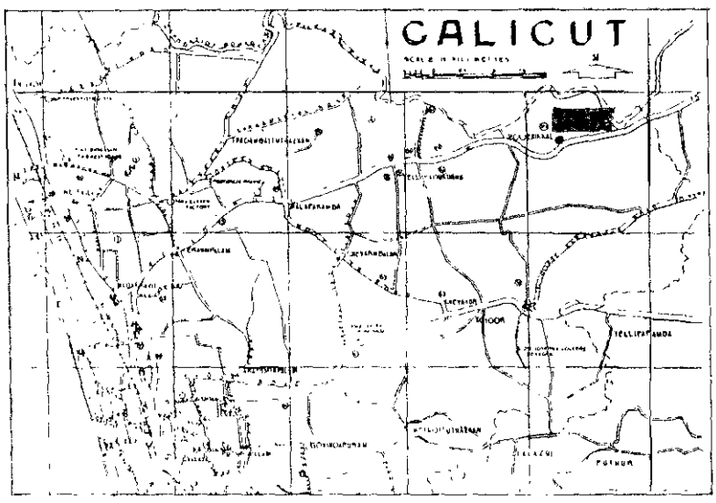
वार्षिक प्रतिवेदन
Annual Report
1996-97

Indian Institute of Spices Research

INDIAN INSTITUTE OF SPICES RESEARCH

An organization under Indian Council of Agricultural Research



0. Indian Institute of Spices Research Calicut & AICRPS HQ

AICRPS Centres

1. Pampadumpara
2. Panniyur
3. Coimbatore
4. Yercaud
5. Mudigere
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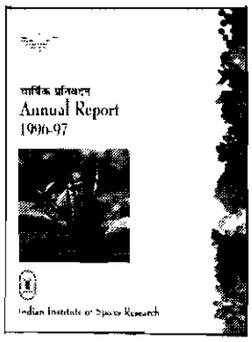
20. Kumarganj

वार्षिक प्रतिवेदन ANNUAL REPORT

1996-97

Indian Institute of Spices Research
Calicut-673 012, Kerala, India



Front cover: Paprikas (*Caspicum* sp.) are chillies with low pungency and high colour value, having greater export potential. Research on paprikas has been initiated at IISR during the year

Back cover (top to bottom)

1. *Coccobius* sp., a potential parasitoid of rhizome scales of ginger and turmeric
2. Seed cultures of vanilla
3. A bold rhizome ginger selection

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FOREWORD

The year 1996-97 was highly rewarding and significant to the Indian Institute of Spices Research as it experienced breakthroughs in developing new technologies in spice crops and high productivity in black pepper. The export of spices touched 2.194 lakh tonnes valued Rs. 1130 crores, an all time record, during the year.

Our research efforts began to show impact on the spices farming community and hundreds of farmers are coming forward to test and adapt various technologies formulated by the Institute for increasing crop production and also management schedules for protection of crops from diseases & pests. There is an ever increasing demand for the planting materials of new crop varieties developed by the Institute and also for biocontrol agents for the suppression of diseases and pests, particularly for the management of *Phytophthora* foot rot of black pepper, soft rot in ginger and rhizome rot in cardamom. *Veritcillium chlamydosporium*, an important biocontrol agent, suppressive to plant parasitic nematodes, is being evaluated under field condition for the management of root knot nematodes in cardamom nurseries.

Biotechnological research in spices is also gaining momentum. Research on paprika, an important export oriented spice crop, has been initiated during the year. 'Organic spices' and 'clean spices' are the other thrust areas which attracted our attention.

IISR adopted the Kodencherry Panchayat in Calicut District for the all-round development and technology transfer. The Agricultural Research Information System (ARIS) cell was established during the year.

The institute collaborates with the Indian Society for Spices in organising seminars/symposia. A National Seminar was organised during 24-25 April 1996 at Calicut on 'Biotechnology of Spices and Aromatic Plants'. The Institute also organised the first interface between the Indian Spices Exporters Forum and scientists of IISR during 11-12 October 1996. The meeting of the Project Monitoring Committee of DBT on IPM was also hosted by the Institute during 18-19 September 1996. This Institute works in close collaboration with Spices Board, Cochin for export oriented research programmes.

Another milestone during 1996-97 was the finalisation of Perspective Plan for the period upto 2020 A.D. A lot of in-house discussions were held for its preparation. The future research areas identified in this document are based on the priorities set for IISR. The Institute provided technical support to Kerala Planning Board in formulating IX Plan proposals of the Govt. of Kerala. It also extended technical support to formulate 'Technology Mission on Black Pepper' of the State Government. We had serious financial difficulties because of unexpected shortfalls in funding. The year also witnessed levying charges for various services rendered by the Institute. The total income generated through sale of planting materials was Rs. 12.69 lakhs.

I am grateful to IISR staff, who continue to work hard inspite of several odds, to all our supporters, collaborators, sister institutions and to the farming community for their continuing support in all our activities. The staff of Indian Institute of Spices Research are pleased to present this Annual Report for the year 1996-97 which illustrates the highlights of our scientific contributions and other activities. We hope that this report is informative and would help you to become even more familiar with our activities.

October 20th 1997

(K.V. PETER)
DIRECTOR

सारांश

फ़सल सुधार और जैवप्रौद्योगिकी प्रभाग

जर्मप्लासम अक्सशन के संग्रह और विशेषण

अन्तर्विशिष्ट संकरण और सोमाक्लोनल भिन्नता से निकाले कोशिका संवर्धन द्वारा मसालों में आनुवंशिक विविधता को परिवर्धित करने के लिए फ़सल सुधार कार्यक्रम का अनुस्थापन किया। इस लक्ष्य प्राप्ति के लिए आधुनिक जैव प्रौघोगिकीकरण का प्रयोग किया। श्रेष्ठ मसालों के कायिक और सूक्ष्म प्रवर्धन के लिए उचित प्रविधियों का विकास इस प्रभाग का दूसरा अधिदेश है। इसके साथ आनुवंशिक आधारित जैविक प्रक्रिया का बहुमूल्य अन्तर्दृष्टि देनेवाले अनेक मूलभूत अध्ययन इस प्रभाग में लागू किए जा रहे हैं।

अनुवंशिक संसाधनों का संरक्षण

इस संस्थान में मसाले जर्मप्लासम का एक भंडार है और हर एक साल देश के विभिन्न भागों से संग्रह करके उसे समृद्ध बनाते हैं। उक्त साल नीलगिरी से पाईपर के 64 उच्च तुंगता के अक्सशन, वालपारी से 20 अक्सशन और मुडिवे (चिकमंगलोर) से 6 अक्सशन का संग्रह करके जर्मप्लासम संग्रह में मिला दिया। केरल में वडकमचेरी (पालघाट जिला) और पारक्कोड़ (पत्तनमतिट्टा जिला) से कृप्ट प्रकार के 48 अक्सशन के साथ अदरक ज़ीन बैंक का संबर्धन किया। उसके साथ दो संग्रह, जिनमें एक सूरत तथा दूसरे

सिक्किम से और एक संग्रह डेराडून से मिला दिया। हल्दी के एक अक्सशन जो तट्टा क्षेत्र (कोल्लम जिला) से संकलित है, हल्दी जर्मप्लासम संग्रह में जोड़ दिया। चिकमंगलोर और दक्षिण कन्नड़ा से वनिला के 14 अक्सशन का संग्रह किया गया और इसके अतिरिक्त एक अक्सशन करुवारकुण्डु (निलम्बोर) से लिया गया। वृक्ष मसालों में जायफल के 8 कृष्ट और 5 वन्य प्रकार सिसिजियम के 3 स्पीसीस, दालचीनी का एक कृष्ट प्रकार और 5 सिनमोमम स्पीसीस को आनमलई पहाड़ी, नीलगिरी (तमिलनाडु) निलम्बुर, कूराचुण्डु, करुवारकुण्डु (केरल), चिकमंगलोर, उत्तर और दक्षिण कन्नड़ा (कर्नाटक) के सर्वेक्षण के बाद संग्रह किया गया। पपरिका में कुल 55 विदेशी क़िस्म, (यु एस ए और जर्मनी से) 12 देशी क़िस्म और कर्नाटक के धारवाड़ क्षेत्र से पपरिका के ब्यादगी धब्बा क़िस्म के 126 संकलन का संग्रह किया गया।

फ़सल सुधार

पाईपलाईन में नई क़िस्में

काली मिर्च संकरज के एच पी 34, एच पी 105, एच पी 728, एच पी 759, एच पी 800 और एच पी 813 और कृष्ट 1041 आदि दक्षिण भारत के उच्च तुंगता क्षेत्रों के लिए पहचान किए आशाजनक क़िस्में है। इलायची के वयनाड़ अक्सशन में वपुक्का क्लोन और ए पी जी 223 उच्चतम क़िस्में है। एस के. पी 21, सी सी एस 1 और मलबार वल्क की अपेक्षा सी एल 37 के ओ पी पौद की उपजता विशेषतया उत्तम होती है। अदरक के दो बड़े प्रकंद चयन पेरुवन्नामुषि में दूसरे क्रमगत साल के लिए श्रेष्ठ निष्पादन प्रस्तुत किए है। वृद्धि विशेषण के संबंध में लौग संतति परख में वी - 95 श्रेष्ठ निष्पादन प्रस्तुत किया। सिनमोमम कैसिया संग्रह के अंतर्गत श्रेष्ठ छाल तेल युक्त तीन क़िस्मों का पहचान किया गया।

अन्तर्विशिष्ट संकरण

दो अन्तर्विशिष्ट संकरण (पी. नाईग्रम x पी. अट्टेन्युवेटम और पी. नाईग्रम x पी. बारबरी) का उत्पादन किया गया। इन्हीं संकरजों का विशेषीकरण हो रहे हैं।

कोशिका जननिकी और पुनरूत्पादी जीवविज्ञान

अदरक के चार अक्सशन में बी. क्रोमोसोमों का पहचान किया गया। पराग अंकुरण और पराग नली की वृद्धि के लिए वृद्धि माध्यम का मानकीकरण किया गया। इसमें 25 सेन्टी ग्रेड की आद्र बनाए रखने वाले पात्र में 15% सुक्रोस, 80 पी पी एम बोरिक आसिड और 120 पी पी एम कैलशियम नाइट्रेट होते है।

जैवप्रौद्योगिकी

इलायची और हल्दी में इन विट्रों निकाले पर्ण ऊतक और कोशिका निलंबन संवर्धन से जीवद्रव्यक को अल किया गया। पपरिका के पौद और फलभित्ति कर्त्तोतक से कैलस संवर्धन को प्रेरित किया गया। मधुरै कामराज विश्व विद्यालय के सहयोग से अदरक और इलायची में भ्रूण संवर्धन में बयोलिस्टिक कण वितरण तरीक़े द्वारा गेस का क्षणिक जीन व्यंजक सफल रूप से प्रेरित किया। पी. कोलुब्रिनम का कैनामाइसिन सूक्ष्मग्राहिता को आमाप किया और कैनामाइसिन का 250 एम जी एल$^{-1}$ कैलस वृद्धि और विविधीकरण के निरोध स्तर पर देखे गये। बीज संवर्धन द्वारा वैनिला में विविधता प्रेरित करने के लिए वैनिला प्लानिफोलिया के लगभग 100 वीज निकाले संततियाँ प्राप्त हो गये। पिमेन्टो के पौद कर्तोतक में प्ररोहों का गुणन पेरित किया गया। अदरक के अंडाशय निकाले कैलस संवर्धन में पौध पुनर्जनन के व्यक्तिवृत्त से अंगविकास और भ्रूणोद्भव दोनों को सूचित करता है। इलायची में 350 सोमाक्लोन को मिट्टी में स्थानांतरित किया गया।

अदरक और हल्दी के विकासात्मक आकारिकी

जिंजिबर और करकुमा के 4 स्पीसीस के आकारात्मक और संरचनात्मक चरित्र का तुलनात्मक अनुशीलन किया गया। राइसोम मोसरेसन तुलनात्मक लिफ अनेटमी, स्टोमाटल पैटर्न, स्टोमाटल इन्टक्स और तेल कांशिका आयाम को 4 जिंजिवर स्पीसीस में कार्यान्वित किया। 4 करकुमा स्पीसीस में मूल और मूल कंद का तुलनात्मक विश्लेपण किया गया। कारवोहाइड्रेट्स, स्टार्च, लिपिड, प्रोटीन और फैबर के ऊतक विज्ञानीय स्थानीकरण विभिन्न अभिरंजन तरीके द्वारा किया गया।

काली मिर्च में प्रकन्द अनुशीलन

क्लम वाँधने की विभिन्न तरीके, जैसे, विदर,काठी तराशी, रूपांतरित तराशी जीभी और द्विकलम वाँधना से पी. नाईग्रम और पी. कोलुब्रिनम का सफल कलम प्राप्त हो गये, जिनमें सबसे उत्तम द्विक्लम वाँधना (78%) हो रहा है। पी. कोलुब्रिलम के परिपक्व प्ररोह कलम बाँधने के लीए अच्छा है और काली मिर्च के दो पर्वसंधि के सांकुरक जल्दी अंकुरित करते हैं। पी. अरवोरियम के मामले में उपरोक्त कोई भी तरीके सफल नहीं हुए।

फसल उत्पादन और फसलोत्तर प्रौघोगिकि का प्रभाग

फसल उत्पादकता की चुनौतियों का सामना करने के लक्ष्य पर एक व्यापक दृष्टिकोण विकसित करने के लिए फसल उत्पादन कार्यक्रमों को रूप दिया। सस्य क्रम योजना का विकास, निवेश का प्रभावी प्रवन्ध, विशेपकर, उर्वरक और पानी,जैवउर्वरक का प्रयोग, सूखा सहयता और मसालों के उच्च गुणवत्ता का अभिनिर्धारण आदि को अग्रता दी गयी। मसालों के फसलोत्तर प्रौघोगिकी पर कार्यक्रम का भी सूत्रपात होता जा रहा है।

निवेश का प्रवन्ध

काली मिर्च के श्रीकरा और शुभकरा किस्मों के लिए सूक्ष्म पोषण,प्रति हेक्टर 5:2:1 किलोग्राम के दर में Zn, B और Mo के साथ 150: 60: 270 के दर में एन पी के लगाना पर्याप्त हो गया। प्रारंभिक अलुशीलन में प्रति हेक्टर 5:2:1 किलोग्राम के दर में Zn, B और Mo लगाने से अदरक और हल्दी की उपजता वढ़ गयी।

काली मिर्च के लिए पोटैशियम स्रोत के रूप में पोटैशियम क्लाराइड की अपेक्षा वोटैशियम सल्फाइट उत्तम हो गया। अदरक और हल्दी की उपजता और वृद्धि सुधार में विभिन्न राँक फॉस्फेट और सूपर फॉस्फेट में कोई महत्वपूर्ण अन्तर नहीं है। अक्तूवर-मार्च में प्रतिदिन सात लिटर प्रति पौधे के दर में ड्रिप सिंचाई करने से काली मिर्च की उपजता 67% तक बढा सकते हैं। जुन-मई के दौरान प्रौढ़ काली मिर्च वेल के लिऐ प्रतिदिन 2.5-3.0 मिल्ली मीटर के अन्तर में पानी का उपभोग करना है जवकि यह 16 साल के जायफल पौधों के लिए प्रतिदिन 3.0-3.5 मिल्ली मीटर थे। जैव उर्वरकों जैसे असोसपिरिल्लम, फॉस्फोवाक्टीरिया और वी ए एम का सम्मिश्रण डालने से कालि मिर्च की संवृद्धि हो गयि।

खेत में वुश काली मिर्च

2x2 मीटर अन्तरालन के क्षेत्र में वुश काली मिर्च रोपने से प्रति होक्टर एक टन काली मिर्च का रोपण किया जा सकता है।

नमकीन अदरक

कम रेशेयुक्त कोमल घने राइसोम द्वारा नमकीन अदरक तैयार करते है। राइसोम को खुदाकर साफ करके लगभग 2-3 हफतों तक 18-20 आपेक्षिक

गुरुत्व के 5 से कम pH के सोडियम क्लोराइड और सिट्रिक आसिड में डुबोकर रखना है। वाह्य छिलका हटाकर लवण जल में परिरक्षित करते हैं। कोमल अवश्था (150 - 170 DAP) में खोद करना नमकीन अदरक तैयार करने के लिए आदर्श दिखाये गये और वरदा इसके लिए आशाजनक रहे है। जापान और मध्यपूर्वि देश में शुद्द मांस और मच्छली की तैयारी में इसका उपयोग करते हैं।

कृषि कार्यिकी अनुशीलन

काली मिर्च के 10 क़िस्मों में उसकी सस्यीय अभिलक्षण और उपापचय अंश के अनुसार शुभकरा और पन्नियूर-उत्तम दिखाए गए।

सूखा सहयता

रंध्री प्रतिरोध, वाष्पोत्सर्जन दर, कोशिका झिल्ली स्थिरता और कैटालेस, पेरोक्सिडेस और SOD जैसे एनजाइम साक्रियता के अनुसार 20 काली मिर्च अक्सशन में नं 1114 और 4057 जैसे दो काली मिर्च अक्सशन अच्छे प्रतिवल सह्यता दिखानेवाले पहचान गए।

केन्द्रक रोपण सामग्रियों का उत्पादन

उक्त साल काली मिर्च के लगभग 75,000 मूल लगाए कतरन, 700 मूल लगाए लाटरल, 20 टन हल्दी, 2 टन अदरक, दालचीनी के 2000 पौदे, लौंग के 1000 पौदे जायफल के 500 कलम, वनिला के 500 मूल लगाए कतरन, इलायची के 15,000 पौदे और इलायची के 210 किलो ग्राम वीज केप्स्यूल आदि का उत्पादन करके विभिन्न विकासात्मक एजेंसियों और किसानों को वितरित किया।

परिपक्वता अनुशीलन

काली मिर्च में पुष्पण के 170-180 दिन के वाद तेल, ओलिओरसिन और पाइपरिन अधिकतम स्तर पर पहूँचते है और 210-230 दिन तक स्थिर रहते है। पत्ते और भेरी में स्टार्च का अंश भेरी के विकास के समय निरंतर वृद्धि दिखाते है। पत्तों की अपेक्षा भेरी म फिनैल अलामिन अमोनिया लैस (पि ए एल) को 2.5 गुणन अधिक सक्रियता है और उसकी सक्रियता लगभग 150 वीं दिन अधिकतम वन गई। अदरक में रोपण के 120 दिन के वाद अधिकतम तेल और ओलिओरसिन देखा गया। वरदा 180 वीं दिन सूखापन में पहूँचते हैं जवकि मारन में इसके लिए 210-240 दिन की आवश्यकता होती है।

गुणवत्ता मूल्यांकन

अदरक के घने राइसोम युक्त 14 जर्मप्लासम अक्सशन में, ए सी सी 15 और 71 में 2% तेल है, ए सी सी 179, 244 और 294 में 6% से अधिक ओलिओरसिन है और ए सी सी 1717 और 179 में 4% से कम कच्चा रेशा है। कैसिया अक्सशनस ए 2 डी 1 और डी 3 में क्रमिक रूप से 2.8, 2.4 और 2.5 प्रतिशत अधिकतम छाल तेल सूचित किया।

अदरक और हल्दी के जैवरासायनिक चरित्रांकन

अदरक के 25 और हल्दी के 15 अक्सशन को उसकी आइसोजाइम पैटर्न (एसिड फॉस्फाटैस, एस्टरेस कैटालेस, एस ओ डी, पोलिफिनोल ऑक्सिडेस और पेरोक्सिडेस), प्रोटीन प्रोफाइल (एस डी एस-पि ए जी ई) के मुख्य और गौण उपापचय द्वारा अस्थिरता का छानवीन किया गया। सामान्यतया एक ही भौगोलिक क्षेत्र का संग्रह यह दिखाता है कि संग्रह में प्रतिरूप सूचित करने के साथ अधिक समानता और गुच्छ भी दिखाया।

फ़सल संरक्षण प्रभाग

नाशक जीव और रोगों के प्रभावी प्रवंध द्वारा मसाल फ़सलों की उत्पादकता के सुधार में फ़सल संरक्षण प्रभाग एक प्रमुख कर्तव्य अदा करते हैं। इस प्रभाग ने प्रमुख रोगों के हेतुविज्ञान, महामारी विज्ञान, प्रधान रोगजनक, कीट और ग़ोल कृमि नाशक जीव की वर्गिकी, प्रतिरोध या सह्यता क़िस्म, प्राकृतिक कीटनाशी और जैविक नियंत्रण के प्रयोग में आनेवाले एकीकृत नाशक जीव और रोग प्रबंध आदि पर अनुसंधान चालू हो रहे हैं। अरासायनिक रूप से परिस्थितिक मैत्री नाशक जीव और रोग नियंत्रण उपाय द्वारा धारणीय कृपि की उच्च अग्रता दी गई। आधुनिक जैव प्रौद्योगिकीय उपकरणों के प्रयोग द्वारा प्रतिरोध क़िस्मों को विकसित करने के लिए भी उद्यम बनाए जा रहे हैं।

हेतुविज्ञान

खीरा-ककड़ी मोजेक वाइरस (सी एम वी) के रूप में काली मिर्च के अवरुद्ध रोग के हेतुविज्ञान को इलक्ट्रोन माइक्रोस्कॉपिक अनुशीलन की पुष्टि की गई। यह अनुशीलन रोग वाधित काली मिर्च के पत्तों में सी एम वी का सान्निध्य स्पष्टतया स्थापित करते है। जायफल के "शाट होल रोग" सिलिन्ड्रो क्लाडियम क्विंकिस-प्टाटम से होती है। मेलैडोगैन इनकोग्निटा और फितियम अफनिडेरमाटम के द्वारा अदरक पौधों के मृदु विगलन रोग के पूर्व प्रबंध में एम. इनकोग्निटा की भूमिका स्पष्टतया स्थापित की। केवल फितियम वाधित पौधों की अपेक्षा एम. इनकोग्निटा के साथ पूर्व निवेशित पौधों का जल्दी नाश होता है।

जर्मप्लासम का छान बीन

काली मिर्च के 50 कोट्टनाडन चयन में 271, 2575 और 4255 जैसे तीन क़िस्मों फाइटोफतोरा काप्सीसी की सह्यता प्रतिक्रिया दिखाते हैं। सिरसी और पेरूवन्नामुपि के रोगवाधित बागों में फाइटोफतोरा सह्यता क़िस्म के खेत परख में पी 24 स्वस्थ वन रहे। पर्ण रोग जैसे, पर्ण अंगमारी, पर्ण दाग़ और सर्कोस्पोरा पर्ण चित्ती के लिए 168 इलायची क्लोन अक्सशनस का मूल्यांकन किया गया। 56 काली मिर्च अस्कशनस को पोल्लू वीटल, लोंगिटारसस नाइग्रीपेन्निस के सुग्राह्य दिखाए गए। फिर भी वन्य पी. नाइग्रम के एक अक्सशन (नं. 2070) नाशक जीव बाधा से मुक्त हो गए। ए सी सी 176, 233, 291, 569, 606, 614 और 624 मूलगांठ गोलकृमि, एम. इनकोग्निटा के श्रेष्ठ सुग्राह्य देखे गए जबकि ए सी सी नं. 1040 और 1090 बिलकारी गोलकृमि, राडोफोलस सिमिलिस के श्रेष्ठ सुग्राह्य देखे गए। छान वीन के दूसरे चरण में हल्दी के दो अक्सशनस (ए सी सी 84 और 179) और अदरक के दो अक्सशनस (ए सी सी 36 और 59) में एम. इनकोग्निटा (ई एम आइ <3; पी एफ < 1) के उच्चतम प्रतिरोध दिखाई पड़ी।

रोग प्रतिरोध के जैव रसायन

ओरतोडिहाइड्रोक्सि फिनोलस (ओ डी फिनोल्स) और कुल फिनोल का अनुपात फाइटोफतोरा सह्य क़िस्म की अपेक्षा सुग्राह्य किस्म में ज़्यादा हो गए।

जैवप्रौद्योगिकी प्रस्ताव

पी. कोलुब्रिनम के पर्णमध्योतक कोशिका से जीवद्रव्यक वियुक्त करके पादपक पुनर्जनन के लिए प्रोटोकॉल मानकीकृत किया गया। ऊतक संवर्धन द्वारा विकसित सोमाक्लोन में नं. 456 पी. काप्सीसी ने सह्यता प्रतिक्रिया दिखाई है। इलायची के मोजेक वाइरस के प्रति 368 सोमाक्लोन का छान वीन किया गया और सवको सुग्राह्य होते दिखाए गए।

मूल गाँठ गोलकृमि में विविधता

विभिन्न स्थानों और विभिन्न मसाल फ़सलों से संग्रहित मूल गाँठ ग़ोल कृमि की संख्या में विचारणीय विविधता देखतें है। मेलोयिडोगैन स्पीसीस के परिनियल पैटर्न स्पीसीस के प्राथमिक पहचान के लिए मदद करता है। उक्त साल अनुशीलन किए गए 5 संख्या ने उनकी परिनियल पैटर्न में उच्च विविधता दिखाई। आइजोएनजाइम अनुशीलन द्वारा मूल गाँठ ग़ोल कृमि संख्या के विविधीकरण अब अमल में आ रहे हैं।

जैविक नियंत्रण

रोगः काली मिर्च के फाइटोफतोरा खुर विगलन रोग के जैविक नियंत्रण पर खेत परख करने पर मूल विगलन के *प्रतिरोध में ट्राइकोडरमा हरसियानम की अपेक्षा* ग्लियोक्लाडियम वाईरन्स उत्तम दिखाई पड़ता है। वी ए एम और जैवनियन्त्रण एजेंट के साथ किए खेत परख से उपचारित बेल में उत्तम वृद्धि और कम नाश (5% से कम) दिखाई पड़ी। कर्नाटक में काँफी और काली मिर्च मिश्रित सस्य क्रम योजना में खुर विगलन के लिए जैवनियन्त्रण का बड़े पैमाने पर निदर्शन करने पर उपचारित बेल में पर्ण का पीलापन 3.9 से 2.6% तक घटे रहे और बेल नाश 20 से 13.5% तक कम कर सके। इन विट्रो अनुशीलन से यह समझा गया कि टी हरजियानम और जी वाइरन्स दोनों के साथ पोटैशियम फॉस्फोनेट (अकोमिन) संगत हो गया। वी. क्लामिडोस्पोरियम ने द्विसंवर्धन में पी. काप्सीसी की वृद्धि को रोक दिया।

दस कृपिजोपजाति के साथ काली मिर्च के बाग़ में खुर विगलन रोग के एकीकृत रोग प्रबंध के अंदर मिट्टी में जैव नियंत्रण एजेंट को पोटेशियम फॉस्फोनेट के साथ छिड़कना या खाई में डालने के फलस्वरूप 83.5% पौधे स्वस्थ बन गए और पर्णो का पीलापन 25% - 37.5% तक की मात्रा से 16.5% तक बना सके। इसके अलावा पी 24 के सभी पौधे स्वस्थ देखे गए।

नाशक जीव कीटः प्रयोगशाला के जैव आमापन से य देखा गया कि वीवारिया वास्सियाना पोल्लू बीटल के नाश का लगभग 20% तक कारण बनते हैं।

अदरक के प्ररोह बेधक, कोनोगिथिस पंक्टिफेरालिस; के सबसे प्रमुख हिमनोप्टेरस परजीव्याभ है ब्राकोन स्पीसीस और अपान्टलस तारागमे (ब्राकोनिडे)। कुप्पाडी (वयनाडु) में काली मिर्च बेल पर शल्क कीट ऐस्पिडियोटस डिस्ट्रक्टर के साथ परभक्षी, सी. सरकुमडाटस डालने पर नाशक जीव का आपतन क हो गया। सी. सरकुमडाटस के लिए नीम का तेल 0.3%, नीमगोल्ड 0.3% और मत्स्य तेल रेसिन 3% सुरक्षित पाये गये, जबकि 1-7 दिन के क्रमिक उपचा के बाद डायमेतोयट 0.1 % और मोनोक्रोटोफोस 0.0 % विषाक्त देखे गये। खेत में अदरक और हल्दी के प्ररोह वेधक के प्रति बासिलस तुरिनजिनसिस के वाणिज्यिक उपज का मूल्यांकन करने पर यह सूचित होता है कि डैपल 0.3% का चार बार (जुलाई, अगस्त, सितम्बर और अक्तूबर के समय) छिडकना नाशक जीव बाधा के नियन्त्रण में ज्यादा प्रभावी बन गये।

प्राकृतिक शत्रुओं के मास कल्चरिंगः काली मिर्च में बाधित शल्क कीटों के प्राकृतिक शत्रुओं के रूप में कैलोकोरस सरकुमडाटस और सी. निग्रिटा के मास कल्चरिंग मानकीकृत किया गया। ये दोनों, शल्क कीटों, अनोयिडेल्ला ओरियन्टालिस, जो प्रयोगशाला कद्दू पर बढ़ते उन पर पलते है।

नेमाटोडः मूल गांठ गोलकृमि के साथ साथ या नेमाट निवेशन के 15 दिन बाद जैवनियन्त्रण एजेंट, पास्टों पेनिट्रान्स का निवेशन करने पर नेमाटोड की संख्या

वडी मात्रा में कम कर सकते हैं और इलायची पौधों के कुल जैवमात्रा की वृद्धि भी होती है।

नाशक जीव प्रबन्ध के लिए प्राकृतिक उपज

काली मिर्च के "पोल्लू बीटल" के नियन्त्रण में एन्डोसल्फान 0.05% जुलाई में छिटकना और उसके वाद तीन बार (अगस्त, सितम्वर और अक्तूवर के समय) नीमाजल 0.05% या नीमगोल्ड 0.3% छिडकने से प्रभावी फल देखे गये। शल्क कीट, लेपिडोसाफस पाइपरिस के प्रति नीम का तेल 0.3%, नीमगोल्ड 0.6% और मत्स्य तेल रेसिन 3% का प्रयोग प्रभावी देखे गये जवकि काली मिर्च के ए. डिस्ट्रक्टर के प्रति मत्स्य तेल रेसिन 3% का प्रयोग ज्यादा प्रभावी देखे गये।

समाज विज्ञान

इस अनुसंधान संस्थान का समाज विज्ञान अनुभाग रोपकों, विकास एजोंसियों और व्यवसायों के साथ जुडे रहते हैं। यहाँ कृषि जैविकीय दत्त, किसानों के बीच प्रौद्योगिकियाँ स्थानांतरित करने में आनेवाली सामाजिक और आर्थिक समस्याओं के अनुशीलन का विश्लेपण और उसका निदर्शन प्रशिक्षण और प्रदर्शन का आयोजन आदि इस अनुभाग में होता है।

निदर्शन परख

नारियल और काली मिर्च प्लाँट में एच.पी.टी का प्रयोग करने से काली मिर्च का उत्पादन 0.5 से 1.3 किलोग्राम बेल$^{-1}$ तक वढ गये और खुर विगलन रोग का आपतन 0.8% से 2.5% तक कम कर दिये। विभिन्न इलायची पर आधारित सस्य क्रम योजना के साथ 7 किसानों के प्लाँट में एच पी टी लगाने से इलायची की उपजता में महत्वपूर्ण वृद्धि देख सकते हैं।

आई आई एस आर ने कोटंचेरी पंचायत को गोद लिया

आई आई एस आर कालिकट ने संपूर्ण विकास के लिए कोटंचेरी पंचायत को गोद लिया। अक्तूबर 14-15 तक इसने एक संगोष्ठी और प्रदर्शन का आयोजन किया। श्री. वी. के.राजन, कृषि मंत्री, केरल सरकाल ने संगोष्ठी और प्रदर्शन का उद्घाटन किया जिसमें विभिन्न विकास एजेंसियों और गैर सरकारी संगठने ने भाग लिया। कृक्षि, पशुपालन, उघान कृक्षि, पुष्प कृपि, और शाका कृपि जैसे सामान्य रुचि के विभिन्न विषयों पर लक्चर किया गया। अनुविर्ति कर्रवाई के अनुसार गोद लिये गाँवों में निर्देशात्मक सर्वेक्षण आयोजित किया गया और उसमें किसानों के प्रमुख समस्याओं का पहचान किये गये।

प्रशिक्षण कार्यक्रम

"मसाले उत्पादन प्रौद्योगिकी" (तीन बार) "काली मिर्च में फाइटोफतोरा खुर विगलन रोग प्रबन्ध" (दो वार), "मसालों में पौधाघर प्रवन्ध" और "ऑन फॉम प्रोससिंग इन स्पाइसस" (दोनों एक बार) आदि पर चार प्रशिक्षण कार्यक्रम आयोजित किये गये जिनमें विभिन्न राज्यों के 74 अधिकारियों ने भाग लिया था। अलहवाद कृपि संस्थान, अलहवाद, उत्तर प्रदेश के बी. एस. सी (कृषि) अंतिम साल के 17 छात्रों के लिए "मसालों पर खेत प्रशिक्षण" आयोजित किया गया।

प्रदर्शनें

संस्थान ने कोटंचेरी गांव के गोद लेने के अवसर पर अक्तूबर 14-15, 1996 में कोटंचेरी में एक प्रदर्शन आयोजित किया। इसके अतिरिक्त संस्थान ने विभिन्न अवसरों पर पाँच प्रदर्शनों में भाग लिये जैसे: (1)सामूरिन स्कूल, कालिकट में 1996 अप्रैल 5-12 तक रीजियनल इंजिनीयरिंग कॉलेज द्वारा आयोजित यूरीका 96 (विज्ञान और प्रौद्योगिकी प्रदर्शन) (2)

कैवेली, कालिकट में 1996 सितम्बर 13-14 तक एन डब्ल्यू डी पी आर ए द्वारा आयोजित कैवेली पंचायत की 40 वीं वार्षिकी (3) 1996 दिसम्बर 4-5 तक सेन्ट जोसफस कोलेज, देवगिरी, कालिकट की 40 वीं वार्षिकी (4) 1996 दिसम्बर 22-25 तक चात्तमंगलम पंचायत, कालिकट की 40 वीं वार्षिकी (5) 1996 दिसंवर 27-30 तक चेरुवाटी पंचायत, कालिकट की 40 वीं वार्षिकी।

कृषि अनुसंधान सूचना प्रणाली का सेल

समाज विज्ञान अनुभाग के अधीन आई आई एस आर कालिकट में एक कृषि अनुसंधान सूचना प्रणाली का सेल कार्यान्वित किया।

कृषि विज्ञान केन्द्र

उक्त साल, कृपि विज्ञान केन्द्र ने 58 अल्पकालीन प्रशिक्षण कार्यक्रम आयोजित किया। कुल मिलाकर 1975 प्रशिक्षणार्थियों ने इन्हीं प्रशिक्षण कार्यक्रमों में भाग लिये। पौध और पशु स्वास्थ्य केन्द्र में कुल 1730 प्रकरण उपचारित किये गये। उक्त अवधि में इस केन्द्र के अधीन एक कृत्रिम वीर्य सेचन केन्द्र का प्रारंभ किया गया। उसकी निधि योजना के अधीन रोपण सामग्रियों की बिक्री तथा परामर्श और पंजीकरण शुल्क के रूप में 91, 357 रूपये समाहित किये गये।

INTRODUCTION

The Indian Institute of Spices Research was started in 1975 as a Regional Station of the Central Plantation Crops Research Institute (CPCRI), Kasaragod, to initiate research on spices. Based on the recommendations of the Quinquennial Review Team appointed by the ICAR, this Regional Station was elevated as National Research Centre for Spices in 1986 by merging the CPCRI Regional Station at Calicut and the Cardamom Research Centre at Appangala, Karnataka. Acknowledging the contributions of this centre in the field of spices research and development during the span of a decade, the ICAR upgraded NRCS into the Indian Institute of Spices Research (IISR) on 1 July 1995.

