of National Horticultural Research and Development Foundation, Nasik. Under the

programme, KVK has identified 15 potential turmeric farmers and 5 ginger farmers in Calicut. A total of 636 kg turmeric rhizomes of IISR Prabha, IISR Prathibha and IISR Alleppey Supreme and 125 kg of ginger variety IISR Varada were given to farmers. Yields of ginger and turmeric were 1.5 tonnes and 5.6 tonnes respectively. 150 kg of ginger seed rhizomes were procured through KVK and sold to 42 farmers and 440 kg turmeric seed rhizomes were sold to 69 farmers.

Publication of e- book on Inventory of Agriculture of Calicut District

This is a KVK venture to provide all the agriculture based information from a single source for the benefit of farmers and all other stake holders in agriculture and allied fields. The inventory of agriculture is a comprehensive data base of Calicut district and provides the basic information on the present state of agriculture in the district, details of various research and development organizations relevant to farming community and different schemes that are in operation in the district.

KVK website

A website for KVK was launched in Malayalam for the benefit of farming community of Calicut. The site contains information about all the mandatory activities of KVK, success stories, planting material availability and links to market information in addition to online registration for training programmes.

Fig 13.4. Black pepper field day at Coorg

Extension activities at Cardamom Research Centre, Appangala (Fig 13.4 & 13.5)

Activity	Date	No. of participants
Seminars		
Farmer's-Scientist's interaction in Krishi Utsav programme organized by Department of Agriculture, Sakleshpur	14 Oct 2010	350
Farmer's-scientist's interaction organized by Hassan Planter's Association, Sakleshpur	2 Nov 2010	350
Krishi Mela at College of Forestry, Ponnampet	04 Dec 2010	75
Farmer seminar, Rotary Club, Sakleshpur	07 Dec 2010	100
Regional seminar on black pepper and cardamom organized by Spices Board, Madikeri	11 Mar 2011	140
Field days		
Black pepper field day organized by Department of Horticulture, Somwarpet at Cardamom Research Centre, IISR, Appangala.	08 Feb 2011	50
Small Cardamom field day at Suvarnagedde estate, Engilkere, Sidapur	23 Feb 2011	25
Study tours		
Study tour of black pepper farmers from Idukki district to CRC, Appangala	03 Feb 2011	35
Exposure visit on Spices and Precision Farming organized by ATMA, Kannur, Kerala to CRC, Appangala	17 Mar 2011	44

Fig. 13.5. Study tour of farmers at CRC, Appangala

Fig. 13.6. View of exhibition organized during Kissan Mela

Karshika Sankethika Darshanam

Karshika Sankethika Darshanam 2011, Kissan Mela & Technology Expo was organized from January 27-29, 2011 at IISR, Chelavoor Campus. Mr. K K Raghavan, Joint Rubber Production Commissioner, Rubber Board, Calicut, inaugurated the mela. Dr. V A Parthasarathy, Director of IISR chaired the inaugural session. Dr. I John Kutty, Associate Director of Research, Kerala Agricultural University, Pattambi, Corporation Councilor Mr. M P Hameed and Dr. C V Sairam, Principal Scientist, Agri Economics, Zonal Director Unit, KVK Bangalore offered felicitations. Fifteen exhibition stalls of different organizations displayed their technologies/ products (Fig. 13.6). Over 200 farmers and 500 students attended the three days programme. A quiz programme on Agriculture for school students was also organized. Dr. T Pradeep Kumar of Kerala Agricultural University, Dr. Manju Sasidharan of Kerala Veterinary University, Pookode and Mr. R Suresh, Project Officer, Horticorp delivered specific talks to farmers.

RECOGNITIONS

SARDAR PATEL OUTSTANDING ICAR INSTITUTION AWARD 2009

For the second time IISR has been adjudged as the best ICAR institution award instituted by the Council in the name of Sardar Vallbhbhai Patel. The Institute has bagged this coveted award earlier also in the year 1999. The award includes a cash prize of ₹ 5.0 lakhs and a citation presented by Sri. Sharad Pawar, Union Minister of Agriculture during the ICAR Foundation Day Celebration held on 16th July 2010 (Fig 14.1).

TOLIC AWARD 2010

Institute received TOLIC Official language Implementation Award 2010 from Town Official Language Implementation Committee (TOLIC), Calicut for the implement of the official language activities in the institute like, implementing OL rules, hindi correspondence, conduct of hindi workshops, hindi week and publications such as Masala Samachar (biannually), Anusandhan ke mukhya ansh, extension bulletin i.e. Kalimirch, Haldi, Adrak, dalchini and popular articles in hindi (Fig 14.2).

Fig. 14.1. Director, IISR receiving the best ICAR institute award from the Union Minister of Agriculture

Fig. 14.2. TOLIC Official language Implementation Award 2010

EDUCATION AND TRAINING

Post Graduate studies

Ph.D

Jaleel K, Molecular and biochemical characterization of ginger germplasm, Acharya Nagarjuna University.

Dhanya K, Detection of probable plant based adulterants in selected powdered market samples of spices using molecular techniques, Mangalore University.

Aravind R, Studies on endophytic colonization of bacteria in black peppr (*Piper nigrum* L) roots against *Phytophthora capsici* and *Radopholus similis,* Mangalore University.

Retheesh, ST, Development of transgenic vanilla (*Vanilla planifolia* Andrews) resistant to *Cucumber mosaic virus,* Mangalore University.

Ashis GR, Biochemical, molecular and Spatial (GIS) variability in Garcinia with special reference to *G. gummigutta* (L) Robsn and *G. indica* Choisy, Mangalore University.

M.Phil

Simi Mohan, Micropropagation and molecular characterization of three species of garcinia, Bharathidasan University, Tamil Nadu.

MSc/ Post MSc training

Thirteen M.Sc. students carried out their M.Sc. project work in biotechnology, biochemistry, microbiology and bioinformatics.

Summer training for MSc students

One month summer training on biochemistry, biotechnology and bioinformatics was conducted for 19 M.Sc. students during 5th May - 4th June 2010.

Awards

Best poster award for the research paper "A new species of entomopathogenic nematodes, *Steinernema* sp. n. (Rhabditida: Steinernematidae) from ginger (*Gingber officinae* Rosc.)" authored by Rashid Pervez, Eapen SJ, S Devasahayum and TK Jacob, 13th Indian Agricultural Scientists and Farmers Congress, University of Allahabad, Allahabad.

MJ Narasimhan Academic Merit Award for the research paper 'Development of *Agrobacterium* mediated transformation protocol and transgenic lines of black pepper for resistance against viruses' authored by Jiby MV and Ishwara Bhat A, Indian Phytopathological Society Annual Meeting, Gujarat Agricultural University, Anand.

Best poster award for the research paper 'PASSCOM – A database of secondary metabolites of spices' authored by Riju A, Sithara K, Balaji S, Suja SN, Sathyanath V, Dhanya KP, Anil Paul, Shamina A and Eapen SJ, National Consultative Meet on Bioinformatics in Horticulture (Hortinformatics – 2010), IISR, Calicut.

Second best poster award for the research paper 'Western Ghats region is hot spot for Piper species diversity' authored by Utpala Parthasarathy, Jayarajan K, Saji KV and Parthasarathy VA, National Conference on Horticultural Biodiversity, Bengaluru.

Best participant award for Dr. Rashid Parvez in ICAR sponsored Summer School on Advances in Entomopathogenic Nematodes for Eco-Safe and Economic Pest Management held at Rajasthan College of Agriculture, MPUA&T, Udaipur.

Trainings attended by the staff

Officials attended	Training Programme	Date	Organization
R Suseela Bhai and E Jayashree	General management programme for middle and senior level women scientists	22nd Nov - 3rd Dec 2010	Administrative Staff College of India, Hyderabad.
Utpala Parthasarathy	Science administration and research management	6th Sep - 17th Sep 2010	Administrative Staff College of India, Hyderabad.
R Suseela Bhai	Molecular diagnostics for pathogens infecting crop plants	16th Feb - 3rd Mar 2011	CTCRI, Trivandrum
TK Jacob and VK Abubacker Koya	Employer's perspective on labour-related laws	11-13 Nov 2011	NAARM, Hyderabad
Rashid Pervez	Advances in entomopathogenic nematodes for eco-safe and economic pest management	14th Sep - 4th Oct 2010	Rajasthan College of Agriculture, MPUA&T, Udaipur
K Jayarajan	SAS software packages	13–18 Dec 2010	UAS, GKVK, Bengaluru
R Ramakrishnan Nair	SAS software packages	3-9 Mar 2011	CTCRI, Trivandrum
R Praveena	Viral genomics and transgenic development	8-28 Sep 2010	IARI, New Delhi
Santhosh J Eapen	Unlocking the power of knowledge management in the smart enterprise	16-18 Aug 2010	IIM, Kozhikode
SJ Ankegowda	Research station management	17-22 Jan 2011	ICRISAT, Hyderabad