MANDATE

The Indian Institute of Spices Research will serve as an institute of excellence for conducting and coordinating research on all aspects of spices improvement, production, protection and post harvest technology.

- To extend services and technologies to conserve spices genetic resources as well as soil, water and air of spices agroecosystems
- To develop high yielding and high quality spices varieties and sustainable production and protection systems using traditional and nontraditional techniques and novel biotechnology 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

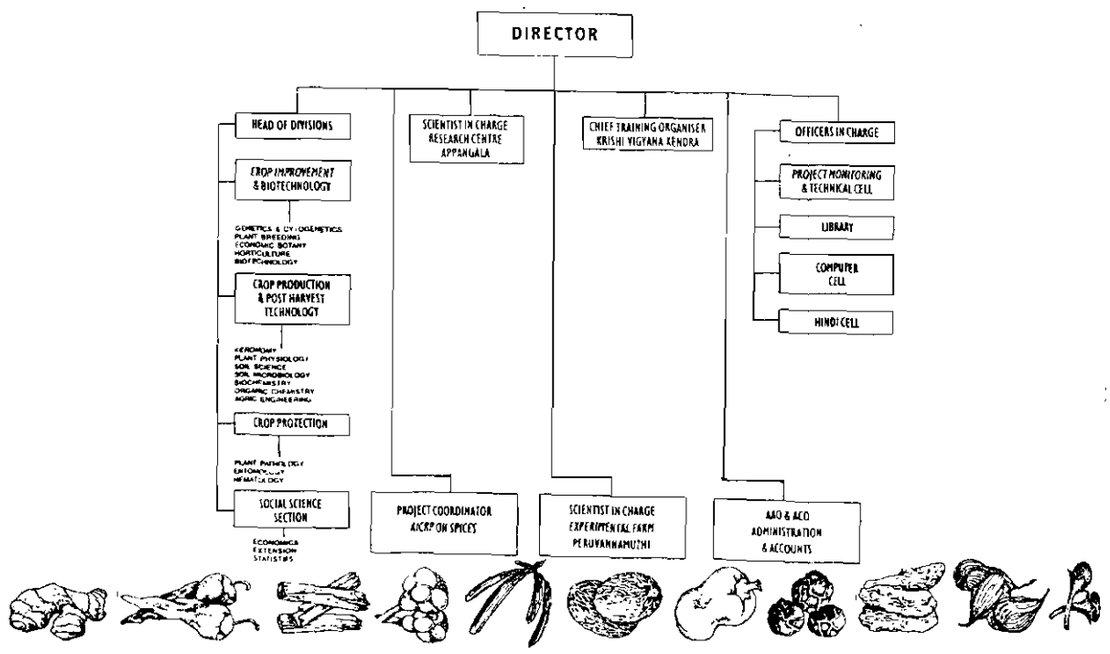
Location

The headquarters of the IISR is situated in Calicut (Kozhikode) city, where Vasco de Gama had landed on 20 May 1498. The experimental farm of the Institute is located at Peruvannamuzhi, in the foot-hills of the Western Ghats. The only subcentre, the Cardamom Research Centre, is at Appangala in Coorg (Kodagu) District, Karnataka (see inside front cover).

Organizational setup

The Director is the administrative head of the Institute and its other centres. The Institute Management Committee, Research Advisory Committee, Policy Committee and Staff Research Council assist the Director in matters relating to management, research and extension. Multidisciplinary research on different aspects of black pepper, cardamom, ginger, turmeric, nutmeg, clove, cinnamon, allspice, vanilla and paprika is conducted in three divisions and a section - Division of Crop Improvement & Biotechnology, Division of Crop Production & Post Harvest Technology, Division of Crop Protection and Social Science Section (see chart below). Besides, IISR is also the head quarters of the All India Coordinated Research Project on Spices with a network of 20 centres spread over 15 states. Krishi Vigyan Kendra, established in 1992 at the Experimental Farm, Peruvannamuzhi, concentrates on transfer of technology.

ORGANISATIONAL SETUP OF IISR



Apart from the research activities, the Institute is recognized as a centre for post graduate studies by the University of Calicut and Kerala Agricultural University. It offers consultancy and training in different fields (see inside back cover) and disseminates the information generated through regular publications and other mass media.

Natural resources setup

The institute's main campus is located 12 km away from the Calicut Railway Station on the Calicut - Wynad road in 14 ha of land. The research farm at Peruvannamuzhi (Calicut District) is 51 km away from Calicut city. The farm has 94.08 ha land at a MSL of 55m with sandy and laterite soil and a pH of 5 - 5.8. The area receives an annual rainfall of 4000 mm in 130 - 140 rainy days and the temperature varies from 21 - 34°C. The Cardamom Research Centre, Appangala is 8 km away from the famous hill station, Mercara (Madikeri) in Karnataka on the Bhagmandala road. The farm has 14 ha of land at an altitude of 1000 m above MSL.

Weather data for 1996-97

Month	No. of rainy days		Rainfall (mm)	
	Peruvannamuzhi	Appangala	Peruvannamuzhi	Appangala
April 1996	4	7	31.00	103.60
May	5	3	72.00	28.20
June	16	17	836.00	685.80
July	25	24	1177.00	824.80
August	25	29	817 .40	504.50
September	22	19	452.00	233.70
October	15	16	426.00	373.50
November	9	4	134.00	32.00
December	7	3	106.60	64.90
January 1997	1	2	2.50	3.40
February	0	0	0.00	0.00
March	3	8	15.00	45.40
Total	**132**	**132**	**4069.50**	**2899.80**

RESEARCH ACCOMPLISHMENTS

1

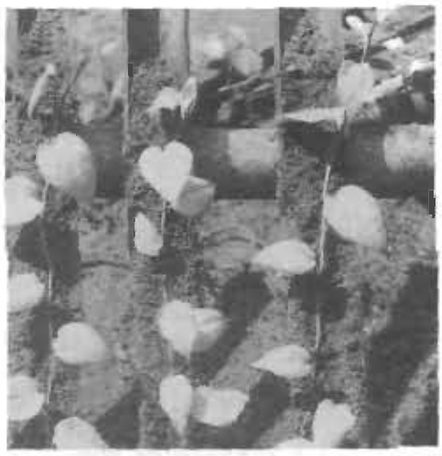
CROP IMPROVEMENT AND BIOTECHNOLOGY

Twenty one research projects including three ICAR adhoc projects were handled by the Division of Crop Improvement and Biotechnology. Out of these, 8 projects were on black pepper, 4 each on cardamom, ginger and turmeric, 3 on tree spices and one each on vanilla and paprika. There were 7 projects in biotechnology, 5 in germplasm conservation, 3 each in plant breeding and horticulture and 2 on basic studies of spices. The salient findings during the year are:

The spices germplasm repository was enriched with 90 black pepper accessions, 51 ginger accessions, one turmeric accession and 15 vanilla accessions. In tree spices, eight cultivated and five wild nutmeg types, three species of *Syzygium*, one cultivated cinnamon and five *Cinnamomum* spp. were collected. In paprika, a total of 55 exotic, 12 indigenous lines and 126 collections of Bydagi Dabba type paprika from Dharwad area were added.

Black pepper hybrid, HP 813, in a garden at Valparai (3500 ft above MSL)

Six hybrid lines and one cultivar of black pepper, 2 selections of ginger with bold rhizomes, 3 cassia lines with high bark oil and a high yielding clone of nutmeg were identified for further evaluation. Among the Wynad accessions of cardamom, vazhukka clones and APG-223 were superior. Four pollu beetle resistant lines were planted in the field for evalutation. Inter specific crosses involving *Piper nigrum* L, *P. attennatum* and



Rooted cuttings of an interspecific hybrid of Piper nigrum *and P. attenuatum*

P. barberi were made and the seedling progenies are multiplied for further studies. *Vanilla planifolia* x *V. aphylla* crosses resulted in development of fruits.

Developmental morphology and anatomical characterisation of *Zingiber* and *Curcuma* species were done. Cytological studies in ginger revealed that chromosome number is 2n=22 and four cultivars were found to possess B chromosomes.

Over 100 progenies of vanilla were developed through embryo culture. Callus cultures were initiated from fruit explants in paprika. Plant regeneration from anther was achieved in ginger. About 200 somaclones of cardamom were transferred for hardening. Protoplasts were isolated from cardamom, ginger and turmeric and culturing is in progress. Transient gene expression of GUS was successfully induced in embryonic cultures of ginger and cardamom using biolistic particle delivery system.

Double grafting was found better for successful grafting of *Piper nigrum* and *P. colubrinum*. Root stock studies in clove was done using 11 *Syzygium* sp. and initial union was observed in four species.

Secondary protocorm formation in seed cultures of Vanilla planifolia

Multiple shoots in a seedling explant of allspice, Pimenta dioica

GEN. I(813)

COLLECTION, CONSERVATION AND EVALUATION OF BLACK PEPPER GERMPLASM

(P N Ravindran, B Sasikumar, V S Korikanthimath Johnson K George & B Chempakam)

A. Survey and collection of *Piper* germplasm

Sixty four accessions of high elevation *Piper* species viz. *Piper mullesua, P. schmidtii, P.wightii* etc. were collected from Nilgiris. Another 25 accessions from Valparai and 18 from North Kanara, South Kanara and Chickmagalore were also collected.

B. Characterization of *Piper* species

Matured leaves and berries were sampled for chemical analysis from the following species, *P. attenuatum, P. barberi* and *P. longum*, and cultivars viz. Karimunda, Aimpirian, Cheriyakaniakadan, Uthirankotta, Perumkodi, Panniyur-1, Panniyur-3, Panniyur-4, Subhakara and Pournami. Total protein was extracted and subjected to SDS-PAGE followed by silver staining. Number of bands in the electrophoretograms varied from 11 to 18 among the species/cultivars tested.

GEN. IX(813)

COLLECTION, CONSERVATION, CATALOGUING AND EVALUATION OF CARDAMOM GERMPLASM

(Ravindra Mulge & M N Venugopal)

A. Consolidation of germplasm bank

Germplasm collections which were planted in different blocks were assembled in a single block. A total of 240 accessions of cardamom and related genera were planted in a single block. Five clones of each accession were planted with a spacing of 2m between plants, 2.5m between accessions and 3m between sub blocks. Collections made in 1995 comprising variants of compound panicle types, capsule shape and size, high yielders, foliar disease resistant types and short duration with staggered flowering are established in a clonal block for further multiplication and evaluation. For proper cataloguing of the germplasm collections following the IPGRI descriptor for cardamom, a list of important characters to be recorded in the ensuing season is prepared. Regrouping of 201 cardamom accessions was done based on panicle character and pubescence.

B. Reaction to foliar diseases

Reaction of 168 cardamom accessions to the natural infection of leaf blight (*Colletotrichum gloeosporioides*), leaf blotch (*Phaeodactylium venketesanum*) and leaf spot (*Sphaceloma cardamomi*) was assessed and based on 0-5 rating scale, fiftyseven leaf blight resistant accessions are identified.

C. Observational trial on large cardamom

For conducting an observational trial, clones of Sawney, Ramsky, Golsey and Zangu valley were procured. Clones are under multiplication for laying out an observational trial.

GEN. II(813)

COLLECTION, CONSERVATION, CATALOGUING AND EVALUATION OF GINGER AND TURMERIC GERMPLASM

(P N Ravindran, B Sasikumar, Johnson K George & K P M Dhamayanthi)

A. Maintenance of germplasm

Four hundred and fortyseven accessions of ginger and 697 accessions of turmeric and 9 accessions *Kaempferia* are maintained. New collections were made from Vadakumcherry,

Palghat District (13 accessions), Parakode and Malayalapuzha, Pathanamthitta District (35 accessions), Surat, Gujarat (2 accessions), Dehradun, U.P. (1 accession) and Sikkim (2 accessions). In turmeric, one collection was made from Thatta, Quilon District.

B. Yield evaluation of ginger bold rhizome accessions

Selected bold rhizome accessions of ginger were evaluated for yield and dry recovery at Peruvannamuzhi and Kumarakom in replicated trials. Mean yield and dry recovery of the accessions are presented in Table 1.1 When fresh yield and dry recovery are considered together, Acc. 117 and 415 are found promising.

C. Yield evaluation of high curcumin turmeric selections

Ten selected high curcumin lines of turmeric were evaluated in a replicated trial at Peruvannamuzhi. Yield of these accessions ranged from 12.65 to 19.38 kg per $3m^2$ bed where as the dry recovery varied from 19-25% (Table 1.2).

D. Multiplication of Alleppey turmeric

Fourty five accessions of Alleppey turmeric were multiplied for further evaluation. Yield and dry recovery of the accessions were recorded (Table 1.3).

Table 1.1. *Yield and dry recovery of bold rhizome ginger accessions*

Accession	Peruvannamuzhi		Kumarakom	
	Mean yield (fresh) (kg bed^{-1} ($3m^2$)	Dry recovery (%)	Mean yield (fresh) (kg bed^{-1} ($3m^2$)	Dry recovery (%)
117	13.50	22.00	25.99	17.56
35	14.67	17.50	21.16	13.78
49	12.33	22.00	-	-
27	13.00	22.00	-	-
3573	5.03	23.00	23.88	18.74
142	7.83	23.00	20.79	15.27
15	9.60	19.50	-	-
415	12.33	22.00	24.79	16.82
116	7.33	15.00	21.81	17.32
294	12.23	22.00	24.68	15.77
204	11.40	23.00	28.01	12.92
64	13.17	19.50	-	-
179	13.03	23.00	22.11	15.62
71	8.50	21.50	15.87	16.89
244	13.13	17.50	-	-
$LSD_{0.05}$	1.13	-	4.60	-
C V %	14.88	-	19.50	-

able 1.2. *Yield and dry recovery of high curcumin turmeric selections*

Accession	Mean yield kg bed^{-1} (3m^2)	Dry recovery (%)
109	14.12	25.00
330	16.62	22.50
126	19.38	19.50
319	14.48	20.75
329	16.19	22.00
295	16.44	19.00
42	17.38	22.50
290	12.97	22.00
160	15.45	20.50
173	12.65	22.75
LSD $_{0.05}$	0.86	-
CV%	10.82	-

Table1.3. *Yield and dry recovery of 45 accessions of Alleppey turmeric*

Accession	Mean yield kg bed^{-1} (3m^2)	Dry recovery (%)
575	15	24
576	10	24
577	19	25
578	8	20
579	16	20
580	14	24
581	3	25
582	15	24
583	3	22
584	15	24.5
585	16	23.5
586	6	-
587	16	21
588	15	24.5
589	11	24.5
590	8	-
591	15	23.5
592*	4	-
593	15	20.5
594*	2	-
595	14	22.5
596	16	22.5
597	12	-
599	12	21
601	13	24.5
602*	1.5	-
603	16	24.5
604	16	24
605	16	23
607	19	22
608	11.5	21
609	16	-
610	16	-
614*	4	-
615*	3.5	-
617*	1.5	-
623*	5	-
625*	0.5	-
628*	5	-
630*	3	-
631*	0.5	-
632*	4	-
634*	4	-
637*	14	25.5

* Dry recovery not assessed due to insufficient quantity of material

E. Multiplication of OP progenies of turmeric

Twenty eight OP progenies were multiplied in pot culture. Two morphological variants (lanceolate and dwarf stature) and 2 late maturing types were noticed among the progenies. Seeds from Acc.122, 180 and 127 were collected and sown.

F. Variability studies for shelf life of dry ginger

Dry ginger of 31 accessions were put in cloth bags and stored under ambient conditions. Incidence of beetle borers, moth borers and psocids were scored on a 1-5 scale. No beetle damage was observed in Acc. 71, 11 and 31 but the infection was maximum in Accn. 224, 49 and 63. Similarly, there was no moth borer attack on Acc. 208, 224, 11, 12, 15, 20, 6, 59, 74. Acc. 224 was highly preferred by moth borers and beetle borers. Acc. 68 was free from psocid attack, whereas Acc. 151 had maximum psocid damage. This preliminary study indicates that ginger accessions vary widely in their reaction to storage pest attack. Acc. 11 is relatively resistant to storage pest attack except psocids. IISR Varada (Acc. 64) was also having some tolerance to the storage pest damage.

G. Cataloguing of ginger germplasm

Fifty accessions were grown in $3m^2$ bed and observations were recorded on yield attributes. Good variability was observed for plant height and yield per plant (Table 1.4).

GEN. VI(813)

COLLECTION, CONSERVATION, CATALOGUING AND EVALUATION OF GERMPLASM IN TREE SPICES

(B Krishnamoorthy, J Rema, P A Mathew & V S Korikanthimath)

A. Collection and conservation

Eight cultivated nutmeg types, five wild nutmeg types, three species of *Syzygium*, one cultivated cinnamon type and five wild cinnamon species were collected from Anamalai hills, Nilgiris, Nilambur, Koorachundu, Karuvarakkundu, South Kanara and Chickmagalur districts (Table 1.5). The collections include *Myristica attenuata* Wall. (wild nutmeg); *Cinnamomum riparium* Gamble, *C. wightii* Meissn and *C. macrocarpum* Hook f. Ten elite nutmeg trees were identified at Koorachundu. Besides, a

Table 1.4. *Yield and yield attributes in 50 accessions of ginger*

Character	Mean	Range	Variance
Shoot height (cm)	46.15±11.00	35-86	121.06
Number of tillers	13.57±4.48	6-25	20-13
Leaf number	15.99±3.34	9-25	11.17
Leaf length (cm)	19.51±4.44	14-25	19.7
Leaf breadth (cm)	2.41±0.46	15-36	0.21
Stomatal index	12.26±2.37	11-60	5.63
Yield per plant (fresh) (g)	271.78±35.20	200-364	1239.05
Yield per $3m^2$ bed (fresh) (kg)	11.08±1.98	4-15	3.93
Dry recovery %	19.08±4.40	12-27	-

number of other tree species were also collected for trial (Table 1.6).

Two hundred and eighty one accessions of cinnamon, 465 accessions of nutmeg, 220 accessions of clove and 137 lines of allspice are being maintained in the germplasm

Table 1.5. *Genetic resources of tree spices collected during 1996-97*

Crop	Place	Number	Remarks
Cinnamomum sp.	Vittal	1	Cultivated type
	Nilgiris	4	High elevation species (wild) like *C.riparium*, *C.wightii* and *C. macrocarpum*
	Valparai	1	Wild cinnamon
Syzygium sp.	Vittal	1	-
	Sringeri to Nemmara (Chickmagalur Dist.)	2	-
Myristica sp.	Karuvorakundu (Malappuram Dist.)	4	Cultivated types
	Koorachundu (Calicut Dist.)	2	-do-
	Soans Farm (Moodbidri D.K. Dist.)	2	-do-
	Peruvannamuzhi to Poozhithodu	1	*M.attenuata*
	Markuli jungle, Kidu	1	Wild species
	Vittal	2	Wild species (This includes a very fast growing species, locally called Chendalika)
	Nilambur forest	1	*M. malabarica*

Table 1.6. *Other tree spices collected during 1996-97*

Crop	Place	Number	Remarks
Tamarind	TNAU	1	Grafts of Periakulam I
Garcinia sp.			
a) *G. cambogia*	Taliparamba	1	Seedlings & 1 accession
	Kumarakam	6	Wild form
b) *G. cowa* (?)	Taliparamba	1	-
c) *G. indica* (kokum)	Karwar, Taliparamba	2	-
d) *G. tinctoria*	Karwar, Taliparamba	2	seedlings raised for planting
Artocarpus lakoocha	Taliparamba	1	-do-

conservatory. Fifty dwarf clove seeds and 20 kg clove seeds were collected from elite clove trees identified at Ashamboo hills and seedlings were raised. Twenty two grafts of four elite nutmeg trees were planted in the field.

B. Studies on dwarf clove seedlings

Dwarf clove seedlings from collections of Black Rock and Castle Rock Estates, Kanyakumari were isolated and kept in polybags for growth studies.

C. Evaluation of nutmeg germplasm

Ten nutmeg accessions (A 11/29, A 11/70, A 9/20, A 9/22, A9/25, A9/79, A 9/86, A 4/12, A 4/22 and A 4/52) identified earlier as high yielding lines continued to perform better. The clonal selection A 9/4 also performed well. It yielded around 800 fruits in the 8th year after planting. Its fruit weight is 85 g, mace weight 2.3g and nut weight 10 g. Clonal and seedling progenies of A 9/4 are raised for field trails. The seedling progenies of nutmeg selection A 11/70, planted at Chelavoor during 1992, started flowering and bearing during 1996. A ratio of 1:1 was observed for male and female progenies.

Myristica fatua var.*magnifica*, a rare and endangered species, had flowered in the 6th year after planting in the coservatory. It wa a male tree, with flower groups of 7 to 10. *Myristica beddomeii* also started bearing.

D. Progeny evaluation of clove elite lines

Peruvannamuzhi: In the clove progeny evaluation trial, observations on growth parameters were recorded and given in Table 1.7. The line B - 95 recorded the maximum height (4.8 m), canopy (2.7m) and girth (15.3mm) with the least coefficient of variations.

Table 1.7. *Growth characters of clove elite line progenies (4th year after planting)*

ELite line no.	Plant ht. (m)		Canopy(m)at 1m		Girth at 40 cm (mm)		No of branches	
	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%
K-6	2.9	38 3	1.7	40.6	6.9	33.3	36.1	56.1
B-76	3.4	43.8	1.6	50.6	11.8	26.3	39.4	41.4
B-95	4.8	7.1	2.7	12.6	15.3	4.9	46.3	19.9
B-59	4.5	16.4	2.6	26.5	15.1	25.8	49.5	30.5
Control	4.0	19.5	2.0	32.5	12.9	23.6	40.7	34.4

Appangala: The trial with 8 Kallar, 6 Burliar and 1 control laid out at Appangala during 1991 was maintained. Flowering was observed in 8 progenies of K-9 and B-2. One line had yielded 50g dry cloves. Bud initiation was observed in September, as against June in plains.

Chelavoor: The progenies of 14 elite lines of Nagarcoil and control planted during 1992 were maintained at Chelavoor campus and the growth of the plants, in general, was satisfactory.

E. Studies on inducing flowering/ fruit set in allspice

An experiment was conducted to find out the optimum period of application of paclobutrazol (cultar) for inducing maximum flowering and the application of 1 g a.i. paclobutrazol during August induced

maximum flowering under Peruvannamuzhi conditions. But the fruit setting is very low (1%).

Allspice plants of 3 years old have started profusely bearing and fruiting at Appangala.

F. QUALITY EVALUATION OF CHINESE CASSIA

Coppicing and bark extraction of 20 Chinese cassia lines were carried out during June 1996 and the accessions A/2, D_1 and D_3 performed better. C_1 recorded the maximum bark oleoresin (13.2) .

Around 500 rooted cuttings of different accessions of Chinese cassia were produced for laying out field trials. "Navashree" and "Nithyashree" varieties of cinnamon were released as national varieties.

GEN XIII(813)

COLLECTION, CONSERVATION AND IMPROVEMENT OF VANILLA

(P N Ravindran, B Krishnamoorthy, K Nirmal Babu & K Kandiannan)

Fifteen accessions of vanilla were collected from Chickmagalore, South Kanara and Karuvarakundu. The total number of accessions in vanilla germplam repository is now 34. Interspecific hybridization is attempted between *V. planifolia* x *V. aphylla* and *V. aphylla* x *V. planifolia*. Twelve accessions of vanilla were planted in the field for evaluation.

GEN. VII.1(813)

BREEDING BLACK PEPPER FOR HIGH YIELD, QUALITY AND DROUGHT

(B Sasikumar, P N Ravindran, T John Zachariah & K S Krishnamurthy)

A. YIELD TRAIL

Field trials at Peruvannamuzhi and Valparai were maintained. Black pepper hybrids HP34, HP 105, HP 813, HP 728, HP 800 and HP 759 as well as cultivar 1041 are the promising lines identified for the high altitude areas of South India. HP 105 yielded 6.18 kg green berries compared to 4.26 kg in HP 813, 3.86 kg in HP 728, 3.35 kg in HP 759 and 3.25 in HP 34. Yield and dry recovery of *P. chaba* were collected from individual vines. The yield ranged from 38-750 g $vine^{-1}$ with a dry recovery ranging from 21.8 - 26.0%.

B. INTERSPECIFIC HYBRIDIZATION IN *PIPER* SPECIES

Laterals of *P. sugandhi* were established in cement tubs and 45 cross combinations involving different cultivated and wild species were attempted.

C. MULTIPLICATION OF DISEASE ESCAPES

Fifty four accessions of Neelamundi (50 OP+4 runners), collected from the hotspot areas of Idukki during 1996, were multiplied for further evaluation.

D. GENETICS OF MENDELIAN TRAITS (LEAF SHAPE) IN BLACK PEPPER

Leaf shape in four species of *Piper* was analysed. The results are given in Table 1.8

Each phenotype (ovate, cordate or elliptical/ oblong leaf shape) may be the result of homozygous arrangement of a particular allele. A heterozygous combination usually produces intermediate type. The parental type occurring in the progenies might be due to selfing.

It is assumed that leaf shape in black pepper is controlled by multiple alleles. Three basic leaf shapes with the following symbols may be recognized.

Cordate	-	C^+C^+
Ovate	-	C^0C^0
Oblong/elliptical	-	cc

Table 1.8. *Genetics of leaf shape in black pepper*

	Group	Leaf shape	
Family-1	(1) Cordate X Ovate	Cordate	Intermediate
	a) Panniyur-1 x Karimunda	5	17
	b) Narayakodi x Neelamundi	7	13
	c) Perambramunda x Karimunda	7	15
	d) Narayakodi x Karimunda	7	13
Family-2	(2) Oblong/elliptical x Ovate	Oblong/ elliptical	Intermediate
	a) Cholamundi x Karimunda	3	19
	b) Cholamundi x Karimunda	6	19
Family-3	(3) Oblong/elliptical x Cordate	oblong/ elliptical	Intermediate
	a) Cholamundi x Panniyur-1	7	15
Family-4	(4) Ovate x Ovate	Ovate	-
	a) Karimunda x Arakulammunda	20	-

GEN. VII.2(813)

BREEDING BLACK PEPPER FOR RESISTANCE TO *PHYTOPHTHORA*, PESTS AND NEMATODES

(P N Ravindran, B Sasikumar, Johnson K George, M Anandaraj, S Devasahayam & Santhosh J Eapen)

Four pollu beetle tolerant lines of black pepper viz. Acc. 816, 841, 1084 and 1114 were multiplied and planted in the field for further evaluation.

GEN. X(813)

BREEDING CARDAMOM FOR HIGH YIELD AND RESISTANCE TO 'KATTE' DISEASE

(Ravindra Mulge & M N Venugopal)

A. Evaluation of selections in MLTs

MLT-1 with Mysore types: Five Mysore type selections along with local checks (CCS-1 & CL-37) were evaluated as a part of MLT under AICRP programme. In the fifth year of CYT the entries did not differ significantly in both vegetative and yield parameters (Table 1.9 & 1.10).

MLT-2 with Malabar types: Thirteen Malabar types identified from RRS, Mudigere, ICRI RC, Saklespur, ICRI, Myladumpara and CRC, Appangala were evaluated along with Malabar and CL-37 seedlings as check. Entries differed significantly for both vegetative growth and yield parameters. Cumulative yield reveals the superiority of CCS-1 followed by CL-37 seedlings, SKP-21 and PV-1 compared to local check (Table 1.11 & 1.12).

B. CYT of hybrids

In the ongoing CYT, six hybrids along with respective parents and one local check

Table 1.9. *MLT-1: Growth parameters*

Entry	Plant height (cm)	No.of leaves	No.of tillers	No. of bearing tillers
SKP-51	222	188	29.5	18.7
MCC-12	223	167	27.7	15.9
MCC-21	205	104	23.6	19.0
MCC-61	171	99	23.0	11.7
MCC-85	202	289	25.7	15.4
CCS-1	189	124	25.0	11.5
CL.37(B)	203	106	23.9	13.1
SEM±	29.43	54.51	3.108	3.05
$LSD_{0.05}$	NS	NS	NS	NS

Table 1.10. *MLT-1 · Yield parameters*

Entry	No.of panicles plant^{-1}	Wet yield (g plant^{-1})			Cum. yield (g plant^{-1})
		1994-95	1995-96	1996-97	
SKP-51	22.9	190	469	83.0	769
MCC-12	20.1	202	521	140.0	863
MCC-21	14.8	147	345	80.0	572
MCC-61	14.7	101	287	73.0	461
MCC-85	19.0	156	547	140.0	843
CCS-I	14.2	279	455	145.0	879
CI.37(B)	15.0	134	527	112 0	773
SEM±	2.521	32.7	88.05	36.7	132.9
$LSD_{0\,05}$	NS	NS	NS	NS	NS

were assessed for growth and yield parameters. Entries did not differ significantly among themselves for plant height, number of leaves, number of bearing tillers, number of panicles and wet yield (Table 1.13).

C. Hybridisation

Seedlings derived from the crosses involving high yielder CCS-1 and disease resistant selections (RR-1, NKE-3, NKE-9, NKE-12, NKE-19 and NKE-26) were raised and seedlings are ready for planting and further evaluation.

D. Multiplication of promising selections

High yielding and qualitatively superior selections viz. APG-221, APG-215, APG-223 and Vazhukka suckers are multiplied vegetatively. Adequate number of clones are available for laying out three advanced yield evaluation trials/MLTs simultaneously, promising disease resistant lines (RR-1 and 5

Table 1.11. *MLT-2: Growth parameters*

Entry	Plant height (cm)	No.of leaves per plant	No.of tillers per plant	No. of bearing tillers per plant
872(CCS-1)	148	89	20.8	13.6
893	128	73	20.3	13.3
800	89	48	13.9	7.9
CL.679	135	64	16.2	11.8
CL.683	180	143	35.6	28.3
CL.726	171	131	30.3	21.0
MUD P-1	179	124	27.4	19.4
PV-1	224	194	41.2	29.7
SKP-14	176	135	30.8	22.8
SKP-72	237	245	40.2	31.2
SKP-21	217	212	34.2	25.1
SKP-100	133	104	31.3	21.9
MCC-34	145	131	26.2	17.6
CL.37 (seedlings)	193	140	24.9	18.2
Malabar bulk	196	187	41.4	30.9
SEM ±	17.16	31.62	4.34	3.65
LSD $_{0.05}$	49.70	91.6	13.13	10.57

NKE entries) were also planted in the clonal nursery for multiplication.

E. Evaluation of disease resistant selections for yield

The yield of disease resistant selections in the five year old trial was collected and cumulative yield data of first, second and third crop were subjected to pooled analysis. In this trial, RR-1, which is a rhizome rot resistant selection, was found to be significantly superior with a mean green yield of 1.631 kg plant^{-1} followed by CCS-1(1.379 kg plant^{-1}) and M-1(1.211 kg plant^{-1}) compared to 0.765 kg plant^{-1} in the local Malabar check (Table 1.14). Five 'Katte' resistant selections viz. NKE-12, NKE-3, NKE-19, NKE-27 and NKE-9 are also found to be significantly superior with mean yield varying from 1.0[illegible] kg to 1.169 kg plant^{-1}. Superiority of CCS-1 over the Malabar type selections (Mudigere-1) was confirmed in this trial warranting its immediate release in the cardamom growing areas of Karnataka and Coorg in particular. Quality characters like driage, fruits to make 1 kg(dry), percentage of bold capsules, number of seeds per fruit and seed and husk ratio have also been collected for the above entries (Table 1.15).

F. Screening of selfed and OP progenies of NKE against mosaic virus

Selfed and OP progenies of top 5 mosaic resistant accessions were screened twice

Table 1.12. *MLT-2: Yield parameters*

Entry	No.of panicles plant^{-1}	Wet yield (g plant^{-1}) 1994-95	1995-96	1996-97	Cum. yield (g plant^{-1})
872(CCS-1)	15.3	161	247	156	564
893	14.1	80	117	60	257
800	09.0	26	74	60	160
CL.679	13.3	33	197	57	287
CL.683	29.0	62	79	55	196
CL.726	23.3	12	79	45	136
MUD P-1	21.8	21	91	53	166
PV-1	30.7	153	235	82	470
SKP-14	23.8	128	142	53	323
SKP-72	32.1	64	167	62	293
SKP-21	26.8	113	328	43	484
SKP-100	23.5	49	107	60	216
MCC-34	19.0	53	83	42	178
CL.37 (Seedlings)	19.5	68	402	69	538
Malabar bulk	23.0	47	281	50	378
SEM±	3.69	48.82	58.83	15.6	76.3
LSD $_{0.05}$	10.688	141.82	170.20	44.90	221.103

Table 1.13. *Hybrids: Yield parameters*

Entry	No.of panicles plant^{-1}	Wet yield (g plant^{-1}) 1994-95	1995-96	1996-97	Cum. yield (g plant^{-1})
800xEB	19.0	87	555	65	707
872xEB	15.5	133	381	83	597
893xEB	14.7	67	361	72	500
EBx800	23.2	183	785	111	1079
EBx872	15.9	124	560	65	749
EBx893	18.3	62	566	84	712
800	24.7	168	168	125	911
872	19.5	74	531	91	696
893	21.5	94	515	143	752
EB(sucker)	15.9	145	383	76	604
CL.37(Seedlings)	18.0	187	626	92	905
SEM±	2.87	42.65	95.08	24.06	127.2
LSD $_{0.05}$	NS	NS	NS	NS	NS

Table 1.14. *Mean yield of disease resistant cardamom collections (green yield plant^{-1} in kg)*

Entry	Mean yield		Entry	Mean yield	
RR-1	1.631	a	NKE-34	0.912	efg
CCS-1	1.379	b	NKE-8	0.900	efg
M-1	1.211	bc	NKE-26	0.887	fg
NKE-12	1.169	c	NKE-72	0.872	g
NKE-3	1.158	c	NKE-4	0.852	g
NKE-19	1.131	cd	NKE-78	0.850	g
MB-3	1.097	cde	NKE-71	0.838	g
NKE-27	1.091	cde	NKE-28	0.795	g
NKE-9	1.073	cdef	MA(Control)	0.765	g
NKE-32	0.938	defg	NKE-11	0.759	g
NKE-31	0.921	efg	NKE-4	0.440	h

$LSD_{0.05}$ = 199.8 Figures followed by the same letter are not significantly different

Table 1.15. *Quality characters of entries in CYT-6*

Entry	Recovery of dry cardamom (%)	No. of seeds fruit^{-1}	Husk/seed ratio	Bold capsules (%)
NKE-3	20.8	19.0	1:2.9	81
NKE-4	21.6	16.1	1:3.1	58
NKE-5	21.8	17.7	1:3.0	73
NKE-8	21.6	16.8	1:3.0	68
NKE-9	20.8	20.6	1:2.9	69
NKE-11	21.4	15.5	1:2.9	66
NKE-12	22.0	20.4	1:3.0	77
NKE-19	21.6	19.2	1:3.0	80
NKE-26	19.8	18.2	1:2.8	68
NKE-27	19.6	20.0	1:2.6	75
NKE-28	19.8	18.2	1:2.8	73
NKE-31	20.8	17.6	1:3.1	81
NKE-32	21.4	16.0	1:2.1	77
NKE-34	22.0	18.0	1:3.5	72
NKE-71	21.4	16.9	1:3.0	67
NKE-72	20.5	16.1	1:2.8	74
NKE-78	21.4	9.9	1:3.1	76
MB-3	21.2	16.8	1:2.7	66
RR-1	20.8	13.3	1:3.1	51
M-1	21.4	15.5	1:2.9	58
CCS-1	21.6	17.9	1:3.0	89
MA(Control)	21.4	15.9	1:3.0	80

using viruliferous aphids. None of the inoculants developed mosaic symptoms after two rounds of screening. The plants are under further screening to confirm their resistance against mosaic virus.