International Deputations

Officials attended	Training Programme	Date	Organization
V Srinivasan	NAIP training on Carbon Sequestration and Climate Change	15th July - 14th Oct 2010	Prof. Rattan Lal, Carbon Management and Sequestration Centre (CMASC), Ohio State University, Columbus, Ohio, USA.
A Shamina	NAIP training on Nutraceuticals in Horticulture	21st Aug - 18th Nov 2010	Profs. John W. Finley and Jack Losso, Food Science Department, Louisiana State University, Baton Rouge, USA.
KS Krishnamurthy	NAIP training on Application of biosensors in Horticulture	15th July - 14th Oct 2010	Dr Marshall Porterfield, Dept of Agricultural and Biological Engineering, Purdue University, West Lafayette, Indiana, USA.
TE Sheeja	NAIP training on Plant variety protection	14 - 25 July 2010	Naktuinbouw, Wageningen, Netherlands

INSTITUTE TECHNOLOGY MANAGEMENT COMMITTEE

The Institute Technology Management Committee (ITMC) was first constituted in 2007 and was reconstituted in March 2011. ITMC is an institutional mechanism to protect/manage intellectual property (IP) generation within the institute, to implement the incentive system and guidelines for IP management and technology transfer/commercialization to encourage greater creativity and rapid innovativeness in the system. ITMC is involved in the initiatives for technology displays and generate income/resources through commercialization. As a first step, registration of IISR trademarks [under Class-3, 4, 30, 31, 41, 42] has been done (Fig 17.1).

Institute has applied for registration of 14 released varieties of spices under PPV&FRA. Through ITMC, modality for use of photographs from the IISR repository through agreement has been standardized. Also initiated the commercialization of plant varieties of IISR through non-exclusive licensing and licensing of the varieties *viz*., IISR Prabha, IISR Prathibha, IISR Alleppey Supreme in turmeric and IISR Varada has been initiated (Fig 17.2).

Technologies from IISR was displayed at the Horticulture-Industry meet conducted at IIHR and published a folder on technologies available at IISR for commercialization.


GOVERNMENT OF INDIA
TRADE MARKS REGISTRY
Trade Marks Act, 1999
Certificate of Registration of Trade Mark, Section 23 (2) Rule 62 (1)
CHENNAI

Fig. 17.1 The trademark registration certificate for IISR issued by the registrar of Trademarks, Chennai.

Consultancy

Through consultancy, 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 were taken up. 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 19 M.Sc. students was jointly organized by HRD Cell and Consultancy Processing Cell (CPC) during 5th May - 4th June 2010. The total revenue through consultancy was around Rs 3.03 lakh with a major share of 39% from analysis of samples for nutrients (NPK) and 12% each from biochemical and bio control agents (mainly *Trichoderma* and *Pseudomonas*). Other consultancy services like summer training to M.Sc. students (33%), visits of scientists to private farms based on requests (4%) etc., also contributed to the CPC revenue.

Fig. 17.2 Director presenting the first license agreement for variety IISR Prathibha to Mr. Vishnu Dasharathe, Aurangabad, Maharashtra.

HINDI CELL 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 are prepared and sent to ICAR, New Delhi, TOLIC, Calicut and Regional Implementation Office, Cochin. Three workshops, How to popularize official language (18th June 2010), Noting and drafting (18th October 2010) and Rules of official language and its implementation (10th February 2011) were organized at IISR, Calicut. Daily a word/phrase in hindi and its transliteration in Malayalam and English was displayed.

Hindi day was celebrated on 14th September 2010 and Hindi week on 1-8th November 2010. During this week various competitions *viz*., Extempore speech, song, debate, noting and drafting, calligraphy, memory test, anthakshari were conducted for the staff members and prizes were distributed to the winners in the valedictory function on 8th November 2010. Mrs. Celein Verghis, Manager (OL), SBT and Secretary, TOLIC, Calicut was the chief guest (Fig 18.1).

Dr. Rashid Pervez, Hindi officer and Ms. N. Prasannakumari, Hindi translator attended subcommittee meeting of TOLIC at SBT, Calicut on 6th August 2010. Mr. B. Krishnamoorthy and Ms. N. Prasannakumari attended the 46th TOLIC meeting on 27th September 2010.

During present year, hindi versions of the half yearly publication of Spices News volume 21 (1 and 2) were published as Masala Samachar. Summary of annual report and project coordinator cell (spices) report was translated in hindi and incorporated in IISR and AICRP's annual report. Published Anusandhan ke Mukhya Ansh (2009-10) and bulletins on Dalchini, Vanilla and Joyfal in hindi.

Fig. 18.1. Hindi week celebration

INSTITUTE MANAGEMENT COMMITTEE

1. Dr. VA Parthasarathy, Director, IISR, Calicut.
2. Assistant Director General (Hort.II), ICAR, New Delhi.
3. Dr. M Ananadaraj, Project Co-ordinator (Spices), IISR, Calicut.
4. Dr. RP 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, Tamil Nadu.
9. Director of Research, Kerala Agricultural University, Thrissur.
10. Mr. MJ Ummen, Mangalath Parambil House, Arivilanjapoil P O, Alakkode (Via), Kannur.
11. Sri. G Rathikumar, Deepthi, Kizhakkekara, Kottarakkara, Kollam.
12. Senior Finance & Accounts Officer,CMFRI, Kochi.
13. Administrative Officer, IISR, Calicut.

RESEARCH ADVISORY COMMITTEE (2011-13)

S. No.	Name and address	Position
1	Dr. SB Dandin Vice Chancellor University of Horticultural Sciences, Sector # 60, Navanagar, Bagalkot - 587 102.	Chairman
2	Dr. KV Ramana Former ADG (PC) and PC (Spices) Door No. 86/2-21/2, SangitamVenket Reddy Street, Jawaharlal Nehru Road, Rajahmundry-533103. East Godavari, Andhra Pradesh.	Member
3	Deputy Director General (Hort.) / Asst. Director General (H-.II) ICAR, Krishi Anushandhan Bhavan–II, New Delhi–110012.	Member
4	Dr. BB Vashishtha Former Director (NRC Seed Spices) C-107, Viduth Nagar, Vaishali Nagar, Jaipur – 30202. Rajasthan.	Member
5	Dr. Anil Kumar MBGE & In-charge, Biotechnology, Dept. of Molecular Biology and Genetic Engineering, GB Pant University of Agriculture Technology, Pant Nagar, Uttrakhand.	Member
6	Dr. R Samiyappan Director (Centre for Plant Molecular Biology) Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.	Member
7	Dr. NK Mohan Former Head, HRS, Kahikuchi, Milon Nagar (VIP), Near St. Claret School P.O. Guwahati Airport -7810015. Assam.	Member
8	Dr. VA Parthasarathy, Director, Indian Institute of Spices Research, Calicut, Kerala - 673 012.	Member
9	Sri. MJ Ummen Mangalath Parambil House, Arivilanjapoil P O, Alakkode (Via), Kannur – 670571.	IMC Member
10	Sri. G Rathikumar Deepthi, Kizhakkekara, Kottarakkara, Kollam, Kerala.	IMC Member
11	Dr. B Chempakam Head, Crop Production, Indian Institute of Spices Research, Calicut, Kerala-673 012.	Member Secretary

RECOMMENDATIONS OF RAC

Sl No	Recommendations
1.	Approximate number of core collections to be made and the attributes to be used in characterization may be indicated in Black pepper. Procedure for identifying core collection in black pepper can be specified while finalizing. A small group of concerned scientists shall discuss and define the approaches for developing core collection.
2.	Effect of climate change may be studied in relation to yield reduction in spices
3.	Farmers varieties may be registered with PPV & FRA
4.	Bio-prospecting of genes/allels through functional genomics for specific characters for introgression/ gene pyramiding.
5.	Zinc and boron in combination may be tested on turmeric for quality.
6.	Work out economic optimum levels of response for black pepper targeted yield trial.
7.	Study the partitioning of yield components (harvest and bio mass index) in ginger.
8.	Identification of factors responsible for flowering to avoid alternate bearing
9.	Seed/ capsule coating studies for enhancing quality and shelf life may be included
10.	Use of micro-rhizome technology may be commercialized
11.	Robust diagnostic kits (genus specific/species specific) may be developed for *Phytophthora* sp.
12.	Virus indexing technology may be transferred to the field level.
13.	Studies on biochemical/morphological factors responsible for pollu beetle/ shoot borer resistance in black pepper/ginger/turmeric may be carried out.
14.	Promising EPN collections from NBAII, Bangalore may also be included for evaluation against shoot borer of ginger/turmeric.
15.	For field evaluation of botanical extracts, stabilizers/stickers may be added in the crude extracts.
16.	Less emphasis can be given for the studies on *Pseudomonas aeruginosa* and more focus can be given to *P. putida* and *P. fluorescens.*
17.	Cost benefit: ratio and calendar of operations of new IPM/IDM strategies should be given at the time of conclusion of the study.
18.	Data can be obtained from AICRP centres for the study of spread of varieties
19.	Mechanization has to be tried in spices
20.	Translation of video films (success stories in turmeric) in Tamil and Telugu may be done
21.	Study the 'bioavailability enhancer' property of piperine in Caco-2 cells
22.	Impact of technologies in terms of economic return may be studied
23.	Network with KAU, UAS, UHS for mapping diversity of native spice plants along with ITK.
24.	Marker assisted selection (MAS) studies may be given stress in XII plan
25.	On farm training may be given importance
26.	In tree spices, high density planting, canopy management studies may be given importance.
27.	In annual spices like ginger and turmeric, crop rotation studies may be explored.
28.	Planting of germplasam in Chethali may be speeded up.
29.	Filling up vacancy of Economics, creation of Head, Crop Improvement Division and Head, CRC, Appangala may be expedited.