GEN. XIV(813)

CYTOGENETICS AND REPRODUCTIVE BIOLOGY OF GINGER AND TURMERIC

(K P M Dhamayanthi & B Sasikumar)

A. Cytogenetics

Chromosome analysis: One hundred ginger accessions were planted in earthen pots for getting the root material and flower buds to carry out the chromosome analysis of ginger during July 1996. The cytological technique was standardized for getting well spread, well stained metaphase plates in ginger. Root meristem squashes were prepared from fifty ginger accessions. Among the fifty accessions studied, four accessions i.e. Acc. 9(China), 25 (Maran-Potangi), 294 (H.P) and 348 (*Zingiber* sp-cu) possess 'B' chromosomes. The cultivar China possesses the maximum number of 3B chromosomes whereas the other three accessions had one each.

Heterostyly in ginger: Fifty ginger accessions were planted for morphological characterization studies as a part of cataloguing the ginger germplasm. The same accessions were used for studying the heterostylic nature of ginger. During the crop season (Oct-Nov 1996), out of 50 accessions planted 17 flowered and the same were examined for stylar conditions. It was confirmed that all the 17 ginger accessions possessed only 'Pin' type style and none of them had 'Thrum' type of style.

B. Reproductive biology

Studies were initiated for a thorough understanding of the structure and development of male and female gametophytes and the defects or abnormal features associated with the failure of seed set in ginger.

Male gametophytic study: Attempts were made to assess the structure of pollen, pollen production, pollen fertility, germination percentage and pollen tube growth in ginger. Freshly collected pollen grains of cultivated ginger cv. Maran were used for this study. It is characterized with dimorphic pollen grain. The pollen is spheroidal in shape having cerebroid exine sculpturing with an average size of 99 µm and it has thick intine with several germination sites, whereas the sterile pollen grains are smaller in size and devoid of content. Tetrazoluim test as well as acetocarmine test were simultaneously carried out and both revealed almost similar stainability of 38%. Four hundred and eighty pollen grains were counted from 10 microscopic fields and for pollen tube growth 10 pollen tubes, which undergone normal straight growth, were measured using an ocular micrometer 24 hours after keeping in BOD incubator at 26.5° C. The average pollen germination was 29% and average length of the pollen tube was 272 µm. Abnormality in pollen tube growth i.e. 2-5 additional pollen tubes emerge from the same pollen grain and get twisted or coiled after reaching a particular length, was observed in cultivated ginger. Pollen tube tip bursting was also recorded (9%) as an abnormal feature of the pollen tube growth. In total, the level of abnormality recorded was 16% in cultivated ginger. The pollen tube tip twisting was more in the growth medium containing 10% sucrose, 1% gelatin, 100 ppm boric acid and 150 ppm calcium nitrate. These abnormal features of the gametophyte may be one of the reasons for the failure of fertilization in cultivated ginger types. The effect of following media on pollen germination was assessed; i) pollen in distilled water, ii) pollen kept in sucrose alone (5%, 10%, 15%, 20% and 25%), iii) pollen kept in Brewbaker & Kwack's me-

dium, iv) pollen kept in 15% sucrose, 3% gelatin, 80 ppm boric acid and 12 ppm calcium nitrate (basal medium) and v) pollen kept in various growth regulators at different concentrations (IAA: 5 ppm, 10 ppm, 15 ppm, 20 ppm & 25 ppm, GA: 5 ppm, 10 ppm, 15 ppm, 20 ppm & 25 ppm and Kinetin: 5 ppm, 10 ppm, 15 ppm, 20 ppm & 25 ppm). It was standardized that medium containing 15% sucrose, 3% gelatin, 80 ppm boric acid and 120 ppm calcium nitrate was suitable for pollen germination and kept in an optimal medium for 24 hours whereas in other experiments growth regulators had no effect on pollen germination and pollen tube growth. All the above treatments were tried by using hanging drop method suggested by Shivanna *et al.* (1993) and presented in Table 1.16.

Female gametophytic study: The flower buds of cultivar Maran were collected and various stages of the buds were fixed in Cannoy's fluid. Dehydration, infiltration, embedding in wax were done and microtome sections were prepared for the study. It reveals that the ovules are numerous, anatropous, bitegmic, crassinucellate and the ovules are arranged in an axile placentation. The ovule developmental stages reveal the normal cell division and the possibility of high ovule viability.

Comparative male gametophytic studies on diploid (2n) and tetraploid (4n) ginger: In light of incompatibility barrier broken, when the ploidy level gets raised from the normal level, the tetraploid Maran was subjected to a study for structure and development of male gametophyte and compared with diploid ginger cv.Maran. It was observed from the study that tetraploids are highly potential in terms of pollen production, fertility, germinability and the level of abnormality than the diploid and can be exploited for successful fertilization in future programmes (Table 1.17).

c. Pollination studies

Pollination studies were attempted by adopting various assisted pollination methods. Flowers of different stages viz. bud stage i.e. one day prior to flower opening, immediately after flower opening, 1, 2, 3 hrs after flower opening were selected. The stigma was selected as stigma as such or stigma decapitated and the style as half of

Table 1.16. *Pollen germination and tube growth in ginger*

Growth medium		Germination %		
		At room temp.	In BOD at 26.5° C	In moist container kept in BOD at 26.5°C
Distilled water		0	0	0
Sucrose	5%	0	0	0
	10%	0	0	4.3
	15%	0	0	10.5
	20%	0	0	6.3
	25%	0	0	0.10
Brewbaker and Kwack's medium		0.31	0.54	6.18
Basal medium		7.4	10.53	29.00

Table 1.17. *Comparative male gametophytic studies on diploid (2n) and tetraploid (4n) ginger*

Pollen character	Diploid (2n)	Tetraploid (4n)
Pollen structure-shape	Spheroidal	Spheroidal
Av. size	99µm	121 µm
Pollen production	1,78,500	2,85,650
Pollen stainability	38%	65%
Germination	**29%**	**42%**
Av. length of pollen tube (after 24 hours)	272 µm	324 µm
Pollen tube growth abnormalities	16%	**11%**

the style removed or the entire style removed. The fresh mature pollen grains were collected and used in all the cases. The previous test has proved that pollen germination and pollen tube growth were maximum on a medium containing 15% sucrose, 3% gelatin, 50 ppm toric acid and 120 ppm calcium nitrate and kept in a moist container in a BOD incubator set at 26.5° C for 24 hours. But since the maximum pollen tube growth takes place in 24 hours in optimum medium the prepared pollen suspension with media was allowed to grow for 5,10,15 and 20 hours and thus the suspension was applied through a standard painting brush on the stigmatic surface/cut surface of the style. The following methods were used.

i) Dusting the pollen on the stigmatic surface

ii) Application of pollen with sucrose solution 5%, 10%, 15%, 20% and 30%

iii) Application of pollen with Brewbakers & Kwack's medium

iv) Application of pollen with optimum basal medium (15% sucrose, 3% gelatin, 80 ppm boric acid and 12 ppm calcium nitrate)

In each case pollination was done one hour after flower opening supplemented with repeated pollination of 6 times at one hour interval. Each experiment was tried with 5 flowers and repeated thrice as flowers were limited and many accessions had not produced flowers in this season. None of the experiments was found successful. However, the present study provided many basic informations to overcome the failure of fertilization in future programmes. One hour after anther dehiscence, the complete removal of the style resulted in retention of flowers as the indication of the partial success of pollination, where as in other cases the flowers dry and fall down next day morning. These experiments will be repeated with an improved method to achieve successful fertilization.

The effect of IAA, GA, Kinetin in different concentrations viz. 5 ppm, 10 ppm, 15 ppm, 20 ppm and 25 ppm, was studied. However, the results revealed that growth regulators had no effect on pollen germination and tube growth.

HORT. I(813)

VEGETATIVE PROPAGATION OF TREE SPICES

(J Rema, B Krishnamoorthy & P A Mathew)

A. Clove

Ten species related to clove viz. *Syzygium cuminii, S. fruiticosum, S. zeylanicum,*

S. caryophyllatum, S. lapceolatum, S. heynianum, S. munronii, S. aquea, S. jambas and *S. uniflora* were collected and seedlings were raised for grafting with *S.lanceolatum, S.heynianum, S. zeylanicum, S. uniflora, S. jambas, S. cuminii* and *S. fruiticosum* using soft wood and mature scions of clove by cleft method. Initial union has been obtained with *S. cuminii, S. fruiticosum, S. lanceolatum* and *S. zeylanicum* with soft wood scion. However, no successful union was obtained with mature scions.

B. Nutmeg

Seedlings of *Myristica malabarica, M. fragrans* and *M. attenuata* were raised and grafting was carried out on *M. malabarica* and *M. fragrans* using scions from high yielding female trees. Nutmeg grafts were produced using primary and secondary plageotropic and orthotropic scions of the elite tree (Tree no. 20). The grafts produced were utilized for further evaluation. One thousand nutmeg grafts were produced for distribution to farmers.

C. Cinnamon

Variation in the total carbohydrates, total phenols, nitrogen contents, C/N ratios, reducing sugars, non reducing sugars etc. was observed in different periods of the year and this variation could be attributed as one of the causes for the seasonal variation in rooting of cinnamon.

D. Cassia

Cassia could be successfully rooted by softwood cuttings. However, variability in rooting (7-100%) of cuttings of cassia was observed in the different accessions of cassia maintained in the germplasm.

E. Allspice

Leafy shoots of allspice were treated with IBA 500, 1000, 2000 and 5000 ppm in powder formulation with coirdust as medium for induction of rooting. Rooting was observed in cuttings treated with IBA 500 and 1000 ppm and in control. However, the rooting percentage was very low. Terminal shoots of allspice were treated at bimonthly interval with IBA 1000 ppm, IBA 2500 ppm, NAA 1000 ppm, NAA 2500 ppm and IBA 2500 +NAA 2500 ppm, in charcoal for induction of rooting. No rooting was observed till 8

Table. 1.18. *Grafting of black pepper cv. Subhakara on* Piper colubrinum *Link.*

Grafting/ budding method	Leafy scions				Leafless sicions			
	No.	Success		Days for 50% sprouting of scions	No.	Success		Days for 50% sprouting of scions
		No.	%			No.	%	
Cleft	50	31	62.0	41	50	13	26.0	63
Saddle	50	19	38.0	40	50	6	12.0	66
Splice	50	30	60.0	37	25	14	56.0	68
Modified splice	50	17	34.0	45	25	3	12.0	68
Tongue	50	24	40.0	33	25	3	12.0	66
Double	50	39	78.0	29	25	9	36.0	41
Yemma	50	22	44.0	88	0	-	-	-

months in any of the treatments. The experiment is in progress.

HORT. II(813)

UTILIZATION OF *PIPER COLUBRINUM* LINK AND *PIPER ARBOREUM* AS ROOT STOCKS IN THE MANAGEMENT OF FOOT ROT DISEASE OF BLACK PEPPER

(P A Mathew, J Rema, T J Zachariah & Y R Sarma)

Piper colubrinum and *Piper arboreum* root stocks were raised in polybags (25 cm X 15 cm)using hardwood cuttings. The grafting methods tried were cleft, saddle, splice, modified splice, tongue, double and yemma or chip budding. Runner vines of variety Subhakara were used as scion. Both leafy and leafless scions with one or two nodes were used for grafting. Polythene covers were employed to prevent withering of leafy scions. Grafting was done at a height of 30cm from ground level when the root stock attained 50cm height at the hardwood portion because exploratory trials have indicated that tenderness of rootstocks caused abscission of grafted portion at the nodes. The graftings were done from September to January. Gráft success was assessed based on sprouting of scions, three months of grafting. No plant protection chemicals or fertilizers were used in the trial. Among the two root stocks tested, success could be obtained only with *Piper colubrinum* with the various methods tried (Table 1.18). Therefore, tongue approach grafting has been done with *Piper arboreum* root stock.

All the methods of grafting/budding tried were feasible on *Piper colubrinum*. However, better success was noticed with cleft, splice and double grafting methods. The best results were in double grafting where two root stocks were used. The time taken for scion sprouting also varied; the shortest period of 29 days was in double grafting and longest period of 88 days was recorded with yemma budding. Use of leafless scions indicated poor success in grafting and delayed sprouting of scions. The growth of the scion has been found to be very good with normal healthy leaves. Exploratory trials in the initial stages showed that if the grafting is done on tender, non mature portions the whole graft abscissed at the nearest node. Hence grafting has to be done only on the mature stem of root stock. Two noded scions sprouted faster than single noded scions. However, single noded scions can be used whenever it is necessary to economise planting material.

HORT. III(813)

DEVELOPMENT OF PAPRIKA FOR WARM HUMID TROPICS

(P A Mathew, K V Peter & T J Zacharia)

A. Collection of germplasm

Paprika germplasm from various sources was assembled during the year. The present collection consists of 55 exotic types from Germany and USA, 12 indigenous types and 126 single plant accessions of Byadagi Dabha cultivar from Dharwad District, totalling 193 collections. Since the seeds received were few, efforts were made to plant them in polybags and multiply by selfing. Seeds are thus being collected in all the lines.

A field survey was carried out during December in Dharwad District where Bydagi Dabha chillies are being grown covering 13 villages. These chillies are known for low pungency and high colour. A total of 126 single plant collections were made. Seedlings were raised from these and have been planted in field for evaluation. However, fruit samples collected from these villages were analysed for colour values which ranged from 42654 (Acc. 5-3) Nesselemetric colour value to 2,15,603 (Acc. 7-10) (Table 1.19). The reported colour values range from

Table 1.19. *Paprika accessions with high colour values*

Accession	Colour value (Nesslemetric value)
7-10	2,15,603
12-6	2,06,849
3-6	1.79,950
7-20	1,68,413
4-3	1,66,055
7-21	1,61,396
7-6	1,59,787
3-9	1,48,443
5-3	42,654

40,000 to 1,00,000 only. Considering this there is good scope for selecting types with very high values for colour.

BIOTECH. I(813)

TISSUE CULTURE FOR RAPID MULTIPLICATION AND EVALUATION OF ELITE CLONES OF CARDAMOM

(Ravindra Mulge & M N Venugopal)

A. Field evaluation of somaclones

Three hundred and fifty somaclones derived from a hybrid (Extra bold x PV-1) have been established in the field for evaluation.

B. Production of somaclones

Totally 400 fresh somaclones were produced and plants are under the process of hardening in the green house.

C. Induction of callus in elite clones

Six elite lines were tried for induction of callus using rhizome buds as explants. So far callus cultures of RR-1 and NKE-9 have been established.

D. Screening of somaclones against mosaic virus

A total of 328 somaclones have been screened against mosaic virus through viruliferous aphids (5 apterates somaclone^{-1}) carrying local severe isolate. All plants took infection within 2 rounds of screening.

BIOTECH. II(813)

IN VITRO SELECTION FOR RESISTANCE TO SOFT ROT AND BACTERIAL WILT IN GINGER

(K Nirmal Babu & G N Dake)

A. Production and multiplication of somaclones

Over one hundred somaclones were transferred to field during the year. They are mainly from anther derived callus. Over 500 cultures each of ovary derived somaclones and anther derived somaclones are in various stages of multiplication.

B. Field evaluation of rhizome rot escapes

A promising rhizome rot escape, MP 61.9 gave a per plant yield of 870g fresh weight.

C. Anther culture

A large number (over 500) of anther derived plantlets are in various stages of multiplication.

D. Isolation of protoplasts

Protoplasts were successfully isolated for the first time, from both cell suspension culture as well as *in vitro* derived leaf mesophyll. The protoplast yield was high (1.0 - 2.5 x 10 g^{-1} of leaf) and the viability was 55-72%. The enzyme mixture used was 0.5 - 1.0% macerozyme R10 + 3.0% Hemicellulase + 5-6% onozuka cellulase R10, with 16-18h incubation. Initially the cultures were incubated at 15°C for 10 hours and later at 30°C for rest of the time.

E. Optimization of biolistic process for transient expression of GUS

Transient expression of GUS (B - glucurobidase) was successfully induced in ginger embryogenic callus using biolistic particle gun. The vector used was PAHC 25 with maize ubiquitin (Ubi -1) promoter. The optimum rupture disc pressure was 900 psi and target distance was 9cm. This has tremendous potential in future transformation experiments.

BIOTECH III(813)

MICROPROPAGATION OF BLACK PEPPER

(J Rema & K Nirmal Babu)

A field trial was laid out in the experimental farm of Indian Institute of Spices Research to evaluate the performance of micropropagated black pepper cv.Karimunda against rooted cuttings of Karimunda. One hundred *in vitro* raised plantlets of black pepper cv.Karimunda were hardened and maintained for field transfer. Four pepper varieties viz. Sreekara, Subhakara, Panchami and Pournami are under various stages of multiplication for undertaking field trials in subsequent years. Cost of production of *in vitro* raised black pepper was estimated to be Rs.8.75. The cost of production was worked out taking into consideration the fixed and variable cost for production of ten lakh cuttings in a period of 10 years (Table 1.20).

BIOTECH. IV(813)

BIOTECHNOLOGICAL APPROACHES FOR CROP IMPROVEMENT IN BLACK PEPPER

(K Nirmal Babu, J Rema, B Sasikumar & P N Ravindran)

A. Production of somaclones

Over 75 cultures of somaclones are in various stages of multiplication. About 500 cultures of black pepper embryos were established to standardize protocol for direct somatic embryogenesis.

Table 1.20. *Cost of production of black pepper plantlets through tissue culture*

Item	Cost(Rs)
Investment during establishment	16,14,200
Interest @ 15% compounded	2,42,130
Total investment	18,56,330
Annuity value @15%	3,69,882
Annual maintenance cost	5,05,200
Total cost/year	8,75,082
Averoge number of plantlets year^{-1}	1,00,000
Cost per plantlet	8.75

B. Genetic transformation using biolistics

Optimization of biolistic protocol was done using small cardamom as a model system. Transient expression of GUS was induced in callus cultures at a target distance of 6-9 cm and a rupture disc pressure of 900-1100 psi. The construct used vector was PAHC 25.

C. Kanamycin sensitivity assay

Preliminary studies showed that Kanamycin at concentration of above 250 mg ml^{-1} was toxic.

D. Cell and protoplast culture

Cell suspension cultures were established in black pepper and protoplasts were successfully isolated from *in vitro* derived leaves. Further studies on their growth and development are in progress.

BIOTECH V(813)

IN VITRO CONSERVATION OF SPICES GERMPLASM

(K Nirmal Babu, J Rema, P N Ravindrun & Johnson K George)

All the existing cultures (about 350 accessions) in *in vitro* gene bank were subcultured into fresh medium this year. About 20 accessions of turmeric, 30 lines of vanilla, 14 lines of paprika were added to the *in vitro* gene bank this year. Two high elevation species of *Piper, P. wightii* and *P. schmiditii* were also added to the *in vitro* gene bank as embryo cultures.

BIOTECH. VI(813)

RAPID CLONAL MULTIPLICATION OF TREE SPICES

(J Rema, K Nirmal Babu & P N Ravindran)

Mature explants of cassia and seedling explants of clove, all spice, cassia and nutmeg were established in Woody Plants Media supplemented with kinetin 1mgl^{-1}. Multiple shoots were induced in seedling explants of allspice and clove and mature shoots of cassia. The shoots were transferred to rooting media for induction of rooting. Callus produced from immature seeds of cinnamon produced somatic embryos. Calli were initiated from leaf segments of allspice and clove and were transferred to regeneration media.

ICAR ADHOC PROJECT 1

DEVELOPMENTAL MORPHOLOGY OF RHIZOMES OF GINGER AND TURMERIC

(P N Ravindran, A B Remashree & K K Sherlija in collaboration with K Unnikrishnan, Dept. of Botany, Calicut University)

A. Ginger

Comparative morphology and anatomy of four species of *Zingiber* and turmeric were studied. Histochemical localization of carbohydrates, starch, proteins, fats and oils and fibers were carried out. *Zingiber officinale* and *Z. zerumbet* showed greater accumulation of carbohydrates than *Z. roseum* and *Z. macrostachynum* and the same result was observed in the case of starch deposition also. Proteins stain more in all the meristamatic regions and phloem areas. We could not make out much variation between species.

The oil cells are more in *Z. officinale* followed by *Z. zerumbet, Z. roseum* and least in *Z. macrostachyum*. The apical and nodal regions were having a higher number of oil cells than in the internodal region but the cell size is inversely proportionate to the number of cells.

Greater fiber content is observed in *Z. zerumbet* followed by *Z. macrostachyum*. *Z. officinale* and *Z. roseum* showed comparatively less amount of fibers. The dimensional values of fiber show that *Z. zerumbet* has the highest fiber length, width and wall thickness.

Tetra cytic stomata are found in all the four species. In this the first two subsidiary cells are parallel and rest of the two cells lie right angle to the guard cells. In *Zingiber* species the veins are parallel. But the midvein is thicker than the other lateral veins except in *Z. officinale*. The leaves are isobilateral in all the species.

B. Turmeric

Four species of turmeric namely *Curcuma longa, C. aromatica, C. amada* and *C. zedoaria* were compared anatomically. All these species show more or less the same anatomical characters. However, the number and arrangement of primary vascular bundles, secondary vascular bundles and orientation of endodermoid layer, number and shape of starch grains, number and size of curcumin

cells etc. showed variations in different species. Large number of primary vascular bundles occurs scattered in both outer and inner zone in *C. longa* and *C. amada;* the number is less in *C. zedoaria* and very few in *C. aromatica.* The endodermoid layer forms continuous circle along with pericycle in *C. longa* and more or less circular in *C. amada.* But in *C. aromatica* and *C. zedoaria,* this layer is discontinuous and vary in nature. Due to the broken nature of endodermoid layer, the secondary vascular bundles are arranged in patches in these two species and not in a continuous zone as observed in *C. longa* and *C. amada.* The number, size and shape of starch grains vary in each species, and this is found to be an important distinguishing character among the species. Observations have shown that maximum number and size of curcumin cells are found in *C. longa* compared to other species.

Some *Curcuma* species possess root tubers at the tip or middle portion of adventitious root. The root tuber development takes place by the activity of pericyclic layer, present below the endodermis, which becomes meristematic and divide 2-3 layers and produces vascular elements and parenchyma cells. Due to the active division and enlargement of these parenchyma cells, the root tuber become fleshy.

ICAR ADHOC PROJECT 2

PRODUCTION OF SOMACLONES AND SOMATIC HYBRIDS OF CARDAMOM (*ELETTARIA CARDAMOMUM* MATON)FOR HIGH YIELD AND RESISTANCE TO DISEASES

(K V Peter, Ravindra Mulge, Geetha S Pillai & P Indulekha)

Callus cultures could be established from suckers, rhizomes, panicles and leaf explants of six selected cardamom lines viz. CCS-1, 6/13, RR-1, NKE-9, CL-37 selections 800 and 893. Plants could be regenerated from callus cultures of cardamom (CL-37 x PV-1), which exhibited three distinct morphotypes in cultures. About 500 regenerating cultures are being maintained for continuous production of somaclones. About 200 somaclones were transferred to soil for hardening.

Protoplasts were isolated from *in vitro* derived leaf tissue. Fragile callus of 3.8 X 10^5 per g leaf tissue with 75% viability was obtained in an enzyme solution containing 0.5% macerozyme R10 and 2.0% Nozuka cellulase R10. Callus tissue and cell suspension cultures yielded 1.5 X 10^5 protoplasts per g tissue with 40% viability in an enzyme solution containing 1.0% macerozyme R10 and 2% Nozuka cellulase R10. The protoplasts regenerated cell wall and the cells divided to form microcalli.

Cultures were established from rhizome bud explants of *Hedychium* species as source tissue for protoplast isolation.

ICAR ADHOC PROJECT 3

DEVELOPING HARDENING PROTOCOLS FOR TISSUE CULTURED PLANTS OF SPICES

(J Rema, P N Ravindran, D Minoo, A Sajina & P Indulekha)

Work on establishment of hardening facility with controlled light, humidity and temperature has been initiated. About 100 cultures each of black pepper, long pepper, cardamom, ginger, camphor, ocimum and mentha are being multiplied to develop sufficient planting materials. Two hundred rooted plantlets of black pepper and cardamom are ready for hardening experiments under controlled conditions. Initial anatomical studies revealed poorly developed vascular tissues of the leaf and stem in *in vitro* raised plantlets of black pepper.

CROP PRODUCTION AND POST HARVEST TECHNOLOGY

This division has undertaken 15 research projects including three externally funded projects. The projects are eight in Agronomy, one each in Soil Science, Physiology, Biochemistry and Post Harvest Technology. The salient achievements during the year are:

In a cropping system involving nutmeg and black pepper, the consumptive use of water for black pepper vine ranged from 2.5 to 3.0 mm day^{-1} during January to May and for nutmeg 3.0 to 3.5 mm day^{-1}. Irrigation of black pepper @7 l day^{-1} during October to March increased the yield. In cardamom based cropping system, yield of cardamom as a sole crop was higher than mixed crop yield. Among different sources of potassium, potassium sulphate was found better for black pepper and response of two released varieties Sreekara and Subhakara to fertilizer was better with NPK dose of 150:60:270 with Zn, B and Mo @ 5:2:1 kg ha^{-1}. Application of Zn, B, & Mo @ 5:2:1 kg ha^{-1} for ginger and turmeric increased the yield by 35% and 41%, respectively. The relative agronomic efficiency of different sources of rock phosphate did not show any significant difference. In the trial with biofertilizers, application of *Azospirillum*, phosphobacteria and VAM, the combination of all the three recorded enhanced growth.

Bush pepper planted in the field

Among 10 varieties of black pepper tried for

their growth and yield performance, Subhakara and Panniyur-1 were found to be superior.

Cultivation of bush pepper at 2m spacing with a population of 2500 plants ha^{-1} and application of NPK @ 10:5:70 g $bush^{-1}$ twice a year (i.e. during May and September) recorded 3288 kg of black pepper ha^{-1} in Panniyur-1 and 2500 kg ha^{-1} in Subhakara.

Black pepper accessions 1114 and 4057 showed better stress tolerance as indicated by stomatal resistance, traspiration rate, cell membrane stability and activity of three enzymes viz. catalase, peroxidase and superoxide dismutase.

In black pepper, maximum accumulation of essential oil, oleoresin and piperine was recorded at 170-180 days after flowering. Phenylalanine Ammonia Lyase (PAL) was identified as the key enzyme in the formation of secondary metabolites. PAL activity in rhizomes of 6 varieties of turmeric indicated rhizome as the probable site of synthesis of precursors of curcumin. High levels of volatile oils and oleoresin were seen 120-170 DAG and stabilized towards maturity. In ginger Acc. 15 and 17 had 2% oleoresin Acc. 117 and 179 had 4% crude fibre. Essential oil and oleoresin contents were high during 120-130 days after maturity and declined thereafter.

The newly released variety, Varada was promising for making salted ginger compared to Maran and Sabarimala.

Isozyme characterisation in ginger and turmeric accessions indicated that accessions from one geographical area showed more similarity. Turmeric accessions showed more variability than ginger.

Apart from these, planting materials were distributed to various developmental agencies and farmers.

Salted Ginger

AGR. VI(813)

STUDIES ON THE IMPACT OF INPUT TECHNOLOGIES ON THE YIELD PERFORMANCE AND QUALITY ATTRIBUTES OF BLACK PEPPER

(K Sivaraman, K Kandiannan, A K Sadanandan & K S Krishnamurthy)

A. Irrigation requirement of black pepper

As in the previous years irrigating black pepper vines @ 7 l per day per vine through drip between October to May recorded maximum yield of green pepper per vine (4.07 kg) compared to control (1.33 kg vine^{-1}) in the field experiment. In general, drip irrigation was far superior to other types of irrigation.

B. Agro-physiological studies

The growth parameters and yield recorded during the third year of planting indicated that the performance of Subhakara was superior compared to other tested cultivars (Table 2.1).

Table 2.1. *Growth and yield of black pepper varieties during third year of planting*

Variety	Canopy height (cm)	Canopy radius (cm)	Total laterals vine^{-1}	No. of spikes lateral^{-1}	Green yield (g vine^{-1})
Subhakara	400.3	37.2	18.6	5.6	1229
Sreekara	356.7	38.8	15.8	4.8	185
Panchami	308.6	39.4	15.5	1.2	89
Pournami	309.5	41.0	12.8	3.4	466
P-24	408.9	46.0	10.1	3.0	82
Panniyur-1	377.8	41.8	16.3	0.7	547
Panniyur-2	322.9	47.1	15.9	0.1	70
Panniyur-3	307.4	38.2	13.2	0.7	94
Panniyur-4	229.0	38.8	14.9	0.7	530
Panniyur-5	333.3	53.0	14.0	1.2	187
$LSD_{0.05}$	27.1	5.9	2.3	1.2	198.4

Protiens, total phenols, total free amino acids and total non-structural carbohydrates were analysed at bimonthly intervals in ten released varieties of black pepper. In general, all varieties showed similar trend with respect to the accumulation of these metabolites. Protein content was high during June, then started declining, again showed little increase in October and December and then reached the lowest level in February (Table 2.2).

Sreekara and Subhakara maintained the highest level at all stages. All varieties recorded high amount of total phenols during June and August. The lowest amount was recorded in December which coincided with the berry maturity. Total free amino acids was low in June (Table 2.3). No specific trend was noticed with respect to accumulation pattern of amino acids. All varieties maintained high levels in October and February. Sreekara accumulated the

Table 2.2. *Protein content (mg g^{-1} dw) of released varieties of black pepper during different months*

Variety	Sampling month				
	June	August	October	December	February
Subhakara	217.0	98.1	133.7	139.9	68.9
Panniyur - 1	186.2	82.9	131.6	145.5	79.3
Panniyur - 4	193.6	82.1	144.3	131.8	79.0
P-24	195.5	93.4	130.5	107.2	69.8
Panniyur - 2	184.5	90.2	133.0	122.1	75.1
Pournami	177.7	98.0	138.6	114.8	77.7
Panniyur - 3	187.6	98.9	136.2	128.7	83.7
Panchami	170.7	104.4	130.5	125.2	74.7
Panniyur - 5	166.3	90.8	123.4	129.1	72.9
Sreekara	215.5	100.0	139.1	146.7	80.3
$LSD_{0.05}$	10.26	12.4	10.3	9.2	7.46

Table 2.3. *Free amino acids (mg g^{-1} dw) content of released black pepper varieties*

Variety	Sampling month				
	June	August	October	December	February
Subhakara	120.23	149.58	211.71	121.14	201.23
Panniyur-1	79.07	138.34	249.73	86.41	161.43
Panniyur-4	66.80	140.38	248.29	95.29	159.3
P-24	76./10	123.67	201.95	110.80	171.19
Panniyur-2	95.46	136.12	233.53	105.38	176.39
Pournami	155.40	94..44	283.70	114.53	186.43
Panniyur-3	138.38	75.13	193.44	109.48	21.79
Panchami	157.82	106.68	207.85	116.66	111.65
Panniyur-5	162.93	99.15	181.85	92.11	148.85
Sreekara	160.34	118.98	265.09	95.27	259.19
$LSD_{0.05}$	13.13	20.15	23.95	10.26	14.89

maximum amount at all stages. Total non-structural carbohydrates was low in June then increased in August in all varieties . After August, some varieties showed increase while others maintained the same level. Sreekara recorded the maximum

amount at all stages. In general, Sreekara, Subhakara and Panniyur-1 were superior with respect to these metabolities.

AGR. XIV(813)

INVESTIGATIONS ON SPICES BASED CROPPING SYSTEMS

(V S Korikanthimath, Rajendra Hegde, K Sivaraman, M N Venugopal & A K Sadanandan)

During the year 1996-97, the growth characters and yield of cardamom and component crops like pepper and arabica coffee were recorded. The impact of crop combination on build up of soil borne disease was recorded in each crop combination.

A. Growth and yield of component crops

During the year, cardamom as a sole crop continued to record the highest yield of 345.62 kg (dry) ha^{-1} followed by combination of cardamom with clove (293.92 kg (dry)ha^{-1}) and cardamom+nutmeg (231.06 kg (dry)ha^{-1}). The lowest cardamom yield of 162.54kg (dry) ha^{-1} was in the cardamom and cinnamon combination. Arabica coffee (Cuttimora-Cauvery) as a sole crop recorded the maximum yield (1913 kg dry berry ha^{-1}) compared to 196 kg ha^{-1} in coffee mix cropped with cardamom. Pepper mix cropped with cardamom recorded 115kg (dry) ha^{-1}. Flowering and fruit set were was observed in 32 per cent of allspice plants mix cropped with cardamom.

B. Dynamics of soil fertility (Table 2.4)

pH: Cardamom and nutmeg combination at both the depths (0-15 and 15-30 cm) showed higher pH than all other combinations. In case of cardamom+nutmeg, cardamom+ allspice and cardamom+cinnamon, pH decreased with soil depth whereas in other combinations either the pH remained unchanged or increased with depth.

Organic carbon: When compared to uncultivaed check, all the crop combinations showed better organic carbon accumulation and nutmeg in combination with cardamom showed the highest organic carbon content in the top 15 cm layer.

Phosphorus: Crop combination involving cardamom+nutmeg, cardamom+clove and cardamom + cinnamon showed higher phosphorus content in the rhizosphere compared to all other combinations and check. Combination of cardamom with allspice, pepper and coffee as well as sole crops of coffee and cardamom contained lesser phosphorus than even the check at both the depths of rhizosphere.

Potassium: When compared to uncultivated check all the crop combinations excluding cardamom and coffee, cardamom and allspice contained high potassium in the rhizosphere. In general, there was a decrease in potassium content of soil with increased depth, excepting the sole crop of cardamom and check plots.

Calcium: Excepting allspice in combination with cardamom and sole crop of coffee, all other crop combinations contained higher calcium content when compared to check and in general, it decreased with depth in all the combinations.

Magnesium : Cardamom in combination with nutmeg and clove contained higher magnesium when compared to all other combinations and check. In general, its content also decreased with depth.

Iron: Sole crop of cardamom at both the depths contained less iron than the check. In all the other combinations it was higher than the check.