RESEARCH PUBLICATIONS

1. Abirami K, Rema J, Mathew PA, Srinivasan V and Hamza S. 2010. Response of nutmeg seeds to different nursery media. *Indian J. Hort*. 67: 584-586.

2. Ankegowda SJ, Venugopal MN, Krishnamurthy KS and Anandaraj M. 2011. Impact of basin irrigation on black pepper production in coffee based cropping system in high altitude regions of Karnataka. *Indian J. Hort.* 68: 71-74.

3. Ankegowda SJ, Kandiannan K and Venugopal MN. 2010. Rainfall and temperature trends- A tool for crop planning. *J. Plantation Crops*. 38: 57-61.

4. Asish GR, Utpala Parthasarathy and Nithya NG. 2010. Standardization of DNA isolation and PCR parameters in *Garcinia* spp. for RAPD analysis. *Indian J. Biotechnol.* 9: 424-426.

5. Balaji S and Chempakam B. 2010. Toxicity prediction of compounds from turmeric (*Curcuma longa* L). *Food Chem. Toxicol.* 48: 2951-2959.

6. Bhai RS, Sithara Raj and Kumar A. 2010. Influence of soil pH and moisture on the biocontrol potential of *Trichoderma harzianum* on *Phytophthora capsici* – black pepper system. *J. Biol. Control*, 24:153 157.

7. Bhai RS, Eapen SJ, Anandaraj M and Saji KV. 2010. Identification of *Phytophthora* and nematode resistant source from open pollinated progenies of black pepper (*Piper nigrum* L.) using a modified protocol. *Indian J. Agric. Sci.* 80: 893-897.

8. Bhai RS and Thomas J. 2010. Compatibility of *Trichoderma harzianum* (Rifai.) with fungicides, insecticides and fertilizers. *Indian Phytopathol.* 63: 145-148.

9. Biju CN, Siljo A and Bhat AI. 2010. Survey and RT-PCR based detection of cardamom mosaic virus affecting small cardamom in India. *Indian J. Virol*. 21: 148–150.

10. Devasahayam S, Jacob TK, Abdulla Koya KM and Sasikumar B. 2010. Screening of ginger (*Zingiber officinale* Rosc.) germplasm for resistance to shoot borer (*Conogethes punctiferalis* Guen.) (Lepidoptera: Pyralidae) in Kerala, South India. *J. Medicinal Aromatic Crops*, 32: 137-138.

11. 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. *Curr. Trends Biotechnol. Pharm*. 4: 454-489.

12. Dhanya K, Syamkumar S, Sijusenan and Sasikumar B. 2011. SCAR markers for adulteration detection in ground chilli. *British Food J*. 113 (5): 656-668.

13. Dinesh R, Srinivasan V, Hamza S, Parthasarathy VA, Aipe KC. 2010. Physico-chemical, biochemical and microbial properties of the rhizospheric soils of tree species used as supports for black pepper cultivation in the humid tropics. *Geoderma*, 158: 252-258.

14. Elizabeth Thomas, Zachariah TJ, Syamkumar S and Sasikumar B. 2011. Curcuminoid profiling of Indian turmeric. *J. Medicinal Aromatic Pl. Sci.* 33: 36-40.

15. Jacob TK and Devasahayam S. 2010. Incidence of Erythrina gall wasp (*Quadrastichus erythrinae* Kim), an invasive insect pest on *Erythrina* spp., in major black pepper (*Piper nigrum* L.) growing areas of Kerala and Karnataka, India, *J. Plantation Crops,* 38: 161-164.

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

17. Kandiannan K, Utpala Parthasarathy, Krishnamurthy KS, Thankamani CK, Srinivasan V and Aipe KC. 2011. Modeling the association of weather and black pepper yield. *Indian J. Hort.* 68: 96-102.

18. Krishnamoorthy KS, Parthasarathy VA, Saji KV and Krishnamoorthy B. 2010. Ideotype concept in black pepper (*Piper nigrum* L.), *J. Spices Aromatic Crops*, 19: 01-13.

19. Nair RR, Shiva KN, Anchu S and Zachariah TJ. 2010. Characterization of open pollinated seedling progenies of turmeric (*Curcuma longa* L.) based on chromosome number, plant morphology, rhizome yield and rhizome quality. *Cytologia,* 75: 443-449.

20. Prasath D, Venugopal MN and Parthasarathy VA. 2010. Inheritance of Cardamom Mosaic Virus (CdMV) resistance in cardamom. *Sci. Hort.* 125: 539-541.

21. Parthasarathy VA, Saji KV and Utpala Parthasarathy. 2010. Biodiversity to enhance export of spices. *Indian J. Hort.*, 67: 57-62.

22. Parthasarathy VA, Dinesh R, Srinivasan V and Hamza S. 2010. Integrated nutrient management in major spices. *Indian J. Fert*., 6: 110-128.

23. Retheesh ST and Bhat AI. 2010. Simultaneous elimination of *Cucumber mosaic virus* and *Cymbidium mosaic virus* infecting *Vanilla planifolia* through meristem culture. *Crop Prot.* 29: 1214-1217.

24. Sasikumar B. 2010. Vanilla breeding - A Review. *Agric. Rev.* 31:139-144.

25. Senthil Kumar R, Krishnamoorthy B, Prasath D,Venugopal MN, Ankegowda SJ and Biju CN. 2010. Variability in Nutmeg (*Myristica fragrans*) under high rainfall and high altitude Kodagu region of Karnataka. *Indian J. Pl. Gen. Res.* 23: 191-194.

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28. Suseela Bhai R. Eapen SJ, Anandaraj M and Saji KV. 2010. Identification of *Phytopthora* and nematode resistant source from open pollinated progenies of black pepper (*P. nigrum*) using a modified protocol. *Ind. J. Agric. Sci*. 80: 893-97.

29. Thankamani CK, Srinivasan V, Krishnamurthy KS and Kandiannan K. 2011. Effect of *Azospirillum* sp and nutrients on yield of black pepper. *J. Spices Aromatic Crops,* 20: 9-13.

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31. Veena SS, Anandaraj M and Sarma YR. 2010. Variability in the sensitivity of *Phytophthora capsici* isolates to potassium phosphonate. *Indian Phytopathol.* 63:71 75.

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) [KV Saji and R Senthil Kumar]
2. Gen. XIX (813): Conservation, characterisation, evaluation and improvement of *Zingiber* and *Curcuma* spp (2007-2012) [D Prasath B Sasikumar and KV Saji]
3. Gen. IX (813): Conservation and characterization of cardamom germplasm (2007-2012) [R Senthil Kumar, CN Biju and TR Usha Rani]
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 PA 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, K Nirmal Babu and R Senthil Kumar]

Mega Project II: Breeding improved varieties of spice crops for yield, quality and tolerance to biotic and biotic stresses [Project Leader: B Krishnamoorthy]

1. Gen. XVII (813): Breeding black pepper for high yield and caryophyllene (2007-2011) [KV Saji and T John Zachariah]
2. Gen. XVII (813): Breeding black pepper for *Phytophthora* resistance (2007-2011) [K Nirmal Babu, TE Sheeja and Suseela Bhai]
3. Gen. XXI (813): Breeding black pepper for resistance to "pollu" beetle (2007-2011) [KV Saji and S Devasahayam]
4. Gen. XXII (813): Breeding black pepper for tolerance to drought (2007-2011) [TE Sheeja and KS Krishnamurthy]
5. Gen. X (813): Breeding cardamom for high yield and disease resistance (2007-2012) [R Senthil Kumar, R Praveena and TR Usha Rani]
6. Gen. XV (813): Investigations on the reasons and solutions for the absence of seed set in ginger (*Zingiber officinale* Rosc.) (2005-2012) [R Ramakrishnan Nair and D Prasath]
7. Biotech X (813): Development of core ESTs and cloning of genes from *Piper nigrum* and *P. colubrinum* (2008-2011) [Johnson K George, KS Krishnamurthy and N Krishna Radhika]
8. Biotech. IX (813): Development of transgenics for resistance to *Phytophthora* and drought in black pepper (2006-2011) [K Nirmal Babu and TE Sheeja]

9. Gen. XXV (813): Genetics of seedling progenies of turmeric (*Curcuma longa* L.) (2007-2011) [R Ramakrishnan Nair]

10. Biotech XI (813): Identification of molecular markers linked to Katte resistance genes in small Cardamom (*Elettaria cardamomum* (L.) Maton) (2009-12) [TR Usha Rani, R Senthil Kumar, R Praveena, D Prasath and K Nirmal Babu]