Manganese: Cardamom in combination with cinnamon showed higher accumulation of manganese when compared to all other combinations and check plot. Reduction in its content was more drastic in combination

Table 2.4. *Dynamics of soil fertility in cardamom based cropping systems*

Treatment	Sample depth	pH	Org.C (%)	P	K	Ca	Mg	Fe	Mn	Zn	Cu
							(ppm)				
Cardamom + Nutmeg (Cardamom)	0-15	5.55	2.49	13.8	135	954	18549	24	1.0	10.4	-
	15-30	4.87	1.15	11.4	71	56	122	43	12.6	3.60	3.09
Cardamom + Nutmeg (Nutmeg)	0-15	5.25	2.86	13.4	222	1049	69	53	24.1	0.90	7.78
	15-30	5.26	2.54	11.9	213	998	168	46	19.2	0.92	9.00
Cardamom + Clove (Cardamom)	0-15	4.30	2.40	16.8	159	562	74	57	19.1	0.72	3.38
	15-30	4.41	1.54	11.0	108	480	48	32	11.2	0.32	11.60
Cardamom + Clove (Clove)	0-15	4.50	2.69	11.2	147	871	201	36	23.8	1.86	6.94
	15-30	4.63	2.07	9.8	136	739	120	55	22.7	0.94	9.80
Cardamom + Allspice (Cardamom)	0-15	5.07	1.70	6.6	59	848	123	52	20.9	0.66	7.62
	15-30	5.07	1.63	6.1	18	602	68	44	17.1	0.28	2.58
Cardamom + Allspice (Allspice)	0-15	4.90	1.37	6.2	222	714	118	56	20.9	0.92	5.38
	15-30	4.58	1.10	5.7	130	561	61	38	18.5	0.34	2.42
Cardamom+Cinnamon(Cardamom)	0-15	4.50	2.43	11.9	40	725	120	58	26.0	1.04	7.24
	15-30	4.26	2.29	9.7	58	708	107	63	26.0	1.02	9.20
Cardamom+Cinnamon(Cinnamon)	0-15	4.74	2.25	7.8	83	864	174	56	22.1	0.88	2.92
	15-30	4.57	1.32	7.8	43	517	77	40	13.2	0.30	4.89
Cardamom + Pepper (Cardamom)	0-15	4.90	2.47	5.8	72	951	148	52	16.4	1.16	11.60
	15-30	5.00	1.76	6.0	5	646	62	48	8.9	0.48	2.16
Cardamom + Pepper (Pepper)	0-15	5.02	2.21	8.9	94	818	114	49	14.0	0.76	6.18
	15-30	4.76	1.50	8.4	51	568	62	31	6.8	0.28	1.58
Cardamom + Coffee (Cardamom)	0-15	4.85	2.13	6.3	57	799	112	50	19.6	0.44	4.69
	15-30	4.83	1.46	6.3	30	560	57	40	10.7	0.30	2.60
Cardamom + Coffee (Coffee)	0-15	4.68	2.07	6.3	212	889	112	53	25.6	0.98	10.00
	15-30	4.82	1.48	6.1	75	596	59	47	13.7	0.44	3.80
Coffee (Sole crap)	0-15	4.31	2.14	6.0	116	750	84	32	16.4	0.92	9.00
	15-30	4.36	0.82	5.5	77	646	49	16	4.9	0.46	3.16
Cardamam (Sole crop)	0-15	4.88	2.64	5.4	180	864	131	55	15.6	0.76	3.22
	15-30	5.28	1.81	5.5	225	796	147	49	9.8	0.62	2.78
Bulk (Sole crop)	0-15	4.87	1.05	7.2	64	805	158	41	23.2	0.60	3.18
	15-30	4.80	1.04	8.5	73	631	107	29	11.2	0.21	1.18

involving cardamom + pepper and sole of coffee at higher depths.

Zinc: Except for coffee + cardamom combination, zinc content showed increased levels in all the crop combinations when compared to check.

Copper : When compared to uncultivated check, all the crop combinations, particularly the rhizosphere of cardamom, showed higher accumulation of copper. This may be mainly due to the Bordeaux mixture sprays given to crops.

c. Dynamics of microflora (Table 2.5)

Bacteria: Vertically as well as laterally, away from the rhizospere, the population of bacteria got reduced. Cardamom in combination with cinnamon and coffee contained higher number of bacteria. Cardamom in combination with clove and nutmeg resulted in lesser number of bacterial population compared to sole crop of cardamom or coffee.

Fungi: In case of fungi also, their population showed reduction away from the rhizospere both in horizontal and vertical distance. Cardamom in combination with cinnamon, pepper and coffee contained higher fungal population than all others. Cardamom in combination with nutmeg and clove showed very poor fungal population, even less than sole crop of coffee or cardamom.

Actinomycetes: Vertical and horizontal distribution pattern of actinomycetes followed the same pattern as that of fungi and bacteria. Highest population of these were noticed in the rhizospheres of cardamom + coffee, cardamom + pepper and cardamom + cinnamon. Very low population of these were found in the rhizosphere of sole crop of coffee.

d. Disease incidence in the cropping system

Incidence of various diseases of main and component crops was recorded during mid and post-monsoon periods using 0-5 rating scale which is based on percentage of infected area. Mosaic infection in the main crop was also recorded and it occured randomly in only two blocks depending on access to inoculum source and alate virulifer-ous aphids.

Since the component crops are yet to develop their canopy, their effect on the diseases of main crop can not be assessed at present. However, some of the common diseases of importance on main and component crops were recorded. Among these, leaf blight of cardamom, anthracnose of pepper, leaf spot of clove and cinnamon are reported to be caused by *Colletotrichum gloesporioides.*

AGR. XVI(813)

IRRIGATION REQUIREMENT OF SPICES BASED CROPPING SYSTEM UNDER COCONUT CANOPY

(K Sivaraman & K Kandiannan)

A group meeting was organised as per the decision of X SRC. As a follow up, action has been initiated to purchase West Coast Tall coconut seedlings (400 numbers) from CPCRI, Kasaragod. The pepper standards (*Ailanthus*) were gap filled and maintained.

AGR. XVII(813)

VERMICOMPOST PRODUCTION USING ORGANIC WASTES AVAILABLE IN CARDAMOM AREAS

(Rajendra Hegde, V S Korikanthimath & S J Anke Gowda)

During the year a study was undertaken to compare the effectiveness of vermicompost vs. normal compost on growth performance of cardamom clones. There were no significant differences in plant height, leafiness and tillering either due to compost or vermicompost after three

Table 2.5. *Rhizosphere microflora population in cardamom based spice cropping systems*

Crop combination	Organism	Microbial population in the rhizosphere at			
		Lateral distance (cm)		Vertical depth (cm)	
		0-15	15-30	0-15	15-30
Cardamom + Nutmeg	B	20.88	17.80	14.75	12.63
	F	22.00	17.75	17.25	14.75
	A	31.00	19.75	19.00	11.13
Cardamom+Clove	B	19.35	18.25	21.00	17.25
	F	17.00	16.38	15.38	15.62
	A	21.00	17.88	16.37	13.62
Cardamom+Allspice	B	32.25	23.62	14.87	14.37
	F	31.00	23.75	19.75	12.25
	A	20.00	19.88	15.00	12.25
Cardamom+Cinnamon	B	47.50	41.62	40.12	36.75
	F	55.25	51.12	45.75	42.38
	A	50.87	49.87	38.62	37.75
Cardamom + Pepper	B	44.50	42.62	40.62	39.75
	F	54.25	51.12	45.75	42.00
	A	50.87	49.87	38.62	37.75
Cardamom + Coffee	B	47.88	45.12	43.37	35.62
	F	49.12	40.50	39.62	35.50
	A	53.75	46.37	47.50	38.25
Cardamom sole crop	B	29.75	24.00	23.75	24.00
	F	27.87	23.37	37.00	27.87
	A	32.00	26.50	25.37	22.87
Coffee sole crop	B	24.12	23.60	18.75	16.87
	F	29.75	23. 37	22.87	18.75
	A	13.62	10.35	11.46	10.25

Values are means of 8 replicotions F=Fungi (10^3); B=Bacteria (10^5); A=Actinomycetes (10^4)

months. An effort was made to compare the efficiency of anaerobic method of composting (Bangalore method) vs. vermicomposting. The cost of vermicompost was Rs. 3.50 per kg compared to Rs. 1.50 per kg of ordinary compost. In various other organisations also, the cost of production of vermicompost is more than double that of anaerobic method. This is mainly due to labour intensive nature of operations. It was also found that vermicompost contained more number of phosphate solubilizing bacteria

and *Trichoderma* fungi. Anaerobically prepared compost contained more number of actinomycetes. Biomass production for nutrient recycling was attempted by growing Co-1 grass in a quarter acre land.

AGR. XVIII(813)

BIOFERTILIZER APPLICATION ON GROWTH, YIELD AND QUALITY OF BLACK PEPPER

(K Kandiannan, K Sivaraman, M Anandaraj & K S Krishnamurthy)

An experiment with eight treatments comprising of individual as well as combined inoculation of biofertilizers viz. *Azospirillum*, phophobacteria and vesicular arbuscular mycorrhizae (VAM) along with uninoculated control was initiated to evaluate their effect on black pepper growth under nursery conditions. Growth characters like height, number of leaves and leaf area were recorded at three and six months after planting. Combined application of all the three biofertilizers recorded maximum growth compared to other treatments (Table 2.6). Uninoculated control recorded minimum values and it is on par with individual application of biofertilizers.

Table 2.6. *Effect of biofertilizers on the growth of black pepper*

Treatment	At 3 months			At 6 months		
	Height (cm)	No.of leaves	Leaf area (cm^2)	Height (cm)	No.of leaves	Leaf area (cm^2)
Azospirillum (Azo)	23.0	4.1	116.6	50.9	7.7	244.7
Phosphobacteria (Phospho)	23.6	4.1	119.5	51.5	8.2	255.7
VAM	25.5	4.3	120.2	53.2	8.6	279.3
Azo+Phospho	25.7	5.1	134.3	54.7	8.7	280.5
Azo+VAM	28.3	5.1	134.8	61.3	9.1	290.4
Phospho + VAM	30.2	5.3	150.2	66.6	9.3	309.9
Azo + Phospho + VAM	32.9	5.3	155.9	77.0	9.4	343.5
Control	18.9	3.9	111.7	45.6	7.7	235.0
$LSD_{0.05}$	7.7	1.0	30.0	17.6	NS	66.3

AGR. XIX(813)

MANAGEMENT EFFICACY OF WHOLE FARM APPROACH IN FARMING - A STUDY ON CARDAMOM BASED FARMING SYSTEM

(Rajendra Hegde, P Rajeev & V S Korikanthimath)

During the year about 170 plants of *Garcinia gummigutta* and *Artocarpus lakoocha* were planted in an existing cardamom plantation at 3x3m spacing. Green manure crops viz. *Crotalaria juncea, Sesbania aculeata, Sesbania aegipitca* were sown in between the rows of cardamom for biomass production and nutrient recycling. Vanilla plants were planted and five honey bee colonies were established. However, due to Thai-sac brood disease all the colonies perished. Fresh efforts are on for re-establishment. Four hundred arecanut and 100 banana plants were planted to develop a multistoryed cropping system. Pepper varietal mixture is to be planted and to be trained on to all the

existing shade trees. Large number of arabica as well as robusta coffee seedlings are being raised to establish coffee plantation under the project.

AGR. XX(813)

PRODUCTION OF NUCLEUS PLANTING MATERIAL OF IMPROVED VARIETIES OF SPICE CROPS

(K Sivaraman, V S Korikanthimath, K Kandiannan, P A Mathew & P Rajeev)

Improved varieties of black pepper, turmeric, ginger, cardamom, nutmeg, clove, cinnamon and cuttings of vanilla are produced and distributed to various developmental agencies and progressive farmers in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Orissa and Andaman & Nicobar Islands. The details are given in Table 2.7.

Table 2.7. *Planting materials produced and distributed from Indian Institute of Spices Research during 1996-97*

Crop	Quanitity
Black pepper rooted cuttings	75,000Nos
Black pepper rooted laterols	700Nos
Turmeric seed rhizomes	20 tonnes
Ginger seed rhizomes	2 tonnes
Cinnamon seedlings	2000Nos
Clove seedlings	1000 Nos
Nutmeg grafts	500 Nos
Vanilla cuttings	500 Nos
Cardamom seedlings	15,000 Nos
Cardamom seed capsules	210 kg

SSC. II(813)

NUTRITIONAL REQUIREMENT OF IMPROVED VARIETIES OF SPICES

(A K Sadanandan, K S Krishnamurthy & K Sivaraman)

A. INORGANIC NUTRITION OF SPICES

Nutritional requirement of improved varieties of black pepper : Response of improved varieties of black pepper (cv. Sreekara and Subhakara) to graded doses of NPK and micro nutrients was studied. Application of NPK @ 150, 60 and 270 kg ha^{-1} with micro mutrients Zn, B and Mo @ 5, 2 and 1 kg ha^{-1} increased the soil availability of nutrients and recorded the highest yield (1.42 t ha^{-1}) during the third year. Pepper trailed on living standard, *Garuga pinnata* gave higher yield (1.04 t ha^{-1}) compared to non living standard (RCC post - 0.71 t ha^{-1}). Among the varieties, Subhakara gave significantly high yield (0.968 t ha^{-1}) compared to Sreekara (0.790 t ha^{-1}) (Fig 2.1).

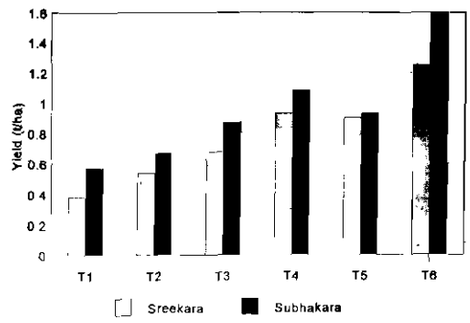


Fig. 2.1. *Respones of two improved varieties of black pepper to fertilizers and micronutrients (T1-Check, T2-NPK @ 50:20:90, T3-NPK @ 100:40:180, T4-NPK @ 150:60:270:, T5-T2+Zn+B+Mo and T6-T4+Zn+B+Mo)*

Bush pepper planted with a planting density of 2,500 plants ha $^{-1}$ recorded a yield of 1695 kg ha^{-1} with the application of NPK @ 10:5:20 g bush^{-1}. The variety, Panniyur 1 recorded the maximum yield (1960 kg ha^{-1}) during the fourth year.

Lime requirement of pepper: Studies on the effect of application of lime @ 1/4, 1/2, 3/4 and full lime requirement in a laterite soil were continued. Soil samples analyzed for pH, nutrients etc. showed that liming increases soil pH and exchangeable Ca in soil. With regard to yield, application of lime 1/2 requirement was found to be optimum and gave 25% increase in yield over no lime application (Fig. 2.2).

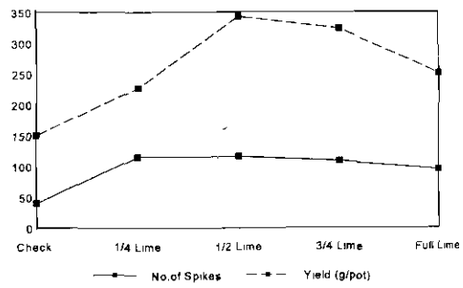


Fig. 2.2. *Effect of lime on yield of black pepper*

Sources of potassium for pepper : Studies on the effect of source of potassium for pepper showed that all the sources contributed to the availability of K in soil. But potassium sulphate was found to be a better source with regard to yield and quality. Potassium sulphate recorded oleoresin 13.5%, oil 4.1% and piperine 6.1% compared to that of 10.7%, 3.3% and 4.7%, respectively, with potassium chloride application (Table 2.8).

Effect of magnesium nutrition in black pepper: The field experiment laid out during June 1995 using 3 varieties viz. Subhakara, Pournami and Panniyur-1 was maintained. Magnesium will be applied @ 0, 50, 75 and 100 kg ha^{-1} during June 1997. There was 87% survival. The experiment is in progress.

B. Identification of low input responsive varieties of black pepper

Studies were conducted during 1996 using rooted cuttings of 10 varieties of black pepper viz. Panniyur - 1, 2, 3, 4 and 5, Sreekara, Subhakara, Panchami, Pournami and Kutching in three types of soil viz. laterite sandy loam, sandy clay loam and loam. After first three months, growth was measured and samples were collected for studying the nutrient composition. It was

Table 2.8 *Effect of different sources of K on yield and quality of black pepper*

Treatment	Soil K (ppm)	Yield (g bush^{-1})	Oil (%)	Oleoresin (%)	Piperine(%)
Check	50	150	4.0	13.1	5.8
KCl	96	290	3.3	10.7	4.7
KNO_3	108	266	4.0	11.7	4.7
K_2SO_4	114	333	4.1	13.5	6.1
Wood ash	84	236	3.3	9.8	4.6
LSD $_{0.05}$	**NS**	113	-	-	-

found that Panniyur 3 had maximum root length and Pournami had maximum shoot length and dry matter production. Panchami had better P and Mg absorption power compared to other varieties. Panniyur -1 has good efficiency to absorb K from soil. Kutching is a good absorber of Ca.

Investigation on nutrient requirement for targeted production of black pepper: A field experiment was laid out at Peruvannamuzhi during 1996 using black pepper cv. Subhakara and standard *Garuga pinnata* to trail pepper. There was 80% survival. Another plot consisting of 60 vines has been selected at Madikeri and basic data like soil nutrient availability, individual yield of vine etc. were collected for superimposing treatments during June 1997.

C. STUDIES ON THE EFFECT OF ORGANIC FARMING IN BLACK PEPPER

Organic farming in bush pepper: Studies on the effect of application of organic manures (poultry manure, goat manure, pig manure and farm yard manure) showed that poultry manure and goat manure were superior than farm yard manure with regard to yield, nutrient availability and quality parameters like oil, oleoresin and piperine content (Table 2.9 & 2.10).

Organic farming-field experiment: In order to evaluate the effect of organics on soil availability of nutrients, yield and quality of black pepper, a field experiment was laid out during June 1995 using cv. Subhakara. The treatments comprising of different sources of organics will be superimposed

Table 2.9. *Effect of different organic manures on yield and quality of bush black pepper*

Treatment	No. of spikes bush^{-1}	Yield (g bush^{-1})	Oil (%)	Oleoresin (%)	Piperine(%)
Check	40	150	4.0	13.1	5.8
Goat manure	65	223	3.3	12.5	6.0
Poultry manure	75	280	3.1	11.2	4.3
Pig manure	64	273	3.3	13.6	6.2
FYM	70	213	3.3	9.6	4.8
NPK@ 1, 0.5, 2	105	290	3.3	10.7	4.7
$LSD_{0.05}$	-	113	-	-	-

Table 2.10. *Effect of different organic manures on nutrient availability in soil (mg kg^{-1})*

Treatment	Av.N	B.P			Mg
Check	85	14	42	510	41
Goat manure	102	41	274	589	82
Poultry manure	106	41	276	546	87
Pig manure	93	33	251	617	90
FYM	93	33	260	575	78
NPK @ 1,0.5,2	99	71	274	726	53

during June 1997. There was 90% survival. The experiment is in progress.

D. STUDIES ON NUTRIENT BUFFER POWER OF POTASSIUM IN DIFFERENT SOILS

Green house experiment with turmeric was conducted using 3 types of soil (Peruvannamuzhi I, II and III) and cv. Alleppey as test crop using four levels of K viz. 0, 50, 100 and 200 ppm. Soil samples for K and plant samples for K uptake and curcumin yield were analysed. K uptake and curcumin were maximum in Peruvannamuzhi III soil series as in previous year.

E. EVALUATION OF DIFFERENT SOURCES OF ROCK PHOSPHATE FOR YIELD AND QUALITY OF GINGER AND TURMERIC

The experiment was laid out with ginger and turmeric separately for evaluation of three sources of rock phosphates viz. Mussoorie Phos, Raj Phos and Gufsa Phos individually and in combination with Super Phosphate and farm yard manure to work out relative agronomic effectiveness. Soil and rhizome samples were taken and analyzed for P availability in soil and P content in rhizome. Growth parameters and yield were recorded. It was found that all the sources were not significantly different with regard to soil availability of P and yield (Table 2.11). Quality analysis is in progress.

F. EFFECT OF MICRO NUTRIENTS ON YIELD AND QUALITY OF GINGER AND TURMERIC

The experiment was laid out during May 1996 with ginger and turmeric separately to study the effect of micro nutrients on yield and quality. Micro nutrients Zn, B and Mo were applied individually and in combination. Soil samples were taken at harvest and analysed for micro nutrients. Rhizome samples were analysed for micro nutrients and uptake was computed. Yield data showed that application of Zn, B, Mo @ 5, 2 and 1 kg ha^{-1} increased the yield by 35% in ginger and by 41% in turmeric over no micro nutrients (Table 2.12). Quality analysis is in progress.

Table 2.11 *Effect of different sources and combination of rock phosphate on availability, composition in plant parts and yield of ginger and turmeric*

Treatment	Ginger				Turmeric		
	Soil P (ppm)	Shoot P (%)	Rhizome P (%)	Fresh yield ($t\ ha^{-1}$)	Soil P (ppm)	Rhizome P (%)	Fresh yield ($t\ ha^{-1}$)
T_1 Check	11.0	0.14	0.20	10.3	11.0	0.18	14.7
T_2 Full SS	18.0	0.16	0.30	20.0	18.0	0.29	22.1
T_3 2/3 MRP + 1/3 SS	12.7	0.19	0.27	19.4	12.7	0.27	19.4
T_4 2/3 RP + 1/3 SS	14.7	0.15	0.27	17.8	14.7	0.27	24.9
T_5 2/3 GP+1/3 SS	14.7	0.15	0.27	17.9	14.7	0.27	25.9
T_6 FYM + 1/2 MRP	15.0	0.16	0.29	18.3	15.0	0.27	28.6
T_7 FYM+1/2 RP	16.3	0.19	0.27	21.0	16.3	0.25	26.4
T_8 FYM + 1/2 GP	16.0	0.19	0.29	20.2	16.0	0.28	31.3
T_9 FYM + 1/2 SS	15.7	0.19	0.30	19.6	15.7	0.29	29.6
$LSD_{0.05}$	2.6	0.02	0.02	3.6	2.6	0.02	6.5

Table 2.12. *Effect of micro nutrients on soil availability, plant composition and yield of ginger and turmeric*

Treatment	Ginger				Turmeric		
	Soil Zn (ppm)	Shoot Zn (ppm)	Rhizome Zn (ppm)	Fresh yield (t ha^{-1})	Soil Zn (ppm)	Rhizome Zn (ppm)	Fresh yield (t ha^{-1})
M_1 Check	0.61	61.0	13.7	14.6	0.61	8.7	22.3
M_2 Mo	0.63	65.0	11.7	17.0	0.63	8.7	27.4
M_3 B	0.69	72.3	14.3	14.8	0.69	8.8	23.1
M_4 Zn	2.10	89.7	19.0	14.9	2.10	13.3	29.1
M_5 Zn+B	2.13	93.0	22.0	17.4	2.13	13.7	28.0
M_6 Zn+ Mo	1.96	107.3	21.7	19.1	1.96	16.3	31.2
M_7 B+Mo	0.71	63.3	13.0	17.6	0.71	8.3	29.6
M_8 $Zn_1B_1Mo_1$	2.22	72.7	26.7	19.8	2.22	13.0	31.4
M_9 Zn_2 B_2Mo_2	3.67	113.7	29.3	17.5	3.67	15.7	27.0
LSD $_{0.05}$	-	9.4	3.0	4.9	-	0.64	6.2

PHY. V(813)

CHARACTERIZATION OF DROUGHT TOLERANCE IN BLACK PEPPER

(K S Krishnamurthy, S J Anke Gowda & Johnson K George)

Twenty black pepper germplasm accessions were screened for drought tolerance in two sets of ten each. The parameters used for screening were stomatal resistance, transpiration rate, cell membrane stability, relative water content and catalase and peroxidase enzyme activities. Stomatal resistance increased and transpiration rate decreased with stress treatment in all accessions. Accessions 1641, 4057 and 1622 maintained lower stomatal resistance and higher transpiration rates during stress period than other accessions. Those accessions which maintain higher transpiration rate (which indicates higher water extraction capacity in spite of stress) and thus all metabilic functions, are preferred under severe stress conditions.

Catalase and peroxidase enzyme activities increased with stress in all accessions. Acc. 1641, 1622 and 4057 showed higher enzyme activities while 891 and 1104 showed the least activity (Table 2.13). Cell membrane damage increased and relative water content decreased with stress, in general. Acc. 4057 and 1622 maintained lesser membrane damage and higher relative water content than other accessions throughout the stress period. Acc. 891 on the other hand showed maximum membrane damage.

When all the above parameters are considered together, it seems that Acc. 4057 and 1622 are better adaptable to moisture stress conditions. In the next set of screening which included Acc. 1107, 1154, 1079, 1092, 4095, 1114, 908, 976, 933 and 1113, Acc. 4095, 1114 and 933 showed better tolerance characters than the rest.

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CHARACTERIZATION OF DROUGHT TOLERANCE IN CARDAMOM

(S J Ankegowda, K S Krishnamurthy & Ravindra Mulge)

Three ecological types namely Malabar

Table 2.13. *Stomatal resistance, peroxidase activity and cell membrane damage in black pepper accessions as affected by moisture stress*

Germplasm accession	Stomatal resistance (Sec cm^{-1})					Peroxidase activity (units $^{-1}$ fw)				Cell membrane damage (% leakage)			
	0*	3 days	6 days	9 days	18 days✧	0*	6 days	12 days	18days✧	0*	6 days	12 days	18 days✧
891	0.69	1.04	2.95	OR	34.00	19.1	24.0	16.4	16.1	4.59	6.73	13.46	16.86
995	0.72	0.91	2.41	OR	0.93	18.8	23.3	17.8	17.3	5.02	6.29	12.75	16.06
4057	1.06	0.90	2.65	4.4	1.05	23.4	24.5	19.3	18.7	6.34	6.89	7.14	7.23
981	1.05	1.11	3.56	OR	43.00	24.3	26.7	21.0	21.0	5.02	6.34	12.11	16.79
1104	1.16	1.00	3.00	OR	0.75	19.3	18.5	16.9	18.0	4.95	5.74	8.10	11.7
1622	1.29	0.98	2.11	3.66	1.02	20.1	21.3	18.5	18.2	4.57	6.11	6.54	7.10
4081	0.99	0.99	3.45	OR	0.79	20.9	20.7	17.4	18.6	5.20	6.40	9.11	15.23
KM69	1.81	1.31	4.67	OR	1.08	23.5	24.8	20.5	19.7	5.74	6.32	8.74	10.18
1641	1.34	1.23	4.11	OR	1.09	22.9	24.3	22.1	22.0	6.54	8.75	12.31	16.15
4072	1.49	1.27	2.37	3.10	1.01	20.0	19.8	17.7	18.3	5.15	7.43	13.11	17.07
$LSD_{0.05}$	0.36	NS	0.78	-	1.72	4.76	3.89	4.71	4.3	1.11	1.23	2.86	4.41

OR-Out of range; * - Control; ✧-Recovery

(CCS-1), Mysore (ICRI-2) and Vazhukka (MCC-21) were planted in cement pots with 12 treatments and three replications. Ten genotypes were planted for rapid clonal multiplication for further screening.

A. Effect of moisture stress at seedling stage

Soil moisture stress treatment was imposed by withholding irrigation on five months old CI-37 seedling grown in polybags. Control plants were irrigated regularly. Data on various growth parameters were recorded on 20 and 35 days after withholding irrigation. Moisture stress treatment reduced the plant height, leaf area, root length, dry weight of leaves, stem and root and relative water content on 20 and 35 days after withholding irrigation. Leaf area and number of leaves showed the maximum reduction due to moisture stress on 35 days after withholding irrigation.

B. Preliminary screening of germplasm lines

Twenty four genotypes were assessed for relative water content, membrane leakage, stomatal intensity and specific leaf weight by collecting leaf samples directly from the field. Genotypes showed significant variation for all the parameters assessed (Table 2.14). Per cent leakage was assessed using conductivity bridge. It ranges from 2.22-10.57 with a mean of 6.17 per cent. Genotypes CCS-1, APG 13, APG 14, APG 17, APG 18, APG 19, APG 20 showed less per cent leakage (<5%), whereas APG 15, APG 16, APG 25, APG 27 and RR 2 showed higher per cent leakage (>8%).

Leaf samples were collected from the field and relative water content was determined in control and stress treatment by leaf disc method. For stress treatment, leaf samples were subjected to 45°C for 3 hours in BOD

Table 2.14. *Genotypic variation in physiological parameters for drought tolerance in cardamom*

Genotype	Per cent leakage	Relative water content (per cent reduction over control)	Stomatal intensity at 60x	Specific leaf weight (mg cm^{-2})
CCS-1	4.09	31.42	10.6	6.19
MCC-61	7.31	24.82	10.4	6.17
MCC-21	5.58	25.07	10.1	5.52
APG10	4.37	16.08	10.8	4.05
APG11	5.42	17.74	10.8	4.05
APG12	4.65	20.83	12.3	4.37
APG13	3.71	18.15	10.6	5.13
APG14	4.92	31.40	16.8	4.23
APG15	8.73	20.75	12.2	5.26
APG16	9.75	23.85	10.8	3.99
APG17	4.29	16.66	11.7	3.21
APG18	2.22	16.21	11.8	4.22
APG19	2.77	45.03	11.4	5.96
APG20	2.63	34.43	10.7	4.84
APG21	7.36	31.60	12.4	4.79
APG22	7.78	30.03	11.1	5.08
APG23	6.34	26.19	15.1	5.06
APG24	7.62	40.84	13.1	4.38
APG25	10.57	18.54	11.2	4.38
APG26	6.11	22.47	-	4.78
APG27	9.04	29.86	11.8	5.01
APG28	6.93	20.40	12.7	4.64
RR1	7.60	39.23	10.7	4.66
RR2	8.25	47.72	11.9	4.46
Mean	6.17	27.06	11.78	4.85
$LSD_{0.05}$	1.27	9.31	1.33	0.37

incubator. Relative water content is expressed in per cent reduction over control. It ranged fro 16.08-47.72 per cent with a mean of 27.06 per cent. MCC-61, APG 10, APG 12, APG 13, APG 15, APG 16, APG 17, APG 18, APG 25, APG 26 and APG 28 showed lower

value (<25%). They may have advantage under drought.

A thin film of xylene and thermocole solution was painted on the leaf surface; after setting the replica bearing the impression of the stomata it is stripped off and examined under a microscope. Number of stomata per microscopic field was counted at 60x. Cardamom is amphistomatus i.e. stomata are present on both the surfaces of the leaf. Stomatal intensity is more in lower (adaxial) surface than the upper (abaxial) surface. It ranged from 10.1-16.8 and 0.071-0.4 per microscopic field in lower and upper surface, respectively. APG 14 and APG 23 showed more than 14 stomata per microscopic field. The genotypes having higher stomatal intensity may have higher transpiration rate and they may not be drought tolerant.

Leaves were cut into 20 cm^2 bits and dried in oven. The dry weight of each leaf bit was recorded. Specific leaf weight was calculated by dividing dry weight by leaf area. It ranged from 3.21-6.19 with a mean of 4.85 mg cm^{-2}

BIOCHEM. I(813)

BIOGENESIS OF PIGMENTS IN SPICE CROPS

(B Chempakam, T John Zachariah & K Sivaraman)

To locate the site of synthesis of curcumin in turmeric, rhizome, root and leaf were analysed for curcumin content and also for the activity of Phenylalanine Ammonia Lyase (PAL), one of the major enzymes involved in the biogenesis of curcumin precursors. The study was carried out at different stages of crop growth in six varieties viz. Suguna, Suvarna, Sudarsana, Prabha, Prathibha and Alleppy, starting from 120 DAG (days after germination) upto the time of harvest.

Rhizomes had a higher content of curcumin in the early stages at 120-150 DAG, which declined and stabilised towards maturity, PAL activity also exhibited a similar trend. In leaves and roots, the contents of curcumin were initially low, which increased as the rhizomes attained maturity (Table 2.15). The presence of enhanced activity of PAL in the initial stages suggests rhizomes as the probable site of synthesis of curcumin precursors.

Among other secondary metabolities, essential oil and oleoresin were high upto 180 DAG, which then remained stable maturity towards (Fig. 2.3). All the six varieties showed the same trend with regard to the parameters studied.

PHT. I(813)

QUALITY EVALUATION IN SPICES

(T John Zachariah & B Chempakam)

A. BIOCHEMICAL CONSTITUENTS AT DIFFERENT DEVELOPMENTAL STAGES OF BLACK PEPPER

Five varieties of black pepper viz.

Table 2.15. *Curcumin and PAL in turmeric during development*

	Curcumin (%)					PAL activity(µM of cinnamic acid released mg^{-1} protein)				
	120*	150	180	210	240	120*	150	180	210	240
Rhizome	8.99	8.64	7.46	7.15	6.91	22.02	25.10	24.40	16.30	14.20
Root	0.96	1.4	1.56	2.01	2.34	12.14	12.40	13.90	14.30	15.30
Leaf	1.28	1.20	1.63	1.71	-	5.2	6.3	7.1	7.3	-

* Days after flowering (DAF)

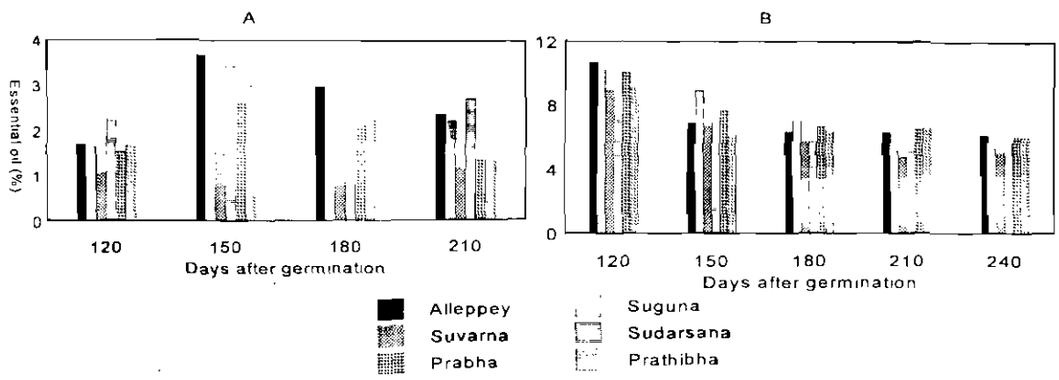


Fig 2.3. *Essential oil in leaf and rhizome of turmeric during development: A-in leaf B-in rhizomes*

Subhakara, Pournami, Panniyur-2, Panniyur-4 and P-24 were screened for essential oil, oleoresin and piperine at different stages. The starch levels and activity of phenyl alanine ammonia lyases also were estimated at these stages. The levels of oil, oleoresin and piperine were maximum around 170 to 180 days after flowering and the enzyme activity was maximum during 150 days. The enzyme activity was 2.5 fold more in the berries compared to leaves indicating its role in the synthesis of secondary metabolites in the berries. The starch level was always in the increasing trend in both leaves and berries.