11. Gen. XXX (813): Evaluation of genetic variability in vanilla with emphasis to disease tolerance (2010-2015) [R Ramakrishnan Nair]

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, SJ Ankegowda and S Hamza]

2. SSC V(813): Studies on allelopathy in tree species-black pepper interactions (2009-2013) [R Dinesh and S Hamza]

3. Agr. XXVIII (813): Input use efficiency in turmeric in relation to quality (2007-2011) [K Kandiannan and V Srinivasan]

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

1. Phy. IX (813): Investigation on factors controlling spiking in black pepper (2008-2011) [K S Krishnamurthy and SJ Ankegowda]

2. Phy. X (813): Evaluation of black pepper and cardamom elite lines for yield and quality under moisture stress (2010 – 2015) [SJ Ankegowda and KS Krishnamurthy]

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. Biochem VII (813): Management of mycotoxins in black pepper, ginger, turmeric and nutmeg (2008-2011) [B Chempakam and R Suseela Bhai]

2. PHT. V (813): Studies on improved processing and quality evaluation of major spices (2010-2013) [E Jayashree, T John Zachariah and NK Leela]

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 (2006-11) [PA Mathew]

2. Hort. VI (813): Induction of orthotropic shoots in plagiotropic grafts of nutmeg (2008-2011) [J Rema and PA 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 (2007-2011) [A Shamina and NK Leela]

2. Biochem. IV (813): Exploration of spices for natural food colours and pigments (2007-2011) [PA Mathew and TJ Zachariah]

3. Biochem. V (813): Cloning of pal gene from turmeric (*Curcuma longa* L.) (2008-2011) [A Shamina and TE Sheeja]

4. Org. Chem. III (813): Flavour profiling of *Zingiberaceae* spices (2008-2012) [NK Leela and S Hamza]

Mega Project VII: Identification, characterization and development of diagnostics against pests, pathogens and nematodes of spice crops [Project Leader: A Ishwara Bhat]

1. Path. XIX (813): Development of diagnostics for viruses infecting small cardamom (*Elettaria cardamomum* Maton) (2008 – 2012) [CN 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) [TK 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 TK 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. Nema. IV (813): Role of phenyl propanoids in black pepper - burrowing nematode interactions (2008-2011) [Santhosh J Eapen and A Shamina]

3. Path. XVIII (813): Isolation and evaluation of antimicrobial compounds from bacterial endophytes against major pathogens of spice crops (2008-2011) [A Kumar and Santhosh J Eapen]

4. 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]

5. Path. XXI (813): Diversity of rhizome – root rot pathogens and their antagonists in cardamom. (2010-2014) [R Praveena and CN Biju]

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

1. Ext. IV(813) : Training of Research and Extension Personnel (2005-2012) [P Rajeev]

2. Ext V(813): A Study on diffusion, adoption and impact of varieties released from IISR and scientific crop management practices (2006-11) [P Rajeev]

Mega Project XII: Developing Customized Software and Expert-System on Spices [Project Leader: S J Eapen]

1. Stat. I (813): Development of databases and software (2004-2012) [K Jayarajan]

II. Externally aided projects

i) Department of Biotechnology, New Delhi

1. DBT-CIB 4: Development of Microsattelite markers, Molecular characterization of small (*Elettaria cardamomum* Maton) & large cardamom, (*Amomum subulatum* Roxb.), identify core collections and developing data base of important genotypes (2006-2012) [K Nirmal Babu, TE Sheeja, R Senthil Kumar and TR Usha Rani]

2. 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]

3. DBT-CP 3: Genetic transformation of black pepper to confer resistance against viruses (2006-2011) [A Ishwara Bhat and R Suseela Bhai]

4. 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 (2006-2012) [M Anandaraj and R Dinesh, NK 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 PA Mathew]

4. Outreach project on *Phytophthora*, *Fusarium* & *Ralstonia* diseases of horticultural and field crops (2008-2012) [M Anandaraj, K Nirmal Babu, R Suseela Bhai, Santhosh J Eapen, Johnson K George, A Kumar and D Prasath]

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) [CN Biju and R Praveena]

iii) National Horticultural Mission, New Delhi

1. NHM-CPPHT-1: Production of nucleus planting materials of improved varieties of spice crops (2005-2012) [CK Thankamani, S Hamza and SJ Ankegowda]

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

iv) 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 NK 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) [R Dinesh, CK Thankamani and TK Jacob]