B. Quality evaluation of ginger accessions with bold rhizomes

Among the 14 germplasm accessions

Table 2.16. *Dry recovery, essential oil and oleoresin at different maturity stages in three varieties of ginger*

Parameter	Variety	Maturity(days)				
		120	150	180	210	240
Dry recovery	Maron	6.0	7.0	13.0	16.0	22.0
	Sabarimala	9.0	7.0	15.0	19.7	24.7
	Varada	10.0	11.0	19.8	21.0	22.0
Essential oil	Maran	5.5	4.4	2.8	3.6	2.4
	Sabarimala	7.0	4.4	3.2	2.7	3.1
	varda	7.5	3.4	2.0	1.9	2.1
Oleoresin	Maran	11.8	12.0	7.4	5.5	5.6
	Sabarimala	14.8	8.6	6.4	4.5	5.5
	Varada	16.0	7.1	4.1	3.5	4.2

evaluated Acc. 15 and 71 had 2% oil, Acc. 179, 244 and 294 had more than 6% oleoresin and Acc. 117 and 179 had less than 4% fibre. Bold rhizomes are known to be very ideal for preparations based on fresh ginger.

C. EVALUATION OF DRY RECOVERY, OIL AND OLEORESIN OF GINGER AT DIFFERENT MATURITY STAGES

Three varieties viz. Maran, Varada and Sabarimala (wild type) were evaluated for dry recovery, essential oil and oleoresin at monthly intervals from fourth month after planting.

Dry recovery of all the three varieties increased as the maturity increased (Table 2.16). Varada reached maximum dry recovery by 180-120 days while Maran and Sabarimala took 230 to 240 days to achieve the same. The three varieties showed maximum oleoresin and oil around 120 days after planting even though yield was negligible at that stage. The level of these constituents decreased and became stable at 210 to 230 days after planting.

D. PREPARATION OF SALTED GINGER

It is prepared by keeping tender ginger without much fibre in brine containing citric acid for about 14 days. It is a very staple item popular in Japan and other middle east countries. Three varieties, Maran, Varada and Sabarimala were evaluated to select a suitable variety to prepare this item. The ideal maturity to prepare this item was between 140 to 170 days after planting. A special planting system may be devised to prepare this item. Bold rhizomes are preferred for this item.

E. COLOUR VALUE IN BAIDAGI CHILLIES

One hundred and twenty six Baidagi chilli collections were evaluated for their colour. The colour value is determined spectrophotometrically by taking the absorbance of 0.01% solution of the oleoresin in acetone at 458 nm. This reading is multiplied by 61000 to obtain Nesslerimetric colour value. The colour value in the samples ranged from 42000 to 2,15,000.

ICAR AD HOC PROJECT 1

INVESTIGATIONS ON CARDAMOM BASED CROPPING SYSTEMS

(V S Korikanthimath, G M Hiremath & D M Javoori

An initial survey was taken up in Uttara Kannada and Kodagu districts and the following cropping systems were identified. 1. Cardamom + Robusta Coffee + Pepper; 2. Cardamom + Arabica Coffee + Pepper (Chettali and Pollibetta areas of Kodagu District); 3. Cardamom + Arecanut; 4. Cardamom + Coconut; 5. Cardamom + Banana + Arecanut (Sirsi and adjoining areas of Uttara Kannada District); 6. Cardamom + Nutmeg + Clove + Allspice (Appangala Research Station). Another system was identified in the Madikeri (Kodagu) area wherein the agroforestry approach is followed for cardamom cultivation.

Silver oak saplings were planted on the waste land of Western Ghats during the year 1987 at a spacing of 3x3m and later pepper (Panniyur) and cardamom (CL-37, Malabar type) were introduced during the year 1991 and 1993, respectively. Since pepper vines were trained on to the oak tree, the spacing of pepper was also same as that of silver oak. Cardamom introduced in between the silver oaks got the spacing of 3m X 0.9m. The planting density per ha worked out to be 1111 each of silver oak and pepper and 3074 of cardamom.

The inteview schedules were prepared for the above mentioned cropping systems and monocrop of coffee, pepper, arecanut and coconut in order to collect the data from the farmers. The schedules contain the informations regarding the requirement of materials,

inputs like manures, fertilizers, pesticides etc. and the operationwise labour requirements during prebearing and bearing periods of the mixed and monocropping systems. The yield pattern of different crops in both the systems, general information and other fixed cost components will also be collected. The data collection work is in progress.

ICAR ADHOC PROJECT 2

BIOCHEMICAL CHARACTERIZATION OF GINGER AND TURMERIC

(T John Zachariah, B Sasikumar & A Shamina)

Twenty five ginger and 15 turmeric accessions were evaluated using isozyme and other biochemical parameters. The isozymes studied are acid phosphatase, esterase, catalase, super oxide dismutase, poly phenol oxidase and peroxidase. Other parameters studied are SDS-PAGE, total protein, total free amino acids and total phenols. Secondary metabolites studied are curcumin, oleoresin and crude fibre. The study established the fact that considerable variability existed in the accessions. However, the variability was more in turmeric (74 to 100%) than in ginger (63 to 96%). The isozyme analysis has shown that accessions collected from one geographical area showed more similarity and clustered together indicating duplication in the collections. For instance, ginger Acc. 63 (Sawthingpui) from Mizoram and Manipur were highly similar while Acc. 2 and 11, Baharica and Edapalayam from Assam and Kerala, respectively, were highly dissimilar. Turmeric accessions 358 and 363 showed maximum similarity of 96% among the populations studied.

CLOSED PROJECT

ICAR AD HOC PROJECT 3

WATER REQUIREMENT OF MULTIPLE CROPPING SYSTEM WITH SPICES

(K V Satheesan & A K Sadanandan - in collaboration with CWRDM, Calicut)

In the present study, two most promising approaches viz. Bowen ratio-energy balance (BREB) method and vapour diffusion model (VDM) have been standardised and used for estimating the consumptive water use of three typical multiple cropping systems with spices prevalent in Kerala viz. black pepper plantation with *Erythirina indica* as standard, black pepper trained on coconut and arecanut palms, and tree spice (nutmeg) intercropped in coconut garden,during the period of moisture stress from January to May of 1994-1996.

The diurnal energy balance components of the black pepper plantation with *Erythirina indica* as standard indicated that during morning hours of typical clear days, the surface soil heat flux (G surf) amounted to nearly 22 per cent of the net radiation (R_n), while latent heat (LE) and sensible heat (H) constituted 63 and 15 per cent of R_n, respectively. This high soil heat flux density reduces the amount of energy available for partitioning into other fluxes resulting in low evapotranspiration rates. During noon times when maximum LE was recorded, it did not exceed more than 60 per cent of R_n for most of the days. The trend in evapotranspiration (ET_c) rates during morning hours on the clear days (sharp reduction in ET_c after attaining peak values at around 10.00 and 12.00 hours) clearly indicated stomatal regulation of ET_c in black pepper when the soil moisture was limiting. It was shown that continuous 20-minute measurements of

evapotranspiration of black pepper plantation is achievable using Bowen ratio - energy balance method.

By adopting the vapour diffusion model, it is possible to partition the stand transpiration rate of black pepper plantation with *Erythrina indica* as standard among different layers of black pepper canopy and *Erythrina indica* canopy. The maximum transpiration rate was noticed from the middle layer of the black pepper canopy, which was largely attributed to the higher leaf area index (LAI) of this layer. Due to low LAI values, the transpiration rate of *Erythrina indica* was remarkably less as compared to that of black pepper. The black pepper alone constituted 71 per cent to 86 per cent of the stand transpiration rate.

The ET_c values of black pepper plantation with *Erythrina indica* as standard obtained by BREB method ranged from 2.45 to 3.15mm day^{-1}, while those obtained by VDM method ranged from 2.86 to 3.40 mm day^{-1}. The crop coefficient values for the crop stand ranged from 0.53 to 0.78 for these two approaches for different months. There is a good agreement between vapour diffusion model and Bowen ratio - energy balance method for estimating the evapotranspiration of black pepper plantation with *Erythrina indica* as standard.

The consumptive water use of the multistoreyed cropping system comprising black pepper, coconut and arecanut (black pepper trained on both coconut and arecanut) was estimated adopting vapour diffusion model. Coconut recorded higher transpiration rate than arecanut and black pepper in this multistoreyed cropping system, which was mainly attributed to high LAI of coconut. The ET_c values of black pepper ranged from 0.31 to 0.42 mm day^{-1}, while those of coconut and arecanut ranged from 3.25 to 3.60 mm day^{-1} and from1.45 to 1.768 mm day^{-1}, respectively. The crop coefficient of black pepper in this multistoreyed cropping system ranged from 0.07 to 0.10, while those of coconut and arecanut ranged from 0.74 to 0.82 and from 0.33 to 0.38, respectively. The highly reduced LAI was the reason for very low ET_c and crop coefficient values of black pepper when it was grown under the shade of coconut and arecanut. While developing an irrigation scheduling programme for component crops in this multistoreyed cropping system i.e.black pepper, coconut and arecanut, these crop coefficient values are more appropriate than those of the pure crops of individual species.

The consumptive water use of the intercropping system comprising coconut and nutmeg (nutmeg intercropped in coconut garden) was estimated adopting vapour diffusion model. In order to find out the pattern of fractional transmittance of radiative energy and its availability to nutmeg trees when it was grown as an intercrop in coconut garden, the light climate below the coconut canopy was characterised and it was clearly brought out that under coconut canopy, light environment was considerably modified in its intensity, quality as well as in periodicity. The ET_c values of nutmeg ranged from 3.60 to 3.95 mm day^{-1}, while those of coconut ranged from 3.35 to 3.86 mm day^{-1}. Under the conditions of high soil moisture availability throughout the period of study (20-24 per cent by volume), nutmeg had recorded higher ET_c values than coconut eventhough its LAI was substantially lower than that of coconut. The crop coefficient values of nutmeg in the intercropping system ranged from 0.80 to 0.94, while those of coconut ranged from 0.74 to 0.92, which can be used for developing an irrigation scheduling programme for the component crops of nutmeg and coconut in this intercropping system.

3

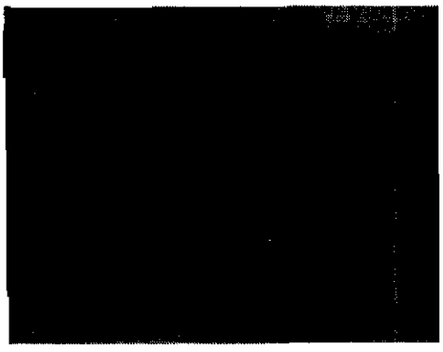
CROP PROTECTION

There were 19 research projects including 6 externally funded projects, in the Division of Crop Protection. Out of these, six are in Plant Pathology, 3 each in Entomology and Nematology and one is a multidisciplinary project. The significant findings in this Divisions are:

The etiology of stunted disease of black pepper was studied in collaboration with ICRISAT and the CMV etiology was confirmed based on EM studies. The role of *Meloidogyne incognita* in rhizome rot was studied and it was found that *Meloidogyne incognita* along with *Pythium aphanidermatum* hastens the disease development.

Screening against pests and pathogens were continued and 3 Kottanadan field selections 2575, 4255 and 2571 were found to be tolerant to *Phytophthora capsici*. Acc. 2070 was resistant to pollu beetle. Two accessions each from ginger (Acc. 36 & 59) and two from turmeric (Acc. 34 & 179) were resistant to *M. incoginita* in cardamom. Studies on the mechanism of resistance in black pepper to *Phytophthora* was initiated. The ratio of total phenols to OD phenols was high in susceptible lines of black pepper compared to tolerant lines.

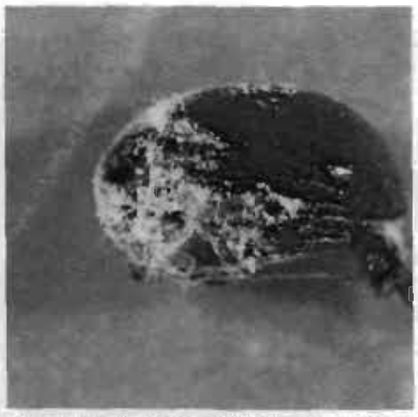
Field trials with *Trichoderma* and *Gliocladium* against foot rot of black pepper, rhizome rot of ginger and cardamom, *Verticillium chlamydosporium* and *Pasteuria penetrans*



Electron micrograph of CMV associated with stunted disease of black pepper

Regeneration of plantlets from protoplasts of Piper colubrinum

against *M. incognita* are in progress. *Beauveria bassiana* caused 70% mortality of pollu beetle in laboratory assays. *B. bassiana* and *V. chlamydosporium* were found to infect the viral vector of cardamom, *Pentalonia nigronervosa* f. sp. *caladii*. *Bracon* spp. and *Apanteles taragame* were recorded on *Conogethes punctiferalis* infesting ginger. *Chilocorus circumdatus* released in the field was effective in reducing the population of *Aspidiotus destructor* in turmeric and ginger. Four rounds of spraying with Dipel 0.3% (a commercial formulation of *Bacillus thuringiensis*) effectively reduced shoot borer infestation in ginger. Several neem formulations and fish oil rosin were also found effective against *L. piperis*. Extracts from *Lawsonia* and *Acorus* caused mortality of *Pentalonia nigronervosa*, the vector of cardamom viral diseases. Field trials with biocontrol agents against *Phytophthora* foot rot was demonstrated in about 3000 ha in farmers' plots. Attempts are made to develop IPM strategies with emphasis on biocontrol. Efforts are also on to develop host resistance in black pepper through developing somaclones. Some of the somaclones developed have shown tolerant reaction to *P. capsici*.



An adult 'pollu' beetle of black pepper infected with the fungal parasite, Beauvaria bassiana

Mass culturing of Chilocorus circumdatus *and* C. nigrita

PATH. II.3(813)

DISEASE MANAGEMENT IN *PHYTOPHTHORA* FOOT ROT AFFECTED BLACK PEPPER PLANTATIONS

(Y R Sarma, M Anandaraj & K V Ramana)

Integrated disease management trial involving soil drench and spray with potassium phosphonate and soil application of biocontrol inoculum along with neem cake was carried out at IISR Farm, Peruvannamuzhi. The plot consisted of 10 cultivars with 40 plants each. During the year vine death was not noticed in the plot. About 83.5% of the vines were totally free from the disease symptoms while 16.5% of vines showed varying degrees of foliar yellowing ranging from 2.5% to 37.5%. Among the cultivars, P 24, a *Phytophthora* tolerant line was free from foliar yellowing.

A field trial was laid out to see the effect of varietal mixture on the disease development. It consists of 3 main plots i.e., *Piper colubrinum*, Karimunda and control, with five *Phytophthora* tolerant lines as sub-plot treatments viz. P24, P339, P1534, H 780 and C 847 with three replications. About 5% mortality of the cuttings was seen and will be replanted during the current year.

The pot culture experiment with potassium phosphonate and *Gliocladium virens* and *Trichoderma harzianum* alone and in combination showed that the *G. virens* was superior to all and was on par with *G. virens* + potassium phosphonate in reducing root rot caused by *P. capsici*.

PATH X(813)

INVESTIGATIONS ON VEIN CLEARING VIRUS OF SMALL CARDAMOM

(M N Venugopal)

A. Standardisation of virus purification

Three buffer systems (Phosphate buffer 0.1M, pH 7; Borate buffer 0.1M, pH 8.2 and Phosphate buffer 0.2M, pH 7.1) with combination of a reducing agent (Thioglycollic acid 0.2%, Mercaptoethanol 0.2%), additives (EDTA 0.01M, DIECA 0.01% and PVP 2%), chemicals to prevent aggregations of virus particles (Triton x-100 & Urea 0.2-0.5M) and clarifying agents (N-Butanol & Chloroform) were tried to purify virus. For concentration of nucleoproteins from infected plants PEG-6000 at 6% and physical method ultracentrifugation on 10% sucrose cushion were used. The purified extracts were tested for the presence of additional band by running on SDS-PAGE. In all the preparations tried, additional protein band (virus band) was not seen on SDS-PAGE or on sucrose gradient indicating the loss of the virus in the purification methods tried so far.

B. E.M. studies

Crude sap, clarified sap and purified preparations were observed under E.M. for detecting the association of virus particles. Based on initial reaction with PMV antiserum, ISEM was tried with both crude and clarified sap by following methods for trapping and decoration. Though few flexuous particles were observed in infected samples (12 x 710-740 nm), consistent association of virus particles was not observed.

C. Screening of elite types

In the three year old trial at Belekere, Sirsi, all the 14 entries took natural infection of virus. However, the number of infected plants was less in Acc. 893 (2/12) and PV-1 (3/12) compared to local susceptible check indicating their resistance.

The work on ELISA, purification and E.M. were done with the co-operation of the Dept. of Applied Botany, Mysore, Dept of Virology, S.V. University, Tirupathi and Centre for Plant Molecular Biology, M.K.U. Madurai.

PATH. XI(813)

STUDIES ON BACTERIAL WILT OF GINGER

(G N Dake & Y R Sarma)

The field trial on biocontrol of bacterial wilt of ginger (including the application of avirulent strains of *Pseudomonas solanacearum)* was maintained. The disease incidence in the trial was erratic and no conclusion could be drawn. The curing of plasmids was continued without much success.

PATH XII(813)

INVESTIGATIONS ON STUNTED DISEAS OF BLACK PEPPER

(Y R Sarma & S Devasahayam)

Three populations of *Toxoptera aurantii* were collected and tested in citrus, coffee and pepper for their multiplication. Though the insects initially colonized the plants, they didn't multiply subsequently. Aphids collected from healthy plants were force fed on CMV infectd black pepper and later transferred to healthy plants. The plants are under observation.

The purified virus preparation was subjected to surcrose density gradient technique and the virus fraction collected was subjected EM studies at ICRISAT. Clear spherical particles typical of CMV were detected, thus confirming the virus etiology of stunted disease of black pepper.

CROP PROT I.1(813)

SCREENING GERMPLASM MATERIALS FOR REACTION TO DISEASES

(Y R Sarma, M Anandaraj & Johnson K George)

OP seedling progenies (1,50,000) from five different cultivars were screened by adopting root inoculation technique. All plants succumbed to infection. Of the 50 Kottanadan selections obtained from CPCRI, Palode, Acc. 2575, 4255 and 2571 showed tolerant reaction (Fig. 3.1).

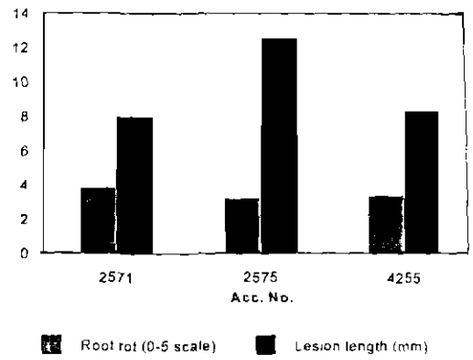


Fig. 3.1. *Reaction of 3 Kottanadan selections to* Phytophthora capsici

In the field evaluation trials at Sirsi during 3rd year, P24 showed minimum vine death of 27.7%, compared to 81% in KS 27 and at Pulppally performance of P24 was the best compared to other cultivars (Fig. 3.2).

A field trial was laid out for large scale testing of *Phytophthora* tolerant lines in a sick plot with 3 tolerant lines i.e. P24, HP 780 and P 339 in combination with Karimunda with a population level of 25, 50, 75 and 100. The trial is in progress.

CROP PROT. I.2 (813)

SCREENING BLACK PEPPER GERMPLASM FOR REACTION TO INSECT PESTS

(S Devasahayam, K M Adbulla Koya & Johnson K George)

A. Screening of wild *Piper nigrum* germplasm

Twenty ascessions of wild *Piper nigrum* available in the germplasm at IISR Experi-

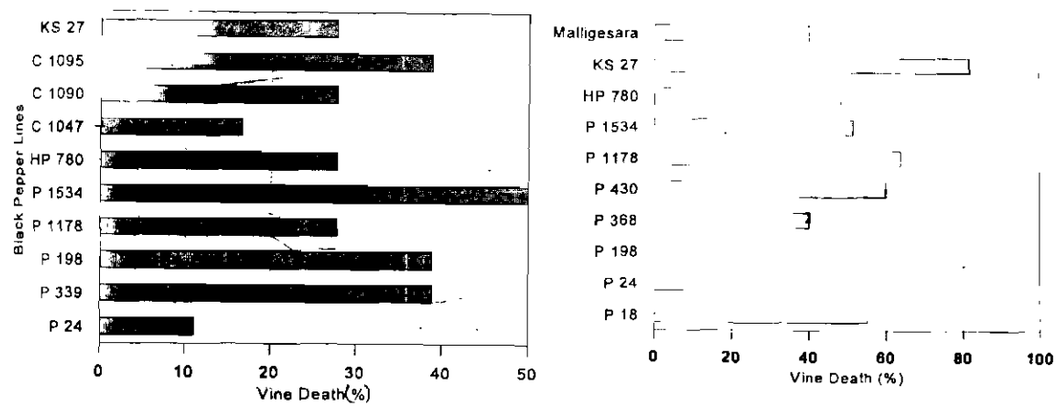


Fig. 3.2. *Performance of* Phytophthora *tolerant lines: A-at Sirsi B-at Pulpally*

mental Farm, Peruvannamuzhi were screened for berry damage by pollu beetle (*Longitarsus nigripennis*) under field conditions. One accession (No. 2070) was free of pest infestation. The incidence of pollu infested berries ranged between 15.0-44.0 per cent in other accessions.

B. SCREENING OF CULTIVATED *PIPER NIGRUM* GERMPLASM

Fifty six accessions of cultivated *Piper nigrum* available in the germplasm were screened for berry damage by pollu beetle under field conditions. None of the accessions was free of pest infestation. (The incidence of pollu infested berries ranged between 11.9-37.7 per cent in various accessions).

CROP PROT. I.3(813)

SCREENING BLACK PEPPER GERMPLASM FOR REACTION TO NEMATODES

(K V Ramana, Santhosh J Eapen & Johnson K George)

Nine wild and seven cultivated black pepper germplasm collections were screened against nematodes. Acc. 176, 233, 291, 569, 606, 614 and 629 are highly susceptible to *Meloidogyne incognita* while Acc. 1040 and 1090 are highly susceptible to *Radopholus similis*. Multiplication of about 200 black pepper accessions through rapid multiplication method has been initiated to ensure availability of nematode free cuttings for screening purposes.

CROP PROT. II(813)

MECHANISMS OF RESISTANCE TO PESTS AND PATHOGENS IN SPICE CROPS

(M Anandaraj, B Chempakam, M N Venugopal, K V Ramana & Santhosh J Eapen)

Biochemical characterization of black pepper lines tolerant to foot rot pathogen, *Phytophthora capsici*, was initiated. The parameters such as total sugars, reducing sugars, amino acids, peroxidase and polyphenol oxidase were studied (Table 3.1). The ratio of total phenols and orthodihydroxy phenols was estimated for

Table 3.1. *Biochemical parameters of* Phytophthora *tolerant lines*

Black pepper line	Total sugar Mg 100mg^{-1} (fw)	Reducing sugar Mg100g^{-1} (fw)	Amino acid Mg100g^{-1} (fw)	Peroxidase units X 10^{-3}	PPO units X 10^{-3}
C 1090	3.74	0.98	2.16	9.28	6.36
A 456	2.87	0.90	2.04	8.44	7.86
A 403	3.97	0.82	1.92	7.70	6.62
K 527	3.11	1.16	2.17	6.91	10.72

PPO - Polyphenol oxidase

Table 3.2. *Phenolic compounds in* Phythophthora *tolerant lines*

Black pepper line	Phenolics		
	Total phenol mg g^{-1} (fw)	OD mg g^{-1} (fw)	TP/OD Ratio
C 347	9.59	4.11	2.33
C 1095	5.55	2.09	2.65
P 198	8.70	3.58	2.42
P 334	7.65	2.68	2.84
HP1	5.66	1.91	2.95
KS27	7.73	2.13	3.63

TP - Total phenols, OD - Orthodihydroxy phenols

five tolerant lines and compared with the susceptible one (Table 3.2). The ratio was 3.63 in susceptible to 2.3 to 2.9 in tolerant lines. This is being continued with other tolerant lines.

ENT. X(813)

BIONOMICS OF MAJOR PESTS OF BLACK PEPPER AND EVOLVING INTEGRATED CONTROL MEASURES AGAINST THEM

(S Devasahayam)

A. Evaluation of neem products

Five commercial neem products (Neemark, Neem gold, Nimbicidine, Neemazal-F and Neemazal - T/S) and endosulfan were evaluated against pollu beetle (*Longitarsus nigripennis)* in the field at Peruvannamuzhi. The treatments included four sprays with neem products, one spray with endosulfan and three sprays with neem products, and two and three sprays with endosulfan. The incidence of pollu infested barries was assessed in various treatments at the time of harvest.

The trials indicated that all the treatments were effective in controlling the pest infestation. However, one spray with endosulfan 0.05% (during July) followed by three sprays with Neemazal-F 0.05% or Neemgold 0.6% (during August, September and October) or two sprays with endosulfan 0.05% (during

uly and September) or three sprays with ndosulfan (during June, July and Septem-ber) were more effective.

Combined analysis of data for two years 1995 and 1996) indicated that three sprays vith endosulfan 0.05% was the most effec-ive treatment followed by the treatments vhich included one spray with endosulfan 0.05% (during July) followed by three sprays vith Neemgold 0.6% or Neemazal - F 0.05% or Neemark 1% (during August, September ind October) or four sprays with Neemgold 0.06% or Neemazal-F 0.05% (during July, August, September and October).

NEMA. III(813)

INVESTIGATIONS ON NEMATODES ASSOCIATED WITH SPICES

K V Ramana & Santhosh J Eapen)

A. Screening of germplasm

Ten ginger germplasm accessions which showed resistance/tolerance to root knot nematode, *Meloidogyne incognita* in the preliminary screening were retested for nematode resistance. Two accessions viz. Acc.36 and 39 possessed high degree of resistance to root knot nematodes (EMI<3 and R<1). Another 31 ginger accessions were screened against *M. incognita* in a greenhouse study. Out of these, 14 accessions showed varying degrees of resistance in the initial round of inoculation. In turmeric, Acc. 84 and 179 showed very high degree of resistance to root knot nematode in the second round of screening. Thirty accessions of cardamom were planted in the field for clonal multiplication.

B. Population variability in root knot nematodes

Two more populations of root knot nematodes, one from cardamom and another from black pepper, were collected from Coorg, Karnataka and were cultured on their respective hosts. Perineal patterns of five more populations were studied.

C. Role of *M.incognita* in rhizome rot complex of ginger

The pot culture trial to study the precise

Table 3.3. *Effect of* Meloidogyne incognita *and* Pythium aphanidermatum *alone and in combination on growth, yield and nematode multiplication in ginger (Mean of five replications)*

Treatment	No.of tillers	Root wt. (g)	Shoot wt. (g)	Rhizome wt.(g)	Total biomass (g)	Final nematode population in root (per g)	Final nematode population in soil (per 100cc)
Check	9.25 a	127.5a	105.50a	270.00a	506.00a	-	-
MI alone	7.60 ab	118.0 a	91.00 ab	182.50 b	391.50 b	1806.34a	123.71 a
Py alone	4.60 bc	35.0 b	57.50 b	181.25 b	273.75 bc	-	-
MI + Py	8.40a	44.0 b	62.50 b	118.75 b	225.25 c	2218.29 a	13.84 a
MI>Py (20 d)	6.8 abc	71.0 ab	91.25 ab	195.00 b	357.25 bc	1607.68a	40.72 a
MI>Py (40 d)	4.0 c	84.0 ab	66.25 b	167.50 b	317.75 bc	1038.01a	38.51 a
Py>MI (40 d)	8.4 abc	45.0 b	65.00 b	127.50 b	237.50 c	1416.45a	10.38 a

Means followed by a common letter in a column are not significantly different
MI - *Meloidogyne incognita*, Py-*Pythium aphanidermatum*

role of *M. incognita* in the rhizome rot of ginger was concluded. The final data on growth and yield are given in Table 3.3. The data showed that all treatments significantly reduced the total biomass as well as the yield. However, *Pythium* infections did not influence the nematode multiplication in any of the treatments. Combined inoculation of *Pythium aphanidermatum* and *M. incognita* was more damaging than either of them alone. This was more so when *Pythium* was inoculated 40 days after nematode inoculation (Fig. 3.3).

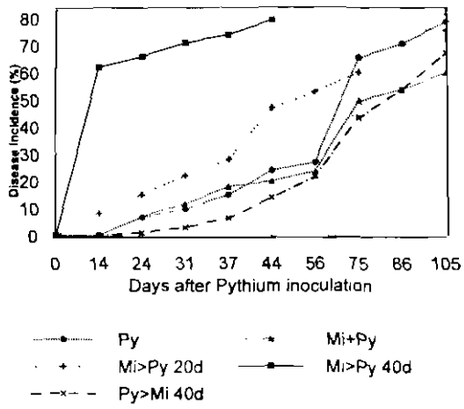


Fig. 3.3. *Interaction of* M. incognita *and* P. aphanidermatum *in causing rhizome rot of ginger*

BIOCONTROL I.1(813)

BIOLOGICAL CONTROL OF DISEASES OF SPICE CROPS

(M Anandaraj, M N Venugopal & Y R Sarma)

Filed trials with VAM and biocontrol agents in black pepper were continued. In the trial with VAM and chemicals, the cumulative mortality of vines ranged from 28.7 and 30.9% (Table 3.4). In VAM main plot, yield was 3615 g vine^{-1} against 1037 g in non VAM plot. Among the treatments, Akomin treated vines recorded and 4181 g^{-1} VAM treatment 4070 g as against 127.5 g in control.

In another trial, where VAM is tried in combination with antagonists such as *Trichoderma* and *Gliocladium* the mortality was more than 5% and the first year's yield did not show any significant difference (Table 3.5). Fluorescent pseudomonads isolated from the rhizosphere of black pepper showed inhibition of *P. capsici* upto 77.77 in *in vitro* studies.

In *in vitro* studies, aquous extracts of *Azadiracta indica, Lowsonia* sp, *Acorus* sp. and *Ocimum sanctum* inhibited *Pythium vexans,* the fungus causing damping off and rhizome rot of cardamom.

BIOCONTROL I.2(813)

BIOLOGICAL CONTROL OF INSECT PESTS OF SPICES

(S Devasahayam)

A. Documentation of natural enemies of insect pests of spices

The natural enemies of various insect pests of black pepper, ginger, turmeric, cinnamon and clove were documented. Among them, *Bracon* sp. and *Apantelus taragamae* (Braconidae) parasitising shoot borer and *Cocobius* sp. (Apheleridae) parasitising rhizome scale of ginger were important. *A. taragamae* was recorded on shoot borer for the first time.

B. Bioassay of microbial pathogens

Laboratory bioassays were conducted to evaluate the pathogenecity of *Beauvaria bassiana* (Source: CCRI, Kalpetta) and *Verticillium chlamydosporium (Source*: Nematology Section) against adults of pollu beetle infesting black pepper. *B. bassiana* caused 20 per cent mortality of pollu beetles when they were allowed to wander over the fungal cultures.

Table 3.4. *Effect of VAM and chemicals on foot rot disease and yield of black pepper*

Treatment	Mortality of vines(%)			Yield vine^{-1}		
	VAM	Non.VAM	Mean of 3 replantings	VAM	Non.VAM	Mean
Control	60.9	44.4	52.7	1226.6	1323.0	1275.0
VAM	10.8	27.7	19.7	6313.3	1828.0	4070.6
Copper oxychloride, Bordeaux mixture	33.8	27.6	30.4	2973.3	8920.0	2460.0
Metolaxyl 100 ppm (Redomil mancozeb)	38.8	21.9	30.4	2821.3	456.0	1639.0
Pottassium phosphonate (Akomin)	10.8	21.9	16.4	4745.0	3633.0	4181.1
Mean	30.95	28.74	29.8	3615.9	1037.0	-
LSD $_{0.05}$	NS	NS	18.12	2122.8	-	1294.3

Table 3.5 *Effect of VAM and biocontrol agents on yield of black pepper*

Treatment	Yield (fresh wt.g vine^{-1})			Mean
	G.virens	*T.hamatum*	*C.odorata*	
Glomus Is. 1	1470	1493	1290	1417
G. gigantea Is. 1	2263	3690	706	2213
Glomus Is. 2	2810	2353	1186	2116
G. gigantea Is. 2	1706	1490	1943	1713
Glomus Is. 3	2706	2656	1650	2337
Glomus Is. 4	3010	1510	2273	2264
Control	2006	1851	1320	1726
Mean	1943	1857	2108	1969
LSD $_{0.05}$	NS	NS	NS	

NS--not significant

c. Evaluation of *Bacillus thuringiensis* in the field

Two commercial products of *Bacillus thuringiensis* (Biosap and Dipel) and malathion (present recommendation) were evaluated against shoot borer of ginger and turmeric in the field at Peruvannamuzhi. The treatments included four sprays of various products during July to October. The incidence of shoot borer on the plants in various treatments was assessed during November. All the treatments were effective in controlling the pest infestation in both ginger and turmeric. However, spraying of

Dipel 0.3% was the most effective treatment. Combined analysis of data for two years (1995 and 1996) also indicated that spraying of Dipel 0.3% was the most effective treatment for the control of shoot borer on ginger and turmeric.

BIOCONTROL I.3(813)

BIOLOGICAL CONTROL OF NEMATODES OF SPICES

(Santhosh J Eapen, K V Ramana & Y R Sarma)

A. Isolation and identification of nematode antagonists

A variety of fungi and bacteria were isolated from the soil samples collected from Nilgiris and Dakshina Kannada.

B. Effect of *Pasteuria penetrans* on root knot nematodes of cardamom

The pot culture trial to study the effect of *P. penetrans* on root knot nematodes of cardamom was concluded. The results showed that the bacterial inoculation simultaneously with root knot nematodes and 2 weeks after nematode inoculation significantly reduced the nematode populations. However, significant growth enhancements were noticed in treatments where *P. penetrans* was inoculated after nematodes (Table 3.6).

The pot culture trials are in progress (i) to study the effect of six isolates of *Trichoderma* species on *Radopholus similis* infesting black pepper, (ii) to test the effect of *Verticillium chlamydosporium* on root knot nematodes in cardamom and (iii) to evaluate promising commercial neem products against root knot nematodes of black pepper.

A nursery trial was laid out at CRC, Appangala to test the efficacy of *V. chlamydosporium* and *P.penetrans* on root knot nematodes of cardamom.

ICAR ADHOC PROJECT 1

THE PARSITIC NEMATODE, TROPHO-TYLENCHULUS PIPERIS AND ITS INTERACTIONS WITH BLACK PEPPER

(K V Ramana, Santhosh J Eapen, K K Gayathri & T P Sreeja)

A. Population dynamics

The population dynamics of *Trophotylenchulus piperis* in black pepper gardens

Table 3.6. *Effect of* Pasteuria penetrans *on growth of cardamom (Mean of five replications)*

Treatment	No.of tillers	Height(cm)	Root wt(g)	Total biomass(g)
Check	1.96 a	75.17 bc	12.30 a	41.02 b
MI alone	1.50 a	51.40 d	8.70 a	29.42 c
Pp alone	2.25 a	81.17 b	10.88 a	40.22 b
Pp>MI(2W)	2.50 a	69.00 bc	8.49 a	24.70 c
Pp>MI (4W)	2.00 a	92.40 a	9.53 a	39.47 b
Pp+MI	2.29 a	64.00 c	10.64 a	16.25 d
MI>Pp(2W)	2.14 a	73.00 bc	14.03 a	54.52 a
MI>Pp(4W)	2.00 a	76.00 bc	12.49 a	59.10 a

MI- *Meloidogyne incognita* Pp - *Posteuria penetrans;* Meons followed by the same letter in a column ore not significantly different

was studied for the third consecutive year. The data showed that the lowest nematode population was observed in August and thereafter it steadily increased reaching a maximum peak during March. There was no significant correlation between the nematode population and any of the meteorological parameters, but rainfall and number of rainy days had a negative influence on the *T. piperis* population level.

B. PATHOGENICITY

Pot culture trials to assess the pathogenicity of *T. piperis* in black pepper was concluded. The final data showed that there was about 3.29 to 16.54 per cent reduction in the growth of the plants inoculated with the nematode in course of four months. But these differences were not statistically significant. However, localized drying of roots was noticed whenever ther is a higher infestation.

C. CHEMICAL CONTROL

Application of phorate @ 3 g a.i. vine^{-1} (the present recomendation) reduced the nematode population considerably, but its effect lasted for only one month.

ICAR ADHOC PROJECT 2

BIOLOGICAL CONTROL OF SCALE INSECTS INFESTING BLACK PEPPER

(S Devasahayam, S Selvakumaran & Mini Kallil)

A. BIOLOGY OF NATURAL ENEMIES

Studies on various aspects of biology of *Chilocorus circumdatus* such as adult longevity, fecundity, duration of developmental stages (Table 3.7) and feeding potential (Fig. 3.4) were conducted. The morphometrics of various stages were also determined.

B. EVALUATION OF NATURAL ENEMIES

The coccinellid predators *Chilocorus nigrita* and *C. circumdatus* were mass reared in the laboratory and were released on black pepper vines infested with *Lepidosaphes piperis* and *Aspidiotus destructor* to evaluate their efficacy in the control of scale insects.

Adults of *C. nigrita* were released at 15 days intervals (3 releases) on black pepper vines infested with *L. piperis* @ 15 adults vine^{-1} per release at Kuppadi (Wynad District) during January-March 1996. Observations recorded on the population of *L. piperis* , 2 months after release indicated that there was

Table 3.7. *Biology of* Chilocorus circumdatus

Stage	Duration(Days)
Egg	5.8 ± 2.0
Larva	8.0 ± 0.6
Prepupa	2.0 ± 0.6
Pupa	6.8 ± 1.1
Total life cycle	22.6 ± 1.9
Preoviposition period	2-3
Adult longevity	32.0 ± 14.4
Fecundity	269.8 ± 8.9 eggs

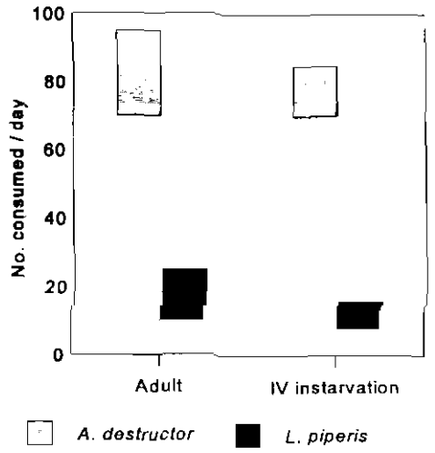


Fig. 3.4. *Feeding potential of* Chilocorus circumdatus

only 10.3 per cent reduction in pest population. The trials indicated that the level and frequency of release of predators was not adequate to control the pest.

In another trial, larvae of *C. circumdatus* were released at 15 days intervals (4 releases) on black pepper vines infested with *A. destructor* @ 20 larvae vine^{-1} per release at Kuppadi (Wynad District) during October-December 1996. Observations recorded on the population of *A.destructor* 2 months after release indicated that there was 92.2 per cent reduction in pest population. The trials thus indicated that release of larvae of *C. circumdatus* was effective in controlling *A. destructor* infesting black pepper.

C. Toxicity of insecticides/plant/organic products to natural enemies

The toxicity of insecticides (recommended for the control of scale insects), plant and organic products to *C. circumdatus* was evaluated to determine the safe periods for release of the predator on black pepper vines infested with *A. destructor*. The trials indicated that dimethoate 0.1% and monocrotophos 0.1% were toxic upto 1 and 7 days respectively, after treatment. Neem oil 0.3 and 0.6%, Neem gold 0.3% and fish oil rosin 3% did not cause any mortality to the predator.

D. Integrated management of scale insects

Plant and organic products and conventional insecticides were evaluated for the control of scale insects infesting black pepper. Fish oil rosin 3% was the most effective product against *A. destructor* and was on par with monocrotophos 0.1%. Fish oil rosin 3% and Neem gold 0.3% were effective against *L. piperis* and were on par with monocrotophos 0.1% and dimethoate 0.1%.

ICAR AD HOC PROJECT 3

CHARACTERISATION, EARLY DETECTION AND MANAGEMENT OF 'KOKKE KANDU' DISEASE OF CARDAMOM

(M N Venugopal, K A Saju & M J Mathew)

A. Large scale testing of phytosanitation

Roguing was followed in four representative plots in the hotspots of the disease and it has been shown that both Kokke kandu and Katte could be kept under check (4.01% compared to 11.54% in control). But the inoculum persisted throughout the year, so also the new incidence which varied during different seasons (0.37-2.9).

B. Identifying indicator/multiplication host(s)

Nicotiana sp., *N. rustica*, *N. benthamiana*, *N. tabaccum* var. *Harrison*, *Physalis indica*, *P. minima*, *Datura stramonium* and *Elettaria cardamomum* were tried for the mechanical transmission using phosphate and borate buffers. So far none of them took infection

C. Characterisation of Car VCV

Purification and EM observation have not shown exact morphology of the virus particles. But ELISA tests using 5 potyvirus, 3 carla virus and 1 cucumovirus antisera have indicated clear affinity to potyvirus.

D. Monitoring of vector population

In situ monthly monitoring of aphid vector (*Pentalonia nigronervosa* f. *caladii*) population showed that (i) aphids exist throughout the year, (ii) population is reduced during monsoon, (iii) population starts building up during September and reaches the peak during rain free winter and summer months and (iv) alate forms are more in summer months.

E. Identification of disease escapes

Thirteen collections of disease escapes

from the hotspots and 168 clonal accessions of germplasm were raised in poly bags in five replications for screening against Kokke kandu during the next season.

F. DEVELOPING VECTOR CONTROL MEASURES

Six entomogenous fungi (two of them are unidentified, isolated from naturally dead aphids) were tested against the cardamom aphid in glass house experiments. *Beauveria bassiana* and *Verticillium chlamydosporium* were found to be promising for the biological control of the aphid.

(The help received from Department of Applied Botany, University of Mysore, Mysore; Department of Virology, S.V.University, Tirupathi and Centre for Plant Molecular Biology, Madurai Kamaraj University, Madurai for the purification, EM studies and ELISA are gratefully acknowledged).

ICAR AD HOC PROJECT 4

INTEGRATED MANAGEMENT OF RHIZOME ROT OF GINGER

(Y R Sarma, P P Rajan & N Beena)

A survey was conducted in the major ginger growing areas of Kerala during October 1996. Healthy as well as diseased samples were collected. Total 150 fields were surveyed and 253 samples were collected. From 101 diseased samples *Pythium aphanidermatum* was isolated. Roots and soil samples of the 149 healthy samples were plated and different fungi and bacteria were isolated. Out of the 68 bacterial isolates tested, 28 were inhibitory to *P. aphanidermatum* in dual culture (35-70%). Out of 109 *Trichoderma* isolates tested, 57 were found antagonistic to *P. aphanidermatum* (25-70%). Out of 132 fungal isolates tested, 64 were inhibitory to *P. aphanidermatum* (25-50% inhibition).

A field experiment was set up at the IISR Experimental Farm at Peruvannamuzhi. Seed treatment with *T. harzianum* (isolate 1) in combination with starch showed good germination and reduced disease incidence (Table 3.8). The different biocontrol agents viz. *T. harzianum, T. hamatum* and *G. virens* when tested alone gave an increased germination percentage and reduced disease incidence over control. However, combinations of these biocontrol agents showed good synergistic effect (Table 3.9).

DBT ADHOC PROJECT 1

DEVELOPMENT OF *PHYTOPHTHORA* RESISTANCE IN BLACK PEPPER *(PIPER NIGRUM* L) THROUGH BIOTECHNOLOGICAL APPROACHES

(Y R Sarma, M Anandaraj & Shaji Philip)

During the last year 1,500 somaclones were screened by adopting leaf inoculation technique and Acc. 456 showed restricted lesions and minimal root rot. The material is being multiplied for further testing.

Toxin extracted from the culture filtrates of *P. capsici* has been used for *in vitro* screening

Table 3.8. *Effect of amendments along with biocontrol agent on rhizome rot of ginger*

Treatment	Germination(%)	Disease incidence (%)
FYM + *T. harziamum*	88.33	0.667
Starch + *T. harziamum*	91.48	0.417
Control	85.64	1.208
$LSD_{0.05}$	04.91	NS

Table 3.9. *Effect of different species of* Trichoderma *and* Gliocladium virens *alone and their combinations rhizome rot of ginger*

Treatment	Germination(%)	Disease incidence (%)
Trichoderma harzianum	88.09	2.143
Trichoderma hamatum	92.32	0.785
Gliocladium virens	91.93	1.571
T. harzianum + *G.virens*	91.95	1.214
T. harzianum + *T. hamatum*	93.21	0.857
T. harzianum+*T. hamatum*+*G. virens*	90.18	0.714
Control	88.80	2.643
$LSD_{0.05}$	04.13	1.425

cell culture and so far no toxin insensitive cell line has been isolated.

Protocols have been standardised to isolate protoplasts of *Piper nigrum* and *Piper colubrinum*. Regeneration upto plant level was achieved with *P. colubrinum* while in the case of *P. nigrum* regeneration upto callus phase has been achieved.

DBT ADHOC PROJECT 2

DEVELOPMENT, PRODUCTION AND DEMONSTRATION OF BIOCONTROL AGENTS UNDER INTEGRATED PEST MANAGEMENT

(Y R Sarma, M Anandaraj, K Vinayagopal & M G Prakash)

The efficacy of biocontrol programmes on foot rot management in black pepper against *P. capsici* and nursery management in small cardamom against *Pythium-Rhizoctonia* complex has been successfully demonstrated in farmers fields. Application of biocontrol agents was carried out in black pepper nurseries of farmers and in Kerala Agricultural Department nurseries at Koothali, Puduppadi, Thikkodi, Thaliparamba and Tribal Development Project in Kodenchery. In Kerala State, field application of biocontrol agents was carried out in Wynad, Calicut, Kasaragod, Kannur, Idukki, Malappuram and Thrissur districts. A total area of 993.28 ha has been covered. The application of biocontrol inoculum in black pepper was carried out in Karnataka State, in an area of 1387.10 ha. Nursery management of small cardamom was carried out in five Spices Board nurseries in Karnataka State, covering an area of 82.51 ha. In Andhra Pradesh 640.00 ha of black pepper under Andhra Pradesh Forest Development Corporation was covered. A small area of 2 ha of betel vine was treated with biocontrol agents. The total area coverage including all the three states is 3104.2 ha during April 1996-March 1997, against the target area of 2000 ha.

Screening of biocontrol agents is in progress For the mass multiplication of *Trichoderma* and *G. virens* cheap technology was developed using locally available materials and their shelf life has been calculated. About 8551.5 kg of biocontrol formulations has been supplied to the farmers. For creating awareness among the farming community about the usefulness of biocontrol agents, seminars have been conducted. Seven popular articles have been published in leading newspapers and agricultural magazines.

CLOSED PROJECT

PATH. II.1(813)

EPIDEMIOLOGICAL STUDIES ON *PHYTOPHTHORA* FOOT ROT DISEASE OF BLACK PEPPER (1978-1996)

(M Anandaraj, Y R Sarma, K V Ramana, N Ramachandran, K K N Nambiar & R N Brahma)

OBJECTIVES

To understand the etiology of the disease, the factors responsible for spread of the disease and the ecology of the pathogen.

SALIENT FINDINGS

A. IDENTITY OF THE PATHOGEN

The fungus was grown on carrot agar and incubated under light to study the morphological characters of the fungus. The sporangial ontogeny was umbellate with cauducous sporangia, which were ellipsoidal with tapering base, obovoid or fusiform with a clear papilla. The L B were 24.6µ and 16.34µ. The L X B ratio was 2.0 - 2.05 in 58.5% of sporangia and 1.5 - 1.8 in the remaining 41.5%. The sporangia were borne on long stalks. Based on the sporangial characters, it was identified as *'Phytophthora palmivora'* MF_4 (Sarma and others 1982). This was later merged with *P. capsici* after redescribing the species (Tsao and Alizadeh 1988) and currently it is designated as *P. capsici*.

B. BIOLOGY OF THE PATHOGEN

Among the selective media tried, PVPH medium was found ideal for *P. palmivora* MF_4 (*P. capsici*) isolation. In P_{10} VP medium along with *Phytophthora, Pythium* was also isolated. Direct isolation from soil was not successful always. But, when black pepper leaf discs were used as baits and plated on PVPH the fungus was isolated. The growth of the fungus (6mm) was minimum at 10°C and maximum at 24°C (46mm) after 72h.

C. GROWTH PATTERN OF BLACK PEPPER VINES AND SPATIOTEMPORAL PATTERN OF SPREAD OF THE DISEASE

Flushing pattern in black pepper in relation to weather: Black pepper being a perennial crop, the production of new leaves and roots depends up on the availability of soil moisture. The production of fresh roots and tender foliage coincide with increase in soil moisture during the south west monsoon season which also activates the fungus, *P. capsici*, in the soil. To quantify the proportion of vulnerable tissues produced during this period, the flushing pattern was studied in two varieties of black pepper namely, Karimunda and Panniyur-1. In each variety 10 vines were selected and from each vine 20 lateral branches were labelled. From each labelled lateral the number of old leaves, internodes and the number of new leaves produced every fortnight were counted starting from last week of May. This study was conducted for two years. The proportion of new leaves to that of old leaves was estimated. During the second year of the study the time taken for the new leaf to expand was also monitored by labelling 100 leaves. The leaf area was measured by taking the length and breadth (Shivashanker and others 1986; Mohankumar and Prabhakaran 1988) of 50 leaves each from the two varieties of black pepper. The mean leaf area was used for computing the proportion of new leaf area added every week. The proportion of new leaves to old leaves was estimated by using the formula $Y=A/\{1+\exp(-a-bt-ct^2)\}$ which is also expressed in the form of $\text{Log e } (Y/A - Y)= a+bt+ct^2$

where, Y=cumulative value of the ratio of new leaves to number of old leaves at time 't' (fortnight) and A=is known as the asymptote of the curve which in simple terms can be explained as the value of 'Y' beyond which there is no increase even if time 't' is extended, c=negative value of coefficient. The parameters 'A', 'ab' and 'c' of the above equation were fitted with a iterative procedure and the values which yielded the lowest deviative sum of squares (i.e., the deviation of observed and expected values squared and added over) was taken as the optimum. There were 357 lateral branches for Karimunda and 238 for Panniyur-1. The rate of growth of new leaves in proportion to the old leaves (dy/dt) curve shows that in Panniyur-1, the rate of new flush production is higher than that of Karimunda and reached the maximum by June 28, whereas in Karimunda it reached the maximum only by July 5, during the first year. During the second year in addition to new leaves, data on leaf area for these two varieties were calculated by measuring the length and breadth of 50 leaves each. In addition to the proportion of new leaves to the old leaves, the proportion of new leaf area to the old leaf area was plotted for both the varieties. In both the years, both varieties produced maximum new flush during July. The rate of increase of new leaf area in proportion to old area (dy/dt) showed a similar trend for both varieties (Fig. 3.5).

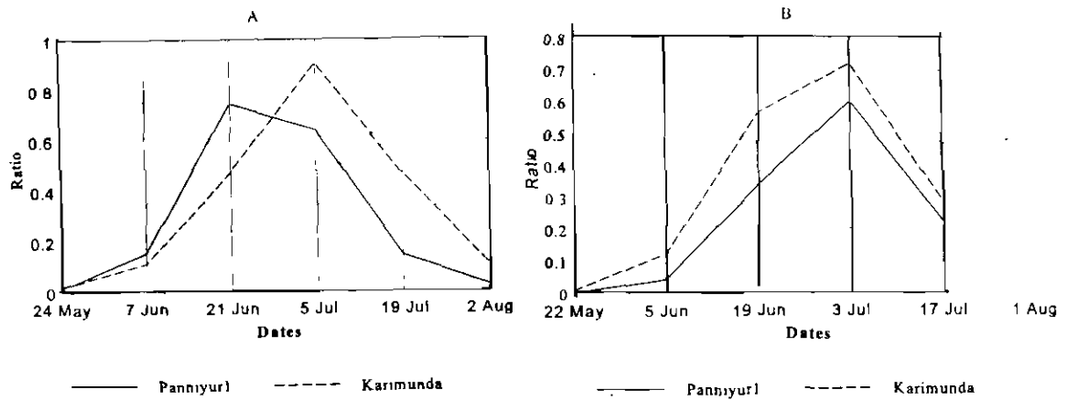


Fig. 3.5. *Flushing pattern in black pepper (dy/dt curves): A-First year; B-Second year*

Feeder root production in black pepper in relation to weather: In black pepper all parts of the plant are susceptible to infection by *P. capsici*. In the soil phase the fungus infects the tender feeder roots at the zone of elongation. To know the period when the maximum feeder root production occurs in black pepper, a study was conducted following soil core method (Bohm 1979). Five black pepper vines were labelled for this study. Soil cores were collected at monthly intervals at three distances (20, 40 and 60cm) from the base of the vine and at three depths (20, 40 and 60cm) with the help of soil auger with an outer diameter of 5cm. From each vine at each distance and depth four samples were collected and pooled. This pooled sample was placed on a 1mm

sieve and washed with tap water. The root bits collected on the sieve were taken and dry weight determined by drying the sample in oven at 90°C for 48h. The mean weight of feeder roots from five vines was taken for plotting the curve. A regression analysis equation of the form $Y=a+bx+cx^2+dx^3$ was fitted to understand the pattern of feeder root production during different periods of the year, where, Y=feeder root production, a=constant intercept and b,c,d are regression coefficients. The curve indicated that maximum feeder roots were encountered during the monsoon period July and August (Fig. 3.6). Based on regression analysis, a response curve of the third degree was fitted for the feeder root production. It showed that maximum feeder roots were produced during July in both the varieties (Fig. 3.7).

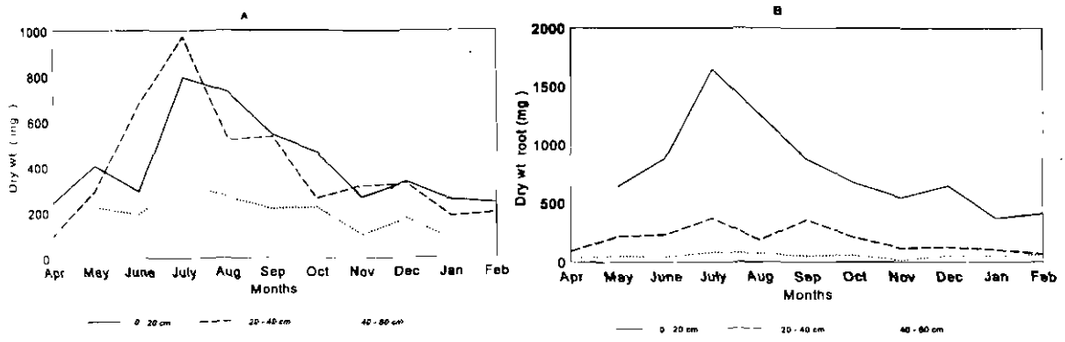


Fig. 3.6. *Feeder root production in black pepper: A-at three distances; B-at three depths*

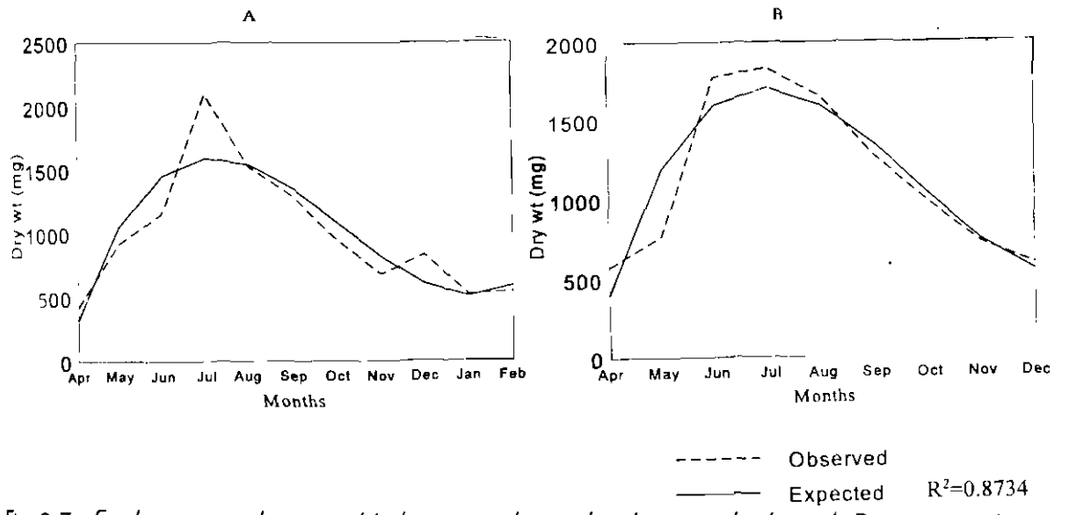


Fig. 3.7. *Feeder root production in black pepper-observed and expected values: A-Peruvannamuzhi; B-Kuppady*

Spatial pattern of spread of *Phytophthora* foot rot disease: The spatiotemporal distance class analysis of *Phytophthora* foot rot disease was studied from the data collected from a black pepper plot with about 400 black pepper vines aged six years planted at a spacing of 3 X 3m. For the analysis, vines from 15 rows (horizontal X) and 26 columns (vertical Y) constituting 390 lattices were considered. The plants were marked as diseased if symptoms such as foliar yellowing and defoliation were noticed. The data on disease incidence were converted into numerical values namely, 1, 2 and 3 which indicated healthy, diseased and missing plants respectively, as per the computer software (Nelson 1995a, 1995b). The occurrence and spread of foot rot disease was monitored at fortnightly intervals beginning from October 1989. The data on the initial occurrence and subsequent spread were analysed using the STCLASS computer software developed by Scot Nelson (1995a, 1995b).

The two dimentional distance class 'X Y' refers to absolute distance between plants within a pair. The distance between two infected plants is obtained from the absolute value differences between their X and Y values. The number of pairs of infected plants observed in each (X,Y) distance class are directly compared to expected values obtained from plots containing the same number of randomly distributed infected plants and their test statistics generated by computer simulation. Pair of infected plants within the lattice is identified and assigned to a (X,Y) distance class. Statistical comparison of observed lattice with computer generated expected patterns were mapped in a distance class matrix. Standardized count frequency (SCF) for each observed (X,Y) distance class is obtained by tabulation of number of times that diseased units are separated by a given (X,Y) distance. The total number of (X,Y) distance class equals the (row x column) dimensions of the observed lattice. Significance of the observed SCF for each X,Y distance class is determined by calculating per cent of times it exceeds or is exceeded by the 400 expected patterns of SCFs, tabulated for the same distance class. The initial occurrence and subsequent spread has shown a non random occurrence and the diseased plants were clustered together in the STCLASS matrix.

D. Ecology of the pathogen

Baiting techniques: Four types of baits namely, castor seeds, black pepper leaf discs, *Albizia falcataria* and *Leucaena leucocephala* leaflets were used. The infected soil and water were used in different proportions ranging from 1:1 to 1:8. The baits incubated in *P. capsici* contaminated soil were infected within 72h. But postitive baiting could be confirmed only after plating the infected baits on selective medium. In case of *A. falcataria* baits the fungus directy sporulated on the infected baits and baiting could be confirmed faster. Among different soil water ratios, 1:4 showed better baiting effeiciency and *A. falcataria* was more efficient than other baits.

Mode of survival: Soil moisture plays an important role in the life cycle of *Phytophthora* spp. and for the build up of transitory inoculum from the residual inoculum left in the field from the previous season's disease. A laboratory study was conducted in which a known inoculum was exposed to varying moisture levels. The survival of isolates of *P. capsici* isolated from root, stem and leaf was studied at four moisture holding capacities namely, 100%, 50%, 25% and 0% (air dry soil). *P. capsici* inoculum in the form of infected black pepper tissues and sand culture inoculum was placed in the plastic containers. Soil samples were collected periodically, soil smears prepared, stained with Ranipal GS and observed for resting structures. A part

Table 3.10. *Effect of moisture on survival of* Phytophthora capsici *isolates*

Moisture (%)	*P. capsici* isolates			Mean
	Root	Stem	Leaf	
100	0.33*	0.66	0.83	0.61
50	0.66	0.50	0.33	0.50
25	0.17	0.33	0.33	0.28
0	0.00	0.00	0.00	0.00
Mean	0.29	0.37	0.32	-

* DPI after six months; $LSD_{0.05}$ Moisture - 0.34; Isolates and M-x I = not significant

of the sample was used for baiting with *A. falcataria* and DPI estimated.

The experiment on survival with four moisture levels was maintained for 2 years and sampling was done at monthly interval. Positive baiting was obtained upto 6 months, but the DPI was reduced drastically even after 1 month of storing, with least DPI in dry soil. The DPI further reduced after 6 months in all the treatments and no positive baiting was obtained in dry soil (Table 3.10). Soil smears indicated the presence of thickened mycelia and chlamydospores.

Spatial distribution of *P. capsici* inoculum in soil around infected plants: The spatial distribution of *P. capsici* was studied by collecting soil somples from 0, 30, 60 and 90cm distance from the base of the vines and at 3 depths namely, 0 - 10, 11-20 and 21- 30cm. Soil samples were collected from four sides of the vines, mixed and a composite sample was used for baiting. Infected baits were washed, surface sterilized and plated on selective medium to confirm positive baiting. The mean number of baits infected at 0 -10, 11- 20 and 21- 30 cm were 6.9, 5.2 and 3.3 (34%, 26% and 16%), respectively, showing that inoculum was concentrated in upper layers of soil.

Production of oospores: *P. capsici* being heterothallic requires another mating type for the production of sexual reproductive structures. The production of oospores was studied using slide culture technique in a synthetic medium containing B - sitosterol (Ribeiro 1978). Black pepper *Phytophthora* isolates when incubated along with isolates from cardamom or coconut produced oospores.

Effect of living plants (hosts and non hosts) on population build up and multiplication of *P. capsici*: *P. capsici* being a wet weather pathogen, requires soil moisture for population build up. Soil moisture also promotes weed growth in black pepper plantations. The effect of black pepper and weeds on the population build up of *P. capsici* was studied in a pot culture experiment. Potting mixture for the experiment was prepared by mixing soil, sand and farmyard manure in the ratio of 3:1:1. *P. capsici* inoculum in the form of contaminated soil @ 500g inoculum which showed a DPI of 32 was added to each pot containing 15 kg soil. Two common weeds namely, *Pueraria* sp., a legume and a grass *Brachiaria lyrizanthes* were planted with black pepper cv. Karimunda laterals. To compare the growth of black pepper plants without *P. capsici* inoculum two controls were maintained, one without inoculum and another where the soil was fumigated with 4% formaldehyde, 25 days before the start of the experiment. Two more treatments were maintained to monitor the population build up of *P. capsici* in the absence of black

Table 3.11. *Effect of black pepper and weeds on populations of* P.capsici *as shown by disease potential index (DPI)*

Treatment	DPI-Months after inoculation				
	4	5	6	7	8
1. Bl. Pepper + Pc	16	16	16	32	8
2. 1 + Rmz 500ppm	8	4	8	32	2
3. 1 + Coc 500ppm	0	0	1	2	0
4. 1 + *Pueraria* sp.	16	8	4	16	8
5. 1 + *B. lyrizanthes*	16	8	16	32	8
6. Bl. pepper in garden soil	1	1	2	2	4
7. Bl. pepper in fumigated soil	0	1	1	2	2
8. 1 + *Pueraria* sp.	16	16	64	32	16
9. 1 + *B. lyrizanthes*	16	16	64	32	16
10. Pc + watering	4	4	4	2	2
11. Pc + no watering	1	1	1	0	0

Pc-*Phytophthora capsici*; Rmz-Ridomil mancozeb; Coc-Copper oxychloride

pepper and living plants and another to study the effect of moisture on populations of *P. capsici*. The growth of black pepper plants was monitored by counting the number of leaves and nodes. Soil samples were collected at monthly intervals and DPI was estimated. The total microbial load namely, fungi, bacteria and actinomycetes was also monitored.

At the start of the experiment there was no difference in the canopy size of plants. The DPI in all the treatments was monitored regularly by baiting with *A. falcataria* leaflets. In T3 where copper oxychloride was drenched there was no positive baiting whereas, in all other treatments there was positive baiting. After 4 months, there was an increase in DPI in all the treatments except in T11 where the inoculum was added and no water was added (Table 3.11). The DPI increased in treatments which contained weeds. Wherever these weeds were planted with black pepper not only the DPI was higher but also the growth was affected and the death of the vines was faster. The increase in pathogen population has affected the growth of vines as indicated by the decrease in canopy size and number of leaves. The number of leaves gradually decreased and ultimately the plants were killed within 4 months.

Competitive saprophytic ability of *P. capsici*: The competitive saprophytic ability (CSA) of *P. capsici* was estimated following Cambridge agar plate method (Rao 1959) with suitable modifications. The growth of *P.capsici* on a nutrient medium competing with saprophytes was indexed. The colonization index was found to be very low. The colonization index in soils amended with organic matter was further reduced as the amended soils promoted the growth of saprophytic organisms.

Effect of organic matter on populations of *P. capsici*: The activity of *P.capsici* in soils amended with organic matter was studied in

ble 3.12. *Soil dehydrogenase activity (µ l Hydrogen/g soil / 24 h) in soils amended with organic matter*

Treatment	Conc.	Dehydrogenase activity-Fortnight after treatment							
	(%)	I	II	III	IV	V	VI	VII	VIII
Farm Yard Manure	1	5.5	5.2	4.4	3.6	3.8	3.1	2.3	1.5
	2	6.6	5.9	4.9	4.0	3.8	3.4	2.1	1.9
	5	9.6	4.9	5.1	4.2	3.2	2.9	1.9	1.2
Bone meal	1	3.9	3.5	2.9	3.6	3.6	3.6	2.5	1.9
	2	4.5	4.7	3.2	4.4	4.1	3.1	3.7	1.8
	5	5.6	4.9	3.9	5.2	4.3	4.4	4.1	1.6
Poultry manure	1	3.4	3.6	1.9	2.8	3.4	2.8	1.9	1.5
	2	4.9	5.0	2.2	3.5	4.1	2.7	2.1	1.6
	5	6.2	5.9	2.6	3.9	4.2	3.9	2.1	1.7
Coir pith	1	2.7	3.8	1.9	2.8	4.0	2.8	1.5	1.6
	2	3.4	5.2	2.0	3.2	3.9	3.5	3.4	2.0
	5	3.8	7.1	2.1	3.9	5.6	5.1	3.8	2.1
Neem cake	1	4.3	4.5	2.7	3.2	4.6	2.7	1.6	1.7
	2	5.3	5.5	3.1	3.9	4.6	3.0	2.0	1.9
	5	11.2	5.7	4.3	5.3	3.5	3.9	2.9	1.9
Garlic + Mustard	1	4.9	2.7	4.4	3.7	3.1	2.5	1.9	1.1
	2	6.1	3.6	5.0	3.5	2.8	1.8	1.5	0.6
Control	-	1.9	1.4	1.4	0.8	1.3	1.2	1.4	0.7
$LSD_{0.05}$	-	2.45	1.15	0.17	0.19	0.94	0.98	0.61	0.50

a pot culture experiment. The treatments included farm yard manure, bone meal, poultry manure, neem cake, coir pith, garlic and mustard extract. Each of the amendments was added to 1kg of soil as per the treatments and the soil moisture was adjusted to 50% water holding capacity. The initial population of *P.capsici* inoculum was estimated and the DPI was 512. Soils amended with organic matter were monitored for the activity of *P. capsici* by estimating DPI, soil dehydrogenase activity and microbial populations. In all the amended soils the population of *P. capsici* was reduced drastically except in coir pith and control. The DPI ranged from 1 to 4 in coir pith and control as against zero in all other treatments. Microbial activity was very high in the first fortnight and later reduced gradually by the eighth fortnight. All the organic amendments showed enhanced saprophytic activity as indicated by soil dehydrogenase activity (Table 3.12) and the number of colonies obtained in soil dilution plating.

Effect of climatic factors on *Phytophthora* leaf infection in black pepper: The studies were conducted in an areca-black pepper mixed cropping system at Central Plantation Crops Research Institute, Research Centre, Kannara.

The black pepper vines were 7 years old, trailed on areca palms spaced at 1.8 X 3.6m. Meteorological parameters namely, ambient temperature, relative humidity, rainfall and sunshine hours were monitored for 3 years (1984-86). The foliar infection was recorded by counting the number of infected leaves in two 0.5 X 0.5 m area in the canopy of each vine at weekly intervals and the sum of this for all the infected vines was taken as the quantum of the disease and compared with the climatic factors preceeding 7 days and correlation coefficients were worked out. The factors such as daily rainfall of 22.2mm, temeperature range of 22.7 - 27.3°C, sunshine 2.88 h day^{-1}, relative humidity ranging from 83.8 to 99% were found to favour the disease.

E. Effect of age of black pepper to infection by *P. capsici*

To investigate the presence of juvenile resistance/tolerance of *P. capsici* an experiment was conducted in microplots under simulated field conditions. Black pepper vines (variety Panniyur-1) were raised in microplots in batches of twenty for 5 years. At the end of 6 years 100 plants in five age groups namely 1-5 years were available for the study. The vines were inoculated with *P. capsici* @ 8, 16, 24 discs $plant^{-1}$ and uninoculated plants served as control. Observations were recorded on the physical conditions of the vines and *P. capsici* population was monitored by estimating the disease potential index using baits. The inoculated plants remained healthy upto four months and later, irrespective of the inoculum load and age of the vines showed declining symptoms such as yellowing, wilting, drying up of a portion of vines and defoliation due to root damage. Some of the vines showing such symptoms started sprouting during monsoon period and others succumbed. In all the cases the root infection had culminated in collar rot. The following three types of collar infection were noticed.

i) Infection spreading from the root system closer to the soil where sudden wilting was seen,

ii) Infection spreading from the roots of the lower tier which resulted in yellowing preceeding death of vines and

iii) Infection reaching a branch of under ground stem which resulted in death of a portion of the vine.

Different levels of inoculum did not show any significant difference in mortality of vines and also difference in DPI. Once the infection reaches the main stem the vine succumbs to infection.