3. NAIP SS-II: Mobilizing mass media support for sharing agro-information (2009-2012) [TJ Zachariah, P Rajeev and TK 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, Division of Crop Production
4	Dr. S. Devasahayam	Head, Division of Crop Protection
5	Mr. B. Krishnamoorthy	Principal Scientist (Plant Breeding)
6	Dr. K. Nirmal Babu	Principal Scientist (Plant Breeding)
8	Dr. T. John Zachariah	Principal Scientist (Biochemistry)
9	Dr. B. Sasikumar	Principal Scientist (Plant Breeding)
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 Science)
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) – up to Nov 2010
24	Dr. V. Srinivasan	Sr. Scientist (Soil Science)
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) – up to May 2010
28	Dr. T.E. Sheeja	Sr. Scientist (Biotechnology)
29	Dr. D. Prasath	Sr. Scientist (Horticulture)
30	Dr. Rashid Pervez	Sr. Scientist (Nematology)
31	Ms. N. Krishna Radhika	Scientist (Biotechnology) – from May 2010

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. K. Jayarajan	Technical Officer (Stat.) (T6)
5	Mr. M. Vijayaraghavan	Technical Officer (T5) (Workshop) – up to June 2010
6	Mr. K.T. Muhammed	Technical Officer (T5) (Farm)
7	Mr. V. Sivaraman	Technical Officer (T5) (Farm)
8	Dr. C.K. Sushama Devi	Technical Officer (T5) (Lib.)
9	Ms. N. Prasannakumari	Technical Officer (T5) (Hindi Translator)
10	Mr. A. Sudhakaran	Technical Officer (T5) (Artist-cum-Photographer)

Administration

1	P.N.M Nair	Admn. Officer - from Dec 2010
2	Mr. V.L. Jacob	Asst. Fin. & Accts. Officer
3	Mr. K.G. Jegadeesan	Asst. Fin. & Accts. Officer
4	Mr. C.Venugopalan	Asst. Admn. Officer - from Oct 2010
5	Mr. R.N. Subramanian	Asst. Admn. Officer - from Nov 2010

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)
3	Mr. K. Kumaran	Technical Officer (T5)
	Mr. V.P. Sankaran	Technical officer (T5)
	Mr. N.P. Padmanabhan	Technical Officer (T5)

Krishi Vigyan Kendra

Technical Officers

1	Mr. P.S. Manoj	(T9) (Hort.)
2	Dr. S. Shanmugavel	(T9) (Veterinary Science)
3	Mr. K.M. Prakash	(T9) (Agronomy)
4	Dr. B. Pradeep	T6 (Fisheries)
5	Ms. A. Deepthi	T6 (Home Science)
6	Mrs. K.K. Aiswariya	T6 (Plant Protection)

IISR Cardamom Research Centre, Appangala

Scientific

1	Dr. S.J. Ankegowda	Sr. Scientist (Plant Physiology)
2	Dr. R. Senthil Kumar	Sr. Scientist (Horticulture)
3	Dr. C.N. Biju	Scientist (Plant Pathology)
4	Dr. T.R. Usha Rani	Scientist (Biotechnology)
5	Dr. R. Praveena	Sceintsit (Plant Pathology)

WEATHER DATA 2010

Cardamom Research Centre, Appangala				
Month	**Temperature (^{0}C)**		**Rainfall (mm)**	**Rainy days (no.)**
	Maximum	Minimum		
January	26.7	13.9	19.2	1
February	29.3	15.3	0.0	0
March	32.2	17.9	1.2	1
April	32.9	19.1	53.6	5
May	29.0	19.0	101.0	10
June	25.4	18.7	333.4	18
July	23.0	17.8	675.2	26
August	23.7	17.6	584.7	31
September	24.3	18.7	306.6	22
October	24.8	18.2	280.6	15
November	25.2	18.1	195.4	14
December	25.3	15.6	18.2	1
Average/Total	26.8	17.4	2569.1	144

IISR Experimental Farm, Peruvannamuzhi				
Month	**Temperature (^{0}C)**		**Rainfall (mm)**	**Rainy days (no.)**
	Maximum	Minimum		
January	32.7	18.6	10.2	2
February	34.3	20.3	0.0	0
March	35.9	24.0	28.8	2
April	35.0	24.1	128.8	10
May	33.7	24.3	179.6	14
June	29.1	23.2	909.0	26
July	27.7	22.7	913.4	28
August	27.1	22.8	552.6	23
September	29.8	22.9	451.0	21
October	30.2	22.6	363.6	19
November	30.6	22.2	575.0	20
December	32.8	20.3	9.0	2
Average/Total	31.5	22.3	4121.0	167