F. Etiology of slow decline disease of black pepper

Black pepper (var. Panniyur-1) vines were grown in microplots under simulated field conditions. When the plants were one year old, they were inoculated with three pathogens viz. *P. capsici, Radopholus similis* and *Meloidogyne incognita* alone and in various combinations. Observations on the occurrence of aerial symptoms were recorded. At the end of second year, surviving vines were uprooted, indexed for root rot, root lesion and root knot. The vines inoculated with *P. capsici* or *R. similis* either alone or in combination started showing symptoms within two months after inoculation. The vines showing declining symptoms succumbed to infection. The surviving vines showed varying degrees of yellowing and root rot (Table 3.13). The pathogens either alone or in combination cause feeder root damage which results in declining symptoms. Control methods against slow decline must take into account the role of both *P. capsici* and plant parasitic nematodes.

G. Sequential inoculation of *P. capsici* and nematodes

Black pepper plants var. Panniyur-1 were

Table 3.13. *Effect of* P.capsici, R.similis *and* M.incognita *inoculation on black pepper vines*

Treatment	Mortality (%)	Yellowing index (0-4)	Defoliation index (0-4)	Dry wt(g) shoot	Dry wt(g) root	Root lesion index (1-5)	Root knot index (0-3)	Root rot index(0-4) Feeder	Root rot index(0-4) Main
P. capsici (Pc)	50.0	1.5	1.5	617.0	66.5	0.0	0.0	3.0	3.0
R. similis (Rs)	50.0	0.6	1.6	486.9	73.0	3.0	0.0	0.0	0.0
M. incognita (Mi)	16.6	1.2	1.2	988.4	124.6	0.0	2.2	2.0	0.0
Pc + Rs	66.6	1.5	1.5	685.6	93.1	2.5	0.0	2.0	2.5
Pc+Mi	16.6	0.8	1.8	989.8	92.6	0.0	2.2	2.4	1.6
Mi + Rs	16.6	1.0	1.5	908.2	40.6	3.0	2.7	2.0	1.8
Pc+Rs+Mi	50.0	2.0	3.0	263.1	20.8	3.3	1.3	3.0	3.0
Control	0.0	0.0	0.0	1288.8	130.2	0.5	0.5	0.0	0.8
Control (Ph+RMZ)	0.0	0.0	0.0	1395.5	224.7	0.0	0.0	0.2	0.2

Foliar yellowing index
0- no yellowing
1- upto 25% leaves yellow
2=upto 50% leaves yellow
3-upto 75%
4-> 75% leaves yellow

Root lesion index
1= no lesion
2= few isolated lesions
3= many lesions
4= lesions coalescing
5= whole root system affected

Root knot index
0= no gall
1= few galls
2= galls on secondary & tertiary roots
3= galls on primary, secondary and tertiary roots

Root rot index
0=no rotting
1=upto 25%
2=upto 50%
3= upto 75%
4=>75%

raised in 12" dia. earthen pots filled with fumigated mixture consisting of forest soil, sand and farm yard manure in the ratio of 3:1:1 and the vines were trailed on wooden poles planted next to the pots. When the plants were one year old, the pathogens where inoculated in various sequences. When all the plants in the treatment where all the pathogens were inoculated showed wilting symptoms, the experiment was terminated and root rot, root lesion and root knot indices were recorded in addition to fresh and dry weights (Table 3.14).

The above ground symptoms of foliar yellowing, wilting and defoliation were shown by the inoculated vines within two months after inoculation. Root rot was maximum in plants inoculated with *P. capsici.* and in plants inoculated with *R. similis* and *M. incognita* first followed by *P. capsici.* Root rot index of 3.8 was recorded in plants inoculated with *R. similis* followed by *P. capsici.* The results show that *P.capsici* and *R. similis* alone and in comibination cause severe root rot leading to reduction in root and shoot development and when both the nematodes were inoculated first followed by *P. capsici,* the symptom development was faster. This clearly indicates that both *P. capsici* and *R. similis* being potential pathogens, their combination results in rapid damage to the root system leading to faster decline of vines.

H. Effect of Vesicular Arbuscular mycorrhizae (VAM) on root rot of black pepper caused by *P. capsici*

Vesicular arbuscular mycorrhizae isolated from black pepper were tested for their efficacy and seven efficient strains have been identified (Anandaraj and Sarma 1994a; IISR 1995). When VAM was incorporated in the

Table 3.14. *Effect of sequential inoculation of* P.capsici *and nematodes on root damage in black pepper*

Treatment	Wilting (%)	Root rot* index (0-4)	Root lesion* index (0-4)	Root knot * index (0-4)	Fresh wt(g) Shoot	Root
P. capsici (Pc)	20.0	4.0	0.0	0.0	118.0	10.9
R. similis(Rs)	20.0	2.6	1.8	0.0	147.0	16.2
M. incognita(Mi)	0.0	1.2	0.0	2.2	198.0	26.4
Rs+Mi	0.0	2.4	2.4	1.0	132.0	13.4
Pc>Rs	0.0	2.6	2.6	0.0	188.0	16.6
Pc>Mi	0.0	2.4	0.0	1.6	172.0	17.2
Pc>Mi+Rs	40.0	2.8	0.6	0.6	146.0	15.0
Rs>Pc	20.0	3.8	2.0	0.0	115.0	9.0
Mi>Pc	40.0	2.8	0.0	1.2	116.4	10.4
Rs+Mi>Pc	100.0	4.0	0.0	0.0	48.0	5.4
Rs+Mi>Pc	60.0	3.6	0.6	0.6	108.0	13.0
Control	0.0	0.0	0.2	0.2	228.0	38.2
LSD $_{0.05}$	-	1.19	0.9	0.6	78.5	13.0

>-Followed by; *0 - no root rot/lesion/root knot; 1 - upto 25% root rot/lesion/root knot; 2 - upto 50% root rot/lesion/root knot; 3 - upto 75% root rot/lesion/root knot; 4 - 100% Root rot/lesion/root knot

Table 3.15. *Effect of VAM on growth of black pepper in nurseries*

VAM isolate	Dry weight (g) Shoot	Root
Glomus sp. isolate 1	189.10a	55.19 a
Gigaspora gigantea isolate 1	167.80 a	46.88 a
Glomus sp.isolate 2	150.30 a	47.81 a
Gigaspora gigantea isolate 2	188.10 a	59.06 a
Glomus sp. isolate 3	130.30 ab	34.69 ab
Glomus sp. isolate 4	125.00 ab	33.88 ab
Glomus sp. isolate 5	127.80 ab	34.69 ab
Control	54.06 b	16.50
LSD $_{0.05}$	74.09	22.42

Means followed by the some alphabet are not significantly different under DMRT

nursery mixture, all the seven isolates enhanced growth of black pepper. The dry weight of shoot and root ranged from 125 to 189 g^{-1} and 33.8 to 59.0g in VAM treated vines as against 54.0g and 16.5g in control, respectively (Table 3.15).

These seven isolates were tried on four varieties of black pepper to study their effect on growth and suppression of root rot caused by *P. capsici*. All the seven isolates of VAM tested colonized the roots and formed arbuscules and *Glomus* spp. formed typical vesicles in black pepper.

There was no significant difference among the four cultivars tested. The experiment was terminated when *P. capsici* inoculated plants in control treatment showed foliar yellowing. Root rot was indexed using a 0-4 scale. The root rot index ranged from 1.1 to 2.1 in various treatments as against 3.5 in control. There was no difference among the cultivars; but there was significant difference in the interaction between varieties and isolates. In *G. gigantea* the root rot index was only 0.8 in both Sreekara and Subhakara as against 3.8 in control, but there was no significant difference in Kottanadan and Panniyur-1 (Table 3.16).

Although there was root rot among the treated vines, none of the treated vines showed any foliar yellowing as the root mass produced might have compensated the damaged roots.

Conclusions

The investigations have revealed that slow decline disease is caused due to feeder root damage by *P. capsici, R. similis* or *M. incognita* either individually or in various combinations. The non random occurrence of foot rot disease and subsequent spread, clustering around the previously infected vines, suggests the importance of phyto-sanitation in reducing the inoculum load. The multiplication of *P. capsici* under weeds calls for clean cultivation after the monsoon. The poor competitive saprophytic ability of *P. capsici*, and the proliferation of saprophytic microbes in soils amended with organic matter calls for cultural control of *P. capsici* using soil amendment with organic matter. The beneficial effects of VAM for growth promotion and disease suppression may be exploited to raise healthy disease free planting material of black pepper.

Table 3.16. *Effect of VAM on root rot of black pepper caused by* P. capsici

VAM isolate	Root rot index in black pepper varieties (0.4)*				
	Sreekara	Subhakara	Kottanadan	Panniyur -1	Mean
Glomus sp. Is-1	1.0	1.0	1.3	1.3	1.1
G. gigantea Is-1	1.5	2.5	1.5	1.0	1.6
Glomus sp. Is-2	2.3	1.3	2.8	2.8	2.1
G. gigantea Is-2	0.8	0.8	1.8	1.8	1.3
Glomus sp. Is-3	2.5	2.5	1.8	1.5	2.0
Glomus sp. Is-4	2.5	1.8	1.5	1.5	1.8
Glomus sp. Is-5	2.3	2.5	1.8	1.5	2.0
Control	3.8	3.8	3.3	3.3	3.5
Mean	1.9	2.0	1.9	1.8	-

$LSD_{0.05}$ VAM isolates - 0.53; VAM isolates x Variety - 1.06

* 0 = Healthy; 1 = 25%; 2 = 50%; 3 = 75%; 4 = > 75% Root rot

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SOCIAL SCIENCES

The Social Science section handled five research projects during 1996-97. The salient findings are:

The cost of cultivation of black pepper and benefit cost ratio (BCR) were worked out. The production of black pepper works out to be Rs. 27.55 kg^{-1} with a BCR of 2.49 for monocrop and Rs. 31.95 kg^{-1} and BCR of 2.10 for mixed cropping system.

Critical analysis of the effectiveness of 'Kurumulagu Samrakshna Samiti' in black pepper is attempted. The high production technology of black pepper, developed by this Institute, was demonstrated in farmers' plots. By adoption of HPT, there was an increase in yield of black pepper from 0.5 kg to 1.3 kg $vine^{-1}$ and foot rot disease was brought down from 2.5% to 0.8%. Similarly, HPT of cardamom was demonstrated in Coorg district of Karnataka. Constraint analysis in cardamom production was done and the constraints were rank ordered based on feed back response.

The section also undertook several extension activities. Several training programmes were conducted and imparted training to farmers and various developmental agencies. Exhibitions highlighting the activities of the Institute were held on 5 occasions in various places. Kodencherry village was adopted by the Institute and a bench mark survey was conducted to identify the constraints. Yellow

Adoption of Kodenchery Panchayat - Inaugural function

leaf disease of arecanut and little leaf disease of black pepper are the major problems. For the overall developmental of this area an IVLP scheme is proposed to be taken up.

An Agricultural Research Information System (ARIS) cell has started functioning and personal information system of IISR scientists was prepared.

Inauguration of a seminar cum exhibition at Kodenchery

A view of the ARIS Cell at IISR

STAT. V(813)

ECONOMICS OF BLACK PEPPER CULTIVATION

(Jose Abraham & M V Prasad)

Surveys for recording data on inputs like planting materials, fertilizers, plant protection chemicals and labour were conducted in Calicut and Wynad districts. Estimates of the cost of production of black pepper under monocropping and inter cropping systems were obtained by incorporating the changes occurred in the various input costs. It was observed that the major component of cost of cultivation of black pepper is labour and the average cost for labour per man day ranges from Rs. 60 to 100. The tentative estimates of cost of production of pepper obtained from the cost benefit analysis are presented in Table 4.1.

The estimates of:

1. Plant density ha^{-1} is 300 vines under mixed cropping and 1000 vines under monocropping
2. Average life of plantation is 15 years
3. Interest rate is 15%
4. Average yield $vine^{-1}$ $year^{-1}$ under mixed cropping is 1.085kg and under monocropping is 1.68kg.
5. Average market rate of pepper is Rs. 60 kg^{-1}

The cost of production of pepper under mixed cropping is higher than that of monocropping system. The reasons are the low productivity of the different varieties usually planted by the farmers and the high competition between the component crops for sunlight, nutrients and water. Moreover, in the present case only the income and expenditure of pepper were considered ignoring the impact of mixed cropping on the whole system.

EXT. I(813)

INCREASING PRODUCTIVITY OF BLACK PEPPER AND CARDAMOM THROUGH LARGE SCALE DEMONSTRATION OF IMPROVED TECHNOLOGIES IN FARMER'S FELD

(A K Sadanandan, Jose Abraham, V S Korikanthimath, Rajendra Hegde & M N Venugopal)

A. BLACK PEPPER

Observations from the five demonstration

Table 4.1 *Cost of production of black pepper under mixed and monocropping systems*

Item	Cost (Rs ha^{-1}) under	
	Mixed cropping	Monocropping
Investment during establishment	13,530	65,490
Interest @ 15% compounded	6,864	33,739
Total investment	20,354	99,229
Annuity value @ 15%	3,480	16,962
Annual maintenance cost	6,905	29,340
Total cost $year^{-1}$ ha^{-1}	10,385	46,302
Average estimated yield kg ha^{-1}	325	1680
Cost of production Rs kg^{-1}	32.00	27.50
Benefit Cost Ratio (BCR)	2.10	2.49

plots involving 1710 vines at Peruvannamuzhi (coconut + pepper) showed that with the timely adoption of HPT, pepper productivity can be increased to 1.3 kg vine^{-1} (from 0.5 kg) and wilt disease can be brought down to 0.8% (from 2.5%).

B. CARDAMOM

Replanting cardamom in a phased manner: During 1996-97 the yield of cardamom was 385 kg (dry) ha^{-1}, in the 2 ha area replanted in 1993. In cardamom the highest yield is obtained either during the third or fourth year of planting depending on level of management. Here too a highest crop yield (1775 kg ha^{-1}) was recorded during the second crop season (1995-96) which subsequently came down during the following year (1996-97). One of the reasons for the low yield after attaining the highest peak yield may be due to the fact that cardamom is a rhizomatus crop and most of the vegetative buds would express their full potentiality due to conversion of majority of the suckers into bearing suckers in the year in which the highest yield was obtained. Since the suckers that have already undergone production die (removed by trashing) during the following season giving rise to sister/daughter suckers, the yield comes down drastically as it has happened during 1996-97. After rebuilding of the clump, once again cardamom picks up the yield and attains an average plateu of yield.

Comparative performance of cardamom and robusta coffee as side (mono) crops: During the third crop season (1996-97) the yield of cardamom was 128 kg 0.4 ha^{-1}. Robusta coffee recorded 980 kg 0.4 ha^{-1} during 1996-97.

Cardamom vs. arabica coffee: Yield of cardamom was 405 kg (dry) ha^{-1} during 1996-97 crop season. An encouraging crop yield of 1256 kg ha^{-1} was obtained in arabica coffee during 1996-97.

Cultivation of cardamom on steep slope: Cardamom planted on steep slope during July 1993, by resorting to soil conservation (bench terracing), besides adoption of other HPT package, recorded 982 kg(dry) ha^{-1}, during 1995-96 and 247 kg ha^{-1} in 1996-97, respectively.

Conversion of marshy area for profitable cultivation of cardamom: Low lying marshy area which had a sparse growth of shade trees and unsuitable for cultivation of any other commercial plantation crops, was successfully converted by resorting to adequate drainage (leader and lateral drains) and planting cardamom in the year 1993. A moderate cardamom yield of 127 kg(dry)ha^{-1} was recorded in 1996-97.

Rapid clonal multiplication of multibranch (MB) in homestead and laying out large scale field demonstrations: High yielding multi branch types of cardamom planted in homestead trench system during June 1994 with 725 clonal multi branch material (suckers) recorded 128 kg dry cardamom in 0.11 ha just with in 20 months after planting in 1996. It also generated 14700 planting units (rhizomes). During August 1996, large scale demonstration was laid out in 4.2 ha area by planting the multibranch suckers in wider spacing of 2.1 X 2.1 m to assess the yield performance.

Trench system of planting with elite clonal material: Another large scale demonstration (2 ha) was laid out by planting elite clonal selections (selected and multiplied right on farmers field by to rapid clonal multiplication) in the trench system of planting to assess the yield performance as well as to generate elite clonal planting material.

EXT. I(443)

TRAINING OF EXTENSION AND RESEARCH WORKERS

(M V Prasad & P Rajeev)

The training programmes conducted at

IISR, Calicut during 1996-97 are given in Table 4.2.

EXT. II(813)

EFFECTIVENESS OF "KURUMULAKU SAMRAKSHANA SAMITI" IN PEPPER PRODUCTION IN KERALA- A CRITICAL ANALYSIS

(M V Prasad & Jose Abraham)

Data on perception about samiti, perception on recommended technology on black pepper, extent of their adoption, perception about samiti organisational climate, supply and services, linkages of samiti, constraints faced by the farmers in adoption and suggestions to solve them were collected from 96 farmers. Data on training needs were also collected from farmers. Data from 52 agricultural officers on perception about samiti, organisational climate in samiti, constraints faced by them in organising samiti and suggestions to solve them were collected.

EXT. III(813)

CONSTRAINT ANALYSIS IN CARDAMOM PRODUCTION - A SYSTEM APPROACH

(P Rajeev & V S Korikanthimath)

A study was initiated in 1995, covering the Kodagu district in Karnataka, to systematically identify, classify and analyse the major constraints of a viable cardamom industry.

Methodologically, the constraints were identified by a critical examination of experiences narrated by a sample of growers. (The critical incident technique was used to analyze the production, technology transfer, marketing and post harvest technology systems). Survey and semi-structured interviews were also used to collect the data. The following constraints were identified in that order of priority as perceived by the sample of growers.

(1) Scarcity of labour force and associated problems of management

Table 4.2. *Training programmes conducted at IISR, Calicut during 1996-97*

Title	Duration	No. of participants
Spices production technology	14-18 May 1996	6
	24-30 October 1996	6
	18-23 November 1996	5
Foot rot disease management in black pepper	24 May 1996	26
	25 May 1996	25
Field training in spices	27 June-3 July 1996	7
	22-28 October 1996	10
Nursery management in spices	7-8 October 96	2
Onfarm processing af spices	6-7 January 97	4
Total	-	91

(2) Pest and disease management; menace of root grubs, persistence of stem borer and problems of early detection and management of the 'Katte' disease

(3) Problems of nursery management due to non availability of quality planting material, low germination percentage in on farm nurseries and failure of tissue culture plants

(4) Quality constraints and scarcity of locally available organic manure

(5) Seasonal fluctuation of prices in a weak market support system

(6) Problems of soil and moisture conservation

Based on the percentage of responses from the growers, constraint index was developed to rank order the constraints. The result of the study serve as a feed back to the scientists, extension scientists and policy makers in their respective spheres of activities. An in depth analysis of selected constraints is also in progress.

OTHER EXTENSION ACTIVITIES

A. CONSULTANCY SERVICES

Scientists from the institute visited plantations and spice gardens at various places to solve the growers' problems. Dr. Y.R. Sarma and Dr. A.K. Sadanandan, Principal Scientists visited Sikkim during 22 - 29 May 1996 and imparted training on ginger and turmeric cultivation to officers of Department of Agriculture & Horticulture, Sikkim.

B. SEMINARS AND SPECIAL LECTURES

Scientists from the institute participated in seminars and farmers' meetings organized by different agencies. The following special lectures on various aspects of spice cultivation were given.

Devasahayam S

Insect pests of spices. 25 October 1996, Govt. College, Vadakara, Kerala.

Rajendra Hegde

Approaches to increase pepper productivity in Kodagu. Farmers' meeting organized by Karnataka State Agricultural Produce Marketing Board, 6-7 December 1996, Gonikoppal, Karnataka.

Ramana K V

Nematodes associated with spices. Training programme on 'Identification of Burrowing Nematodes', 22 November 1996, CPCRI RS, Kayangulam.

Sadanandan A K

Organic and inorganic fertilizer management for sustainable spices production in India. Summer Institute on "Nutrient and pesticide residue management in horticulture crops for yield and quality for domestic and export market", 30 August 1996, IIHR, Bangalore.

Recent advances in the production and processing of large cardamom (*Amomum subulatum*) & improved methods of cultivation and processing of ginger and turmeric. Off-campus Training to Agrl. Officers, 24-25 May 1996, Sikkim.

Integrated plant nutrient management in black pepper. Regional training for senior officers of Dept. of Agriculture, Govt.of Kerala, July 1996, Calicut.

Sarma Y R

Disease management in black pepper. Regional training for senior officers of Dept. of Agriculture, Govt.of Kerala, July 1996, Calicut.

Strategies of biocontrol on management of diseases of spice crops. Summer institute, 22 June 1996, TNAU, Coimbatore.

Integrated disease management in black

pepper. Regional training for senior officers of Dept. of Agriculture, Govt.of Kerala, July 1996, Calicut.

Spices - problems and prospects. Meeting of Association of Microbiologists-Jammu Chapter, 18 October 1996, RRL, Jammu.

Sasikumar B

Spices varieties. 28 October 1996, Manipuram, Calicut, Kerala.

Venugopal M N

HPT of cardamom and pepper - at Gonikoppal & Kodlipet, 2)Biocontrol of foot rot of pepper and soft rot of ginger - at Birunani & Kodlipet and 3) Vanilla and clove cultivation - at Margodu & Kodlipet. Farmers' meetings organized by the Spices Board, 16 -18 December 1996, Kodagu, Karnataka.

c. Exhibitions

The institute conducted an exhibition at Kodenchery from 14-15 October 1996 on the eve of Kodenchery village adoption programme. The Institute also conducted five exhibitions on spices in connection with different occasions viz. 1) EURECCA 96 (Science & Technology exhibition), conducted by Regional Engineering College at Zamorin School, Calicut, 5- 12 April 1996. 2) 40th anniversary of Kaiveli Panchayat organised by NWDPRA, at Kaiveli, Calicut 13-14 September 1996. 3) 40th anniversary of St.Joseph's College, Devagiri, Calicut, 4-5 December 1996. 4) 40th anniversary of Chathamangalam Panchayat, Calicut, 22-25 December 1996 and 5) 40th anniversary of Cheruvady Panchayat, Calicut, 27-30 December 1996.

d. Adoption of Kodenchery Panchayat

Kodenchery Panchayat was adopted by IISR for its all-round development. Sri. V.K. Rajan, Hon. Minister for Agriculture, Govt.of Kerala, formally announced this in a seminar cum exhibition organized during 14-15 October 1996.

e. Mass media

a. Popular articles

About 67 popular articles in Hindi, English, Malayalam, Tamil and Kannada were published in various farm journals and other periodicals (see page No. 126)

b. Radio talks

The following radio talks by the institute staff were broadcasted through All India Radio, Calicut and Madikeri.

Anke Gowda S J

Drought management in cardamom, 7 February 1997, A.I.R., Madikeri

John Zachariah T

Intrinsic quality of spices and its application in the processing industry, 19 December 1996 A.I.R,Calicut.

Kavitha C S

Recipes using green leafy vegetables, 15 May 1996, A.I.R., Calicut

Korikanthimath V S

Fertilizer management in ginger, 10 July 1996, A.I.R., Madikeri

Peter K V

Dos and don'ts in processing of spices, December 1996, A.I.R, Calicut

Prakash K M

Fertilizer application and mulching in cardamom, 29 October 1996, A.I.R., Calicut

Rajendra Hegde

Suggestions to farmers on cardamom and rapid multiplication of pepper, 5 June 1996, A.I.R., Madikeri

Important pre monsoon operations in

cardamom, 8 June 1996, AIR, Madikeri

Whither Kodagu Agriculture - A discussion, 27 August 1996, A.I.R., Madikeri

Answers to farmers questions on HPT of cardamom, 10 December 1996, A.I.R., Madikeri

Answers to farmers questions on mixed cropping in cardamom, 2 March 97, A.I.R., Madikeri

Ravindra Mulge

Nursery management in cardamom, 26 April 1996, AIR, Madikeri

Suggestion to farmers on planting of cardamom and plant protection measures in cardamom and pepper, 6 June 1996, A.I.R., Madikeri;

Transfer of agricultural research results to farmers - A discussion, 11 September 1996, A.I.R.,Madikeri

Answers to question of growers on pepper cultivation, 7th January 1997, A.I.R., Madikeri

Sakeer Hussain A

Role of KVKs in rural development, 10 July 1996, A.I.R., Calicut

c. T. V programme

Doordarshan Kendra, Thiruvananthapuram telecasted on 9 January 1997, a special programme on 'Biological control of *Phytophthora* foot rot of black pepper' based on technologies developed in the institute.

F. TRAINING PROGRAMMES

The training programmes organised during the year by the institute are given in Table 4.2.

Apart from the above, one research scholar from Madurai Kamaraj University was trained on biotechnology techniques.

Appangla centre conducted short term trainings on ' Pepper and cardamom production technology', 'Maintenance and mass multiplication of *Trichoderma*' and 'Use of *Trichoderma* in biocontrol' for the benefit of growers.

5

KRISHI VIGYAN KENDRA

During the period, training programmes were strengthened by incorporating more short term vocational courses in the disciplines of horticulture, agronomy, plant protection, home science and animal husbandry. In addition, KVK actively participated in the National Watershed Programme for Rainfed Areas and OPEC watershed programme by imparting training programmes for the beneficiaries. The activities of Plant and Animal Health Centre were further strengthened by the establishment of an artificial insemination unit. The demonstration units were expanded further and revolving fund was consolidated more by intensifying the production of planting materials. In addition, KVK actively participated in exhibitions and Kisan Melas organised in various parts of the district. Other extension activities during the period include radio talks, field visits, publication of popular articles, reply to farmers queries, animal health campaigns etc.

A training programme in progress

A. Training programmes

The KVK conducted need based and vocational training programmes in Horticulture, Plant Protection, Agronomy & Home Science and Animal Husbandry as detailed in Table 5.1. The beneficiaries were selected by advertisement in dailies and also in association with the Agricultural Department. Due to the unavilability of accomodation facility for the trainees, training programmes were strengthened by incorporating more short term vocational courses in various disciplines. The association of KVK with Agricultural Department in the conduct of training programmes for Mitrakisans of National Watershed Programme is noteworthy. During the year, 39 one day trainings, 11 two day trainings and 14 three day training programmes were conducted and a total of 1935 beneficiaries comprising of practising farmers, farm women, rural youth and extension personnels attended.

B. Exhibitions

KVK participated in 8 exhibitions conducted at Calicut, Kaively, Kodencherry, Mukkom, St.Joseph College, Devagiri, REC Chathamangalam, Cheruvadi and Sulthan Bathery in connection with Kisan Melas and other rural social activities.

C. On farm research

Client oriented programme: Follow up and monitoring of the last year's programme at Pannikkottoor SC colony was carried out.

Problem oriented research: Biocontrol of *Phytophthora* foot rot of black pepper taken up at Chempanoda was continued. Biocontrol agents were distributed to 49 farmers for the control of foot rot disease which is being monitored. A demonstration for biocontrol of soft rot of ginger was

Tablel 5.1. *Training programmes organised by KVK*

Duration	Title
One day duration	*Phytophthora* foot rot management
	Management of dairy animals
	Pest & disease management in vegetables
	Mushroom production
	Nutrition garden
	Intercropping in coconut garden
	Safe use of pesticides
	Vermiculture
	Cultivation of tubercrops
Two days duration	Orchid ond anthurium cultivation
	Vermiculture & mushroom cultivation
	Nursery techniques of tree spices
Three days duration	Nursery techniques of horticultural crops
	Vegetable production
	Operation & maintenance of plant protection equipments

organised successfully in one hectare area at Chempanoda.

Watershed management: KVK conducted training for farmers of various watersheds in the district by collaborating with the State Department of Agriculture.

Establishment of demonstration units: Demonstration units of vermiculture, mushroom apiary & rabbitry were maintained. The unit of orchid, anthurium and palms was expanded.

Literature developed: The following literature were prepared in Malayalam and are being printed i) Package of practices of black pepper ii) Bush Pepper iii) Green leafy vegetables and iv) Mushroom production.

D. PLANT & ANIMAL HEALTH CENTRE

The activities of Plant and Animal Health Centre were expanded with the establishment of an artificial insemination unit. During the period, the centre successfully treated 1693 cases and 917 vaccinations were also given. In addition, the centre conducted three animal health campaigns and also attended eight animal health campaigns organised by the State Department of Animal Husbandry. A demonstration unit of rabbits is also maintained by the centre.

E. REVOLVING FUND

The Revolving Fund flourished during the period. Planting materials of plantation crops, spices, ornamentals and fruits worth Rs.77,417/- were produced under the scheme. During the period a total amount of Rs.13,940/- was also collected from Plant and Animal Health Centre towards the consultation fees and other fees.

F. OTHER EXTENSION ACTIVITIES

The KVK technical personnel visited farmers fields to diagnose various field problems and recommended remedial measures. Also queries of farmers were replied through letters, telephone and radio programmes.

6

ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

The All India Coordinated Research Project on Spices (AIRCPS) has 20 centres dealing with 12 spices viz. black pepper, cardamom, clove, nutmeg, cinnamon, ginger, turmeric, coriander, fenugreek, cumin, fennel and large cardamom. These 20 centres are operating in 15 SAUs besides one under the ICAR Research Complex for NEH region at its Gangtok centre in Sikkim. In addition to these centres, 8 voluntary/participating centres are also functioning under the purview of this project. The AICRPS has 80 research projects under the broad disciplines of Crop Improvement, Crop Production and Crop Protection & Quality.

GERMPLASM SURVEY AND COLLECTION

A. Black pepper

Ten cultivated and 19 wild accessions collected from Sirsi, Siddapur, Honnavar and Kumta taluks and 19 wild types from Malemane and Devimane ghats/forest area were added to the germplasm collection of Sirsi centre. The Panniyur centre strengthened black pepper collections by adding 22 new accessions from the NBPGR Regional Station, Vellanikkara, Kerala making to a total of 65 accessions. Chintapalli centre collected four new pepper wild accessions during the year.

B. CARDAMOM

The Pampadumpara centre collected 5 cultivated types from Idukki district during the current year. At Mudigere, 245 cultivated cardamom accessions are maintained.

C. GINGER

Pottangi centre added three new indigenous ginger accessions collected from K. Naugaon and Tikabali of Phulbani district. The new centre at Raigarh collected 5 local ginger accessions. The Solan centre collected 10 new cultivated accessions from Bilaspur, Himachal Pradesh.

D. TURMERIC

Pottangi collected three new accessions from the survey conducted in Katringia, Phiringia and Tikabali areas of Phulbani District. The Jagtial centre collected 5 types from Adilabad and Chintapalli areas during the current year. Fifteen germplasm of turmeric were collected from the neighbouring district of Faizabad and maintianed at Kumarganj centre. Local cultivars collected from Kalimpong (West Bangal), Assam, Manipur and Nagaland, were added to the germplasm at Raigarh.

E. TREE SPICES

Two cinnamon accessions were collected by Yercaud centre. At Dapoli, the germplasm of cinnamon consists of variety Konkan Tej and the new accession No. 189 and 203 collected from IISR in 1996. A total of 12 cinnamon types are under observation in germplasm collection at Pechiparai which includes 9 selections from IISR, Konkan Tej and two local collections.

Five nutmeg grafts of promising type from Vengurla (V-26), Bhatye (B-72), Dapoli (DPL-6 and DPL-50) and Ag-20 and Ag-71 from IISR, Calicut were added to the germplasm assemblage at Dapoli centre. The germplasm at Pechiparai consists of 12 types ie. 4 elite nutmegs collected from IISR, one type obtained from State Horticultural Farm, Courtallam and seven local collections.

F. SEED SPICES

Coriander: Jobner centre added 44 cultivated coriander accessions from Kota and Jhalawar and 40 exotic accessions. Seventy five new accessions were collected by the Guntur centre from the predominently coriander growing districts viz. Prakasam, Kurnool, Cuddapah and Anantapur of Andhra Pradesh. The Raigarh centre collected 8 local accessions from Raigarh district and 20 accessions from other centres. Seventeen coriander accessions were collected from Trichy, Salem, S.Arcot, Kamarajar and Coimbatore districts by the Coimbatore centre.

Cumin: Fourteen new cumin accessions were collected by Jobner from Merta, Nagaur, Jaitaran and Jodhpur. Jagudan centre made an exhaustive survey in the cumin growing areas of the state and collected 45 cumin genotypes. The Kumarganj centre collected seven germplasm in cumin.

Fennel: Jobner centre made 28 collections from Sirohi and Tonk areas. Survey made by Jagudan centre resulted in the collection of 183 accessions possessing variability for dwarfness, leafyness, earliness etc. A total of 34 germplasm of fennel has been collected and maintained at Dholi. Hisar centre collected 11 germplasm accessions.

Fenugreek: The Jobner centre collected 15 fenugreek accessions from Chituargarh and Pratapgarh areas. Altogether, 92 accessions have been collected and maintained at Dholi. The Jagudan centre collected 15 new entries from the fenugreek growing areas of the state.

GERMPLASM EVALUATION

The germplasm accessions maintained at

different centres are evaluated for their morphological, agronomical, yield and yield attributing characters as well as for disease resistance and quality. The evaluation of the spices germplasm is progressing in all the centres including the 4 new centres started in 1996.

A. Black pepper

Sixty five germplasm accessions were evaluated at Panniyur and the collection from the Nilgiris with a mean green pepper yield of 6.0 kg vine^{-1} stood first followed by Kumbakodi (4.25kg) and Karimunda III (4.08kg). At Yercaud, out of 45 accessions which flowered in 1996-97, the highest green berry yield of 1.330 kg vine^{-1} was obtained in Acc. PN-10. The germplasm accessions were under evaluation in the arecanut plantation at Sirsi since 1995. The new centre Dholi collected Panniyur-1,2,3,4 and 5 Panchami and Pournami and are being evaluated.

B. Cardamom

In the evaluation of germplasm entries, at Pampadumpara out of 69 types flowered in 1996-97, MBP (547.9g) followed by SI (435.9g) gave higher yields. Other promising clones identified are PS-9, Vecraputhran, PS-12, MCC-43, compound panicle, PS-29, PS-10 and PS7. Among the 195 germplasm accessions evaluated at Mudigere, Acc. 103, 99, 91, 123, 105, 114, 74, 95, 11 and 101 were found superior in green capsule yield clump^{-1}.

C. Ginger

At Solan 166 germplasm collections of ginger were evaluated for yield and quality characters. The collections SG-227, SG-554, SG-610, SG-696, SG-54 and SG-638 recorded maximum yield. Ginger Acc. V_1S_1-4 gave maximum rhizome yield out of 147 germplasm evaluated at Pottangi. The Raigarh centre evaluated 5 lines of ginger and RGS-5 performed well giving an yield of 143.3g rhizome plant^{-1}.

D. Turmeric

At Jagtial, based on crop duration, the germplasm collections were grouped into long duration (8-9 months), medium duration (7-8 months) and short duration (6-7 months) types. Distinct variability was observed in the evaluation for growth and yield characters, especially with respect to rhizome fingers. JTS-7 (long duration), JTS-313 (medium duration) and JTS-602 (short duration) gave higher yields.

At Pottangi, among 150 *Curcuma longa* types, PT5-45, 19 C. *aromatica* types, CAS-54 and 3 C. *amada* types CAM-3 gave maximum rhizome yield. Twenty one lines of turmeric were evaluated at Raigarh and CAS-56 yielded highest with 213.7g plant^{-1} followed by Suroma with 191.5g plant^{-1}. Among the 15 germplasm evaluated at Kumarganj, NDH-6 and NDH-2 gave maximum yield (340g and 335g fresh rhizomes clump^{-1}, respectively). Fifty six turmeric germplasm were under evaluation at Dholi.

E. Seed spices

Coriander: Out of 92 collections at Dholi, 9 promising lines viz. Acc. ATP-102, ATP-77, UD-684, UD-685, DH-13, DH-38, DH-48, UD-686 and UD-20 have been identified. At Jagudan, 166 germplasm entries were critically examined and 51 accessions were retained. LCC-177 recorded the highest yield of 1333 kg ha^{-1} in the evaluation of 77 accessions at Guntur centre. At Kumarganj, RD-23 produced 12.76 q seed ha^{-1} followed by DH-52, DH-36 and Rajendra Swathi.

Cumin: At Jagudan, 212 cumin germplasm were critically examined and 142 accessions were retained. In the evaluation of 47 entries, yield differences were significant indicating a greater variability in the germplasm. At Kumarganj NDCL-130 gave

maximum yield of 3.10g plant^{-1} out of 7 accessions tested.

Fennel: At Jagudan, 280 accessions of fennel were critically examined and 158 retained.

Fenugreek: The Jagudan centre critically examined the 73 entries and retained all of them. At Guntur, among the 11 new collections, LFC-74 recorded the highest yield of 1417 kg ha^{-1} followed by LFC-77 and LFC-82 with 1367 and 1183 kg ha^{-1}, respectively. HM-144 produced the highest grain yield followed by UM-304, HM-110,UM-301 and NDM-3 in the evaluation of 26 germplasm at Kumarganj.

CROP IMPROVEMENT

Under the crop improvement programmes, research efforts included were evaluation and selection, evaluation trials viz. IET, MLT, CYT etc., crossing programme, mutation breeding, standardization of vegetative propagation techniques etc.

A. Hybridization and crossing programme

In seed spices, crossing programmes were initiated in Jagudan centre. The centre made 5 successful cross combinations in cumin with Gujarat cumin-1, Hairy cumin, White flowered cumin and "wilt resistant" exotic entry EC-232684. The F1 progenies are under evaluation. In fennel, Gujarat Fennel-I was crossed with "bloomless" and with an exotic German culture (EC-386375) for inheritance of dwarfness. In fenugreek, crosses were made between Methi local and Kasuri as well as with 'Australian type' for powdery mildew resistance and the F2 generation is under observation.

B. Vegetative propagation

An experiment was carried out at Yercaud to standardise the vegetative propagation method in nutmeg using two types of scions viz. orthotropic and semi hard wood. The root stock at 4 stages viz. epicotyl 2, 4 and 6 leaved stages were used. The study indicated that orthotropic scions when grafted on leaved stage root stock recorded 48% success followed by grafting on epicotyl stage of root stock (24.08%). The semi hard wood scions on two leaved stage root stock recorded 45.63% success followed by semihard wood scions on epicotyl stage root stock. (23.03%).

The propagation of cinnamon by air layering has been standardised at Dapoli centre. Standardisation of coppice grafting for conversion of male and poor yielding seedling trees into superior type has been undertaken at Dapoli.

C. Selection for leafy type coriander and fenugreek

About 12 leafy types of coriander were selected at Coimbatore centre from germplasm based on foliage yield on 25, 35 and 45 days after sowing for further identification of promising leafy types. Accessions EC-232666 and UD-435 are promising with an yield of 3.86 and 3.64 kg plot^{-1}, respectively. In fenugreek at Coimbatore, based on the foliage yield harvested on the 35th day of sowing, five accessions were further tested and out of these CF-35 and CF-65 gave higher foliage yield (8.10kg and 7.63kg foliage yield plot^{-1} (size 4m X 2.5m), respectively) as against 3.12 kg of foliage yield obtained in Co-1.

D. Yield evaluation

Under the evaluation programmes MLT, CYT, IET and other evaluation studies are progressing in various centres. There are 4 MLTs in black pepper, 2 MLTs each in cardamom, fenugreek, ginger and turmeric, one MLT each in clove, cinnamon, coriander, cumin and fennel in operation at different centres. There are also IETs in coriander, cumin, fennel, fenugreek, ginger and tur-

meric as well as CYT in large cardamom, ginger, turmeric, coriander and fenugreek.

Black pepper: In the evaluation of OP and hybrid progenies of black pepper at Panniyur, Cul. 4879 (Uthirankotta OP), Cul. 5089 (Irumanian OP) and Cul. 5621 (Kuthiravally OP) recorded maximum yield of 9.52 kg vine^{-1}, 8.42kg vine^{-1} and 7.38kg vine^{-1}, respectively. An MLT (1993) of black pepper was laid out at Pampadumpara, Panniyur, Yercaud and Ambalavayal with 14 cultures. At Pampadumpara, the highest yield was obtained in Panniyur-2 (890g vine^{-1}) followed by Vellanambau (667g vine^{-1}) and Cul 239 (435 g vine^{-1}). At Yercaud, out of the 10 entries flowered, Panniyur-3 has performed well under Shevroy hills with shaded condition with an yield of 950g green berry vine^{-1}, whereas at Ambalavayal, Panchami recorded a higher yield followed by Panniyur-2.

In another MLT at Panniyur, variety Panniyur-5 with an yield of 2.39 kg green berry vine^{-1} ranked first, followed by Panniyur-3 and Cul.54.

Cardamom: The Mudigere centre identified a breeding line with bold and oblong capsules with an yield of 4.0q ha^{-1}. The MLT with Malabar types and Mysore types are being continued in the respective centres. In the MLT (1988) at Pampadumpara, Sel.800 (311.6g) followed by CL-678 (286g) were the highest yielders.

Ginger: At Pottangi, in the IET with 16 entries, Vengsara gave the maximum fresh rhizome yield. In CYT, V1S1-8 was the top yielder and at Solan collections SNR, SG-670 and BDJR 1267 were the high yielders. Acc. 64 gave the highest yield in the MLT-IV with 10 entries at Pottangi and Chintapalli centres.

Turmeric: Fifteen entries were evaluated under IET at Pottangi and PTS-16 was the high yielder. TN-1 among the long duration types and PTS-8 among the short duration types out of six entries each tested under CYT at Pottangi are high yielders. At Dholi, among six elite lines tested under IET Rajendra Sonia gave a better yield than check. In the MLT (1991), PTS-43 produced the highest yield at Pottangi, whereas JTS-2 gave high yield (11.70 kg per 3M^2) at Jagtial. The MLT (1996) is progressing in all other centres. RH-5 out-yielded other varieties at Dholi and Raigarh whereas at Kumarganj, Rajendra Sonia gave the highest fresh rhizome yield; however, RH-5 and Acc.861 were at par and at Chintapalli the highest yield was recorded by BSR-1 (11.5t ha^{-1}).

Tree Spices: The MLTs in clove are under progress at Yercaud, Pechiparai and Dapoli centres. At Yercaud, out of six entries, Sel-1 gave maximum plant height and branches whereas at Pechiparai, Sel-2 recorded maximum plant growth parameters. Sel.189 gave the highest bark yield 892 g plant^{-1} followed by Sel.53 (880 g plant^{-1}) at Yercaud. Acc. 8 recorded the highest yield of 0.785kg dry quills plant^{-1}, followed by Acc. 9(0.515kg) at Thadiyankudissai.

Coriander: In the IET with 11 collections at Guntur, LCC-128 recorded the highest yield of 1150kg ha^{-1}. At Dholi, maximum plant growth was observed in the variety UD-20 and was at par with DH-13 and UD-686. In the CYT (Rabi-96-97), DH-36 produced the highest seed yield of 19.25 q ha^{-1} followed by RD-23, DH-13 and Rajendra Swathi, whereas at Dholi, Rajendra Swathi at Kumarganj gave the highest yield of 19.17q ha^{-1} followed by DH-444 and UD-447. At Jagudan, yield differences among different varieties were significant and DH-43 gave was the highest yield (17.48q ha^{-1}). Of the 9 entries of coriander evaluated in MLT at Jobner, UD-446 recorded maximum grain yield (12.81q ha^{-1}) and contained 0.4% volatile oil. At Guntur, LCC-15 gave the highest yield of 11.17q ha^{-1} and at Hisar,

DH-36 (Hisar) UD-446 (Jobner) and DH-38 (Hisar) gave higher yields of 20.2, 18.5, 18.3q ha^{-1}, respectively with 0.4% volatile oil.

At Raigarh in the varietal trial with 18 entries, the varieties showed marked variation for yield and yield attributes and RD-22 gave highest yield of 17 q ha^{-1}.

Cumin: The cumin entry UC-223, a natural mutant of RZ-19 having low wilt incidence recorded the maximum yield of 2.92q ha^{-1} as against 2.0q ha^{-1} in RS-19 at Jobner.

In the IET with 9 entries at Jagudan, the yield differences were significant. Entries EC-279054 and EC-279081 gave significantly higher yield (8.0q ha^{-1}) over the check (GC-2). These lines were also find resistant to wilt disease. Data of 4 years also indicated significant yield differences and EC-279081 gave the highest yield (8.07q ha^{-1}).

Fennel: Jobner centre identified UF-12, an exotic selection from Italy (EC-243380) an early maturing, dwarf type with 1.9% volatile oil. At Jagudan, JF-192 is identified as most promising. At Hisar, JF-125 (Jagudan), UF-125 (Jobner) and HF-104 (Hisar) entries gave higher yields of 20.9, 20.4 and 20.3q ha^{-1}, respectively. Eight entries were tested in the CYT at Jagudan with GFI (check). Entry JF-29 gave significantly higher yield (29.34q ha^{-1}) over the popular variety GFI. Pooled data of 4 years also indicated significantly higher yield in JF-29 (12.5% higher yield over the check). In the IET, the entry JF-200 gave maximum yield out of 6 entries evaluated at Jagudan.

Fenugreek: Several entries are under evaluation in the CYT at Dholi, Jagudan and Kumarganj. Out of 13 accessions tested, HM-114 produced maximum grain yield (26.47 q ha^{-1}) at Kumarganj, JF-102 and HM-110 at Jagudan and out of 10 entries, check variety Rajendra Kanthi produced maximum grain yield of 13.54q ha^{-1} at Dholi. At Jobner, out of 8 entries in the MLT, none was superior over RMT-1. However, Jobner centre identified UM-143, a local collection from Jodhpur, with an yield of 23.62q ha^{-1}, which is early flowering (50 days) as against 56 days in RMT-1

In the MLT at Hisar, HM-57, a quick growing, dual purpose type gave the highest grain yield of 22.5q ha^{-1} followed by CF-390 (21.7 q ha^{-1}) and HM-103 20.70q ha^{-1}, respectively. At Guntur centre, JF-102 (13.0q ha^{-1}) having long pod and higher no.of seeds pod^{-1} is identified.

CROP PRODUCTION AND MANAGEMENT

A. Black pepper

The Sirsi centre recommended application of 200g, 80g P_2O_5 and 280g K_2O $plant^{-1}$ in two equal splits during May-June and September-October in black pepper-arecanut mixed cropping system under Malnad situation. Studies at Panniyur concluded that in black pepper, irrigation at IW/CPE ratio of 0.25 (100 l of water) applied once in 8-10 days during December to May was effective in increasing the yield in cv. Karimunda.

B. Cardamom

A fertilizer dose of 75:75:150kg NPK ha^{-1} was recommended for cardamom (Mudigere) under natural shade. Further increase in fertilizer levels did not cause much variation in yield. Studies also revealed that influence of micronutrients, Boron and Molybdenum had no significant response on yield. Studies at Mudigere also indicated that application of organic and inorganic manures in different proportions did not affect cardamom yield.

The manurial trial in at Pampadumpara indicated that the favourable effect of higher levels of fertilizer NPK 100:175kg ha^{-1} on the

growth and yield of cardamom. The addition of neem cake @0.5kg plant^{-1} had effect.

C. TURMERIC

In Tamil Nadu, rhizomes are sown during June-July and regular application of fertilizer done during 30,50,90 and 120th days after planting besides periodical weeding and timely irrigation (Bhavanisagar) gave maximum yield.

D. SEED SPICES

Coriander: The coriander crop sown on 25th October at 30 cm row spacing produced maximum seed yield of 20.32 q ha^{-1} as against the minimum of 7.47 q ha^{-1} obtained under "24th November sowing at 40cm row spacing" at Jobner. Coriander variety RCr-41 and UD-20 gave maximum seed yield at 16kg ha^{-1} seed rate whereas UD-436 gave a higher yield with 12 kg ha^{-1} seed rate at Jobner. In the trial conducted at Kumarganj with a view to standardise the time of sowing of coriander with five dates of sowing the sowing done on 15th October gave the highest grain yield of 45.25 q ha^{-1}.

Cumin: Study of irrigation schedule on cumin at Jagudan indicated that irrigation applied at sowing time, 10,30,50 and 70 days after sowing gave maximum yield and is at par with irrigation at the above schedule without the 70DAS irrigation.

Fennel: For weed control in fennel, Hisar centre recommended Pendimethalin @ 1.0kg ha^{-1} pre emergence application + one hand weeding at 50DAS. For a successful crop of fennel (PF-35) sowing should be done during 3rd week of October in Hisar, with irrigation at crown stage and at umbel development stage. The highest seed yield was obtained at Hisar when irrigated at IW/CPE ratio of 0.4 and fertilized with 50kg+30kg P_2O_5 ha^{-1}. At Jagudan, yield due to different irrigation and fertiliser levels were significant. Irrigation at IW/CPE ratio of 1.0 recorded significantly higher yield. Significantly higher yield was obtained by giving 90 kg N and 60 kg P_2O_5 ha^{-1}.

Fenugreek: For fenugreek at Jobner, application of 40kg N and 40kg P_2O_5 gave maximum seed yield of 15.94q ha^{-1} as against the minimum of 13.37q ha^{-1} produced under 20kg P_2O_5 ha^{-1} and no nitrogen. Time of sowing in fenugreek was standardised at Kumarganj in the experiment with 5 dates of sowing, the sowing done on 20th October recorded the highest grain yield of 19.44q ha^{-1}. The optimum time of sowing in fenugreek (cv. Hisar Sonali) was the first week of November at a spacing of 30 x 10cm at Hisar.

E. TREE SPICES

The biofertilizer trial in tree spices is progressing at Yercaud. Preliminary studies in nutmeg indicated that application of 100kg FYM, 400g N, 300g P_2O_5 and 1200g K_2O tree^{-1} year^{-1} along with 50g each of *Azospirillum* and Phosphobacteria increased the yield of nutmeg. Similarly in the case of clove, recommended dose of fertilizer viz. 100 kg FYM, 400g N, 350g P_2O_5 and 1200g K_2O tree^{-1} year^{-1} in combination of biofertilizer 50g *Azospirillum* + 50g phosphobacteria recorded higher yield (3.51kg green buds tree^{-1}) in a 15 years old tree. The drip irrigation studies with dripping of 2, 4, 6 and 8 l of water day^{-1} is in operation in clove at Yercaud; dripping of 8.0 of water per day recorded highest plant height (136.34cm) and no.of branches per plant (41.41 nos).

CROP PROTECTION

A. BLACK PEPPER

Studies at Sirsi indicated that *Phytophthora* foot rot and nematode diseases of black pepper can be managed effectively by following all cultural practices, application of

neem cake (1kg vine^{-1}), phorate 3G (30g vine^{-1}), 1% Bordeaux mixture 3 l vine^{-1} and Bordeaux mixture drench (5 l vine^{-1}) before the commencement of the monsoon as first round (June), Akomin(0.4%) and Ridomil MZ-72 WP (100ppm) as spray (3l vine^{-1})and drench (5l vine^{-1}) in two rounds during August and September. *Phytophthora* foot rot incidence was least (26.79%) when sprayed and drenched with Akomin(0.04%) twice at 30-35 days interval before the onset of monsoon.

Management strategy of *Phytophthora* foot rot standardised at Panniyur namely spraying 0.2% Akomin followed by spraying and drenching 1% Bordeaux mixture was effective in checking the disease under different shaded conditions.

At Chintapalli, the least incidence of the disease was noticed with treatment combinations of all cultural practices + 1 kg neem cake+3g a.i. Phorate (soil application)+1% Bordeaux mixture spray first+Akomin 0.4% spray second round.

In the biocontrol studies of *Phytophthora* foot rot disease, use of antagonistic organisms (*Trichoderma viride* @ 150 g vine^{-1}) along with 5 kg of FYM to the basin of black pepper vines during June is recommended to check the disease at Sirsi. At Sirsi, black pepper cuttings grown under medium light intensity showed vigorous growth and less disease incidence when sprayed and drenched with 1% Bordeaux mixture. Bordeaux mixture spray and drenching to black pepper cuttings controlled the nursery disease in Sirsi. For the control of nursery disease in black pepper, Panniyur centre recommended spraying and drenching with 0.2% Akomin.

The survey conducted for the important pests of pepper in Idukki by the Pampadumpara centre revealed that 55.60% of the pepper plants were attacked by leaf gall thrips and incidence of the others insects like scale insect, shoot borer and pollu beetle was negligible.

B. CARDAMOM

Studies at Mudigere revealed that thrips infestation in cardamom caused quantitative damage in cardamom capsules. Observations revealed that 15% of the harvested capsules had 33% of the surface area scabbed and capsule weight, number of healthy seeds per capsule and oil content of the capsule were reduced significantly with increase in the thrips damage. Efficacy of plant based insecticides was tested at Mudigere for the control of thrips and shoot and capsule borer and the treatment with monocrotophos-phosalone-phosalone spray recorded least thrips damage (25.74%) followed by neemcake (31.77%) and nimbicidine (34.66%).

C. GINGER

Six different fungicides were evaluated against rhizome rot of ginger at Solan. Seed dip treatment with Dithane M-45(0.25%)+ Bavistin(0.1%) for 60 min+thimet 10G soil application at the time of seed bed preparation followed by application of Contof are recommended for checking the rhizome rot. Similarly at Dholi centre, pre-treatment of ginger rhizome with Ridomil MZ @ 3gl^{-1}) for one hour recorded least soft rot disease incidence.

D. TURMERIC

Control measures were developed by the Bhavanisagar centre against the turmeric scale insect, rhizome rot and leaf spot diseases. Treatment of turmeric rhizomes with monocrotophos @ 2ml l^{-1} for 15 minutes and drying under shade for 24 h is recommended to prevent scale insects; the same method of treatment is recommended for preventing rhizome rot using Bavistin. Prophylatic spray with monocrotophos twice at fortnightly intervals against scale insects

and later two sprays of Bavistin at fortnightly intervals against leaf spot disease were recommended.

E. SEED SPICES

Coriander: Survey carried out by the Dholi centre to record the incidence of disease in coriander in the different coriander growing areas in N.Bihar revealed that in all the districts, stem gall disease was more serious besides wilt and *Cercospora* leaf spot. Solarisation studies at Jobner indicated its favourable effect in the control of diseases in seed spices. Solarisation treatment reduced the disease incidence (31.89%) resulting in maximum grain yield of 1.98q ha^{-1} while in control, maximum disease incidence (5.48%) and minimum grain yield (0.98q ha^{-1}) were observed. Biocontrol studies on wilt of coriander at Coimbatore recorded lowest wilt incidence of 5.3% and maximum yield by seed treatment with *Trichoderma viride*.

Cumin: Studies at Jobner confirmed and recommended that the wilt disease in cumin can be minimised by adopting 3 year crop rotation i.e., cluster bean-cumin-cluster bean-wheat-cluster bean-mustard, which recorded the maximum grain yield of 2.58 q ha^{-1} and less disease incidence of 36.5% as against one year rotation in which the disease incidence was 61% and grain yield of 0.82q ha^{-1}.

Fenugreek: At Dholi, 80 fenugreek germplasm accessions were screened against powdery mildew and a few lines gave resistant reaction. Biocontrol studies at Coimbatore indicated that seed treatment with *Trichoderma viride* (4g kg^{-1}) followed by soil application of neem cake (130kg ha^{-1}) recorded lowest root rot incidence (4.9%) followed by soil application of *T.viride* plus soil application of neem cake (6.0%).

PLANTING MATERIAL PRODUCTION

Small scale production of elite/nucleus planting material/ foundation seeds of improved high yielding varieties are taken up by the AICRPS centres. The AICRPS centres are also participating in the Integrated Programme for Development of Spices (IPDS), Dept. of Agriculture & Co-operation, Government of India. Seed spices centres also have Spices Board sponsored programmes for the production of foundation seeds of improved varieties of seed spices.

INSTITUTIONAL ACTIVITIES

1. Institute management committee (IMC)

The Management Committee of IISR consists the following members.

Dr. K V Peter (Chairman), Director, Indian Institute of Spices Research, Calicut

Dr. R N Pal, Assistant Director General (PC), ICAR, New Delhi

Director of Agriculture, Government of Kerala, Thiruvananthapuram

Director, Academic & PG Studies, KAU, Trichur

Joint Director of Horticulture (PC), Government of Karnataka, Bangalore

Ms. Nirmala Sharma, 85, Anoop Nagar, Indore

Mr. V P Joshi, 12, Baidyanath Mallick Lane, Calcutta

Sr. Finance & Accounts Officer, CMFRI, Cochin

Dr.P N Ravindran, Head, Div. of Crop Improvement & Biotechnology, IISR, Calicut

Dr. M N Venugopal, Sr. Scientist (Plant Pathology), IISR Cardamom Research Centre, Appangala

Mr. M Anandaraj, Senior Scientist (Plant Pathology),IISR, Calicut

Ms. K Usha (Member Secretary), Asst. Administrative Officer, IISR, Calicut

During the reporting period, IMC met once on 15 July 1996. Some of the important decisions taken in the meeting are as follows:

The Appangala centre will be upgraded into a Regional Station. The formation of three divisions viz. Division of Crop Improvement & Biotechnology, Division of Crop Production & Post Harvest Technology and Division of Crop Protection, and Social Science section was approved by the IMC. The committee also approved the list of the equipments to be purchased during 1996-97.

2. Research advisory committee (RAC)

The Research Advisory Committee of IISR comprises of the following members.

Dr. S N Rao (Chairman), Director of Research (Retd.), APAU, Hyderabad

Dr. T N Ananathakrishnan, Director, Entomology Research Institute, Loyola College, Madras

Dr. M C Nair, Professor & Head (Retd.), Plant Pathology, KAU, Vellayani

Dr. C S Narayanan, Head, Division of Food, RRL, Thiruvananthapuram

Dr. C K George, Executive Director, Spices Board, Cochin

Dr. R K Sharma, Professor, Plant Breeding & Genetics, RAU, Jobner

Ms. Nirmala Sharma, 85, Anoop Nagar, Indore

Mr. V P Joshi, 12, Baidyanath Mallick Lane, Calcutta

Dr. R N Pal, Assistant Director General (PC), ICAR, New Delhi

Dr. K V Peter, Director, Indian Institute of Spices Research, Calicut

Dr. Y R Sarma (Member Secretary), Head, Division of Crop Protection, IISR, Calicut

The RAC meeting for the year was held on 12 - 13 January 1996. Some of the important observations of the RAC are:

The Perspective Plan of IISR should be modified; IISR should give priority for research on biotechnological aspects of disease/pest resistance; Setting up of Advanced Centre for Biotechnology, Advanced Centre for *Phytophthora*, Centre for Biosystematics and Centre for Biocontrol; More

emphasis should be given for conventional breeding programmes; Advanced training may be given to scientific personnel for better competence.

3. Staff Research Council (SRC)

The Staff Research Council of IISR included the following members.

Dr. K V Peter (Chairman), Director, Indian Institute of Spices Research, Calicut

Dr. R N Pal, Assistant Director General (PC), ICAR, New Delhi

Dr. P C Sivaraman Nair, Director of Research (Retd.), KAU, Trichur

Dr. V K Gupta, Professor & Head, Dept.of Plant Pathology, Dr.Y.S. Parmar Univ.of Agric.& Forestry, Solan

Dr. C K George, Executive Director, Spices Board, Cochin

Dr. M Aravindan, Principal Scientist & CTO, KVK, Calicut

Dr. S Edison, Project Coordinator, AICRP on Spices, Calicut

All principal investigators of projects

Mr. Santhosh J Eapen (Member Secretary), Scientist Sr. Scale (Nematology), IISR, Calicut

The X Staff Research Council meeting was held during 6 - 8 May 1996 at Calicut. Apart from the IISR scientists and Director, Dr. C K George, Executive Director, Spices Board and Dr. V K Gupta, Professor & Head, Dr. Y S Parmar University of Horticulture & Forestry, Solan, attended the meeting. In the plenary session held on 8th, officials from other organizations and developmental departments also participated. IISR Research Highlights 1995 - 96 was also released on this occasion. The progress of research in 37 institute projects and 10 adhoc projects was reviewed in this meeting. It recommended closure of one project and approved seven new research projects.

The Mid Term Review of research projects was conducted during 6-7 November 1996 at Calicut. Dr. K V Peter, Director, chaired the meeting in which the progress of 48 institute projects and 12 adhoc research schemes were presented and reviewed.

4. Improtant seminars/meetings

a. National seminar on biotechnology of spices & aromatic plants

IISR in collaboration with Indian Society for Spices organized National Seminar on Biotechnology of Spices and Aromatic Plants at Calicut during 24 - 25 April 1996. The seminar was inaugurated by Dr. Jayant Patil, Member (Agri.), Planning Commission, Govt.of India. About 120 delegates attended the seminar in which 43 research papers were presented.

b. IISR annual day

IISR annual day was celebrated on 1 July 1996. Mr. K K Sreedharan Nair, Editor, Mathrubhumi Daily was the chief guest. Various cultural programmes and planting of tree saplings in the campus marked the occasion.

c. PMC meeting on biocontrol

A meeting of the Project Monitoring Committee (PMC) of the mission mode project of Dept.of Biotechnology, Govt.of India on Development, Production and Demonstration of Biological Control Agents under IPM was held at IISR, Calicut during 10-11 September 1996. Dr. Jayaraj, National Professor, Dr. M S Swaminathan Research Foundation, Madras and Chairman, PMC, Dr. Seema Wahab, Director, DBT, Dr. Jayarajan, former Professor & Head, TNAU etc. attended the meeting. About 18 principal investigators from different centres partici-

pated in the meeting and progress of various projects was reviewed.

D. INTERFACE WITH SPICES EXPORTERS

An interface between All India Spices Exporters Forum and scientists of IISR was held during 11-12 October 1996. Dr. K L Chadha, DDG(Hort.) delivered the key note address. Mr. V Jayasankar IAS, Chairman and Dr. C K George, Executive Director, Spices Board were also present.

5. GUEST LECTURES

Seven guest lectures were delivered by distinguished visitors during the year.

Topic	Date	Name & Affiliation
Sustoinability of Rice-Wheat System	19 April 1996	Dr. Nagorajan, Director, D'te of Wheat Research, Karnal
Agricultural Research in India	29 May 1996	Dr. M S Swaminathan, Chairman, MSSRF, Chennai
Spices Research: Future Needs	14 June 1996	Dr. K V Ahammed Bavappa, Former Director, CPCRI, Kasaragod
Integrated Pest Management	9 August 1996	Dr. S Jayaraj, National Professor, Dr. M S Swaminathan Research Foundation, Madras
Application of Biotechnology and Tissue Culture in Agriculture	29 August 1996	Dr. R D Iyer, Former Head, Div.of Genetics & Plant Breeding, CPCRI, Kasaragod
Agricultural and Scientific Communication	24 January 1997	Dr. R D Sharma, Director (P&I), ICAR, New Delhi
Recent Advances in Plant Bioechnology in India	20 February 1997	Dr. V L Chopra, National Professor, B P Pal Chair, NRC Plant Biotechnology, New Delhi

6. LIBRARY AND INFORMATION SERVICES

During 1996-97, Rs.4,04,400/- was spent for purchase of books and journals for IISR library. Apart from annual reports, newsletters, technical reports etc., it added 59 books, 97 reprints and 116 bound volumes of journals during this period. 'Spices Bibliography' Part 1 and 2 were compiled and published in the Journal of Spices and Aromatic Plants, Volume 5(1&2). Four issues of 'Agri Science Tit Bits' were also brought out and sent to different organizations and coordinating centres dealing on spices. Besides the institute staff, 310 research workers from other universities and organizations also availed the library services. IISR library also handles the sale of institute publications, distribution of extension pamphlets to growers and despatch of reprints on request.

7. IISR PUBLICATIONS

Biological Control in Spices. Anandaraj M and Peter K V (Eds.), Indian Institute of Spices Research, Calicut, pp60.

Research Highlights 1995-96. Eapen S J and Ramana K V (Eds.), Indian Institute of Spices Research, Calicut, India. 8pp.

Annual Report 1995-96. Eapen S J and Ramana K V (Eds.), Indian Institute of Spices Research, Calicut, India. 127pp.

Indian Institute of Spices Research at a Glance. Prasad M V and Nirmal Babu K (Eds.), Calicut, India.

Annual Report 1995-96 - AICRP on Spices. Edison S and Johny A K (Eds.), Indian Institute of Spices Research, Calicut, India 103 pp.

Spices News - Volume 7 (1&2). Sasikumar B, Johny A K and Sherief P A (Eds.), Indian Institute of Spices Research, Calicut, India.

IISR Current News - Volume 2 (4 to 12) and 3 (1 to 3). Eapen S J, Prasad M V and Sherief P A (Eds.), Indian Institute of Spices Research, Calicut, India.

8. AWARDS & RECOGNITIONS

Anke Gowda S J was awarded Ph.D. in Crop Physiology by University of Agricultural Sciences, (UAS) Bangalore.

Korikanthimath VS was awarded Ph.D.degree in Agronomy by UAS, Dharwad.

Prasad M V was awarded Ph.D. degree in Agri. Extension by APAU, Hyderabad.

Rajeev P was awarded Ph.D.degree by IARI, New Delhi.

Shaji Philip, Anandaraj M & Sarma Y R - **C.S.Venkata Ram memorial Award for the best original paper in PLACROSYM XII** held at RRII Kottayam for their paper titled "Comparative study of protoplast isolation and development in *Piper nigrum* (Black pepper) and *Piper colubrinum*".

9. TRAINING & VISITS

A. TRAININGS

Dhamayanthi K P M 'Advanced chromosome techniques', 30 June - 2 August 1996, University of Calcutta, Calcutta.

Eapen S J, Ravindra Mulge and *Rajendra Hegde* 'Computer Applications to Biological Research', 28 -30 January 1997, CPMB, TNAU, Coimbatore, Tamil Nadu.

John Zachariah T 'Pesticide residue analysis', 9 - 20 September 1996, TNAU, Coimbatore.

Jose Abraham, Usha K and *Gopinathan T* 'Agricultural Research Financial Information System (ARFIS)', 21 - 23 April 1996, NAARM, Hyderabad

Kandiannan K 'PC Trouble Shooting', 22 - 27 April 1996, Computer Maintenance Corporation (CMC), New Delhi.

'Data Collection & Acquisition Techniques', 3 - 17 February 1997, Centre for Advanced Studies in Agricultural Meteorology, College of Agriculture, Pune.

Krishnamurthy K S 'Purification and Characterization of Plant Proteins and Basic Recombinant DNA Techniques', 24 February - 3 March 1997, Indian Institute of Science, Bangalore.

Prasad M V 'Management Information System for Agricultural Research', 11-22 June 1996, NAARM, Hyderabad.

Prasannakumari N Hindi 'Translation', 1 October - 31 December 1996, Central Translation Bureau, Bangalore.

Sankaran A P and *Jayardhanan P K* 'Payroll/ GPF system', 13 - 19 February 1997, NAARM, Hyderabad.

Shanmugavelu S 'Orientation training programme for newly recruited staff of KVKs', 19 - 21 September 1996, KVK,Myrada,Talamalai, Tamil Nadu.

Venugopal M N 'Biological and immunological techniques for identification and detection of plant viruses' 19 August - 9 September 1996, S.V. University, Tirupathi.

8. Visits abroad

Krishnamoorthy B International training course on 'Conservation and Utilisation of Plant Genetic Resources'organized by DSE/ZEL from 13 September to 9 October 1996 at Leipzig, Zschortau, Federal Republic of Germany.

10. Participation in seminars/symposia

- National Seminar on Biotechnology of Spices and Aromatic Crops, 24-25 April 1996,Calicut-*All scientists and research associates from IISR Calicut*
- Project Monitoring Committee Meeting - *Development, Production and Demonstration* of Biocontrol Agents (Department of Biotechnology, New Delhi), 10-11 September 1996, Calicut-*Peter K V, Sarma Y R, Anandaraj M* and *Devasahayam, S*
- Interface - Spices Exporters and Scientists, 10- 11 October, Calicut-*All scientists of IISR Calicut*
- Southern Zonal Meeting of Indian Phytophthological Society & Symposium on 'Epidemiology of Plant Disease Management', 21-22 November 96, University of Agricultural Sciences, Dharwad-*Anandaraj M, Rajan P P* and *Beena N*
- Review-cum-Action Plan Meeting of KVK, 30 November 2 December 1996, KVK, College of Agriculture, TNAU, Madurai - *Aravindan M* and *Manoj P S*
- Ninth International Conference on Plant Pathogenic Bacteria, Centre for Advanced Studies in Botany, University of Madras, Madras - *Dake G N*
- ICAR Regional Committee Meeting, 26 - 28 June 1996, UAS, Bangalore, and

  Project Coordinators' Annual Conference, 5-7 August 1997, ICAR, New Delhi - *Edison S*
- PLACROSYM - XII, 27-28 November 1996, RRII, Kottayam - *Edison S, Sadanandan A K, Ramana K V, Zachariah T J, Nirmal Babu K* and *Shaji Philip*
- Seminar on 'Organic Farming', 11 July 1996, Spices Board, Cochin - *Kandiannan K*
- National Seminar on Organic Farming and Sustainable Agriculture, 9-11 October 1996, University of Agricultural Sciences, Bangalore, and

  Third National Agricultural Science Congress, 12-15 March 1997, Punjab Agricultural University, Ludhiana - *Korikanthimath VS* and *Rajendra Hegde*
- National Seminar on Participatory Technology Development, 21-22 November 1996, Kerala Horticultural Development Project, Trivandrum - *Korikanthimath VS* and *Rajeev P*
- Workshop on Impact Assessment of Working in Western Ghat Forests, 3-5 March 1997, Ministry of Environment and Forests, Govt. of Karnataka, Madikeri - *Korikanthimath VS, Rajendra Hegde, Rajeev P* and *Anke Gowda S J*
- Regional Official Language Conference, 20 - 21 March 1997, Manglore - *Krishnamoorthy B*
- Review-cum-Action Plan Meeting of KVKs, 8 - 9 April 1996, KVK, Suttur, Mysore - *Manoj P S* and *Sakeer Hussain*
- ICAR Regional Committee Meeting, 26 - 28 June 1996, UAS, Bangalore - *Peter K V*

- Second International Crop Science Congress, 17 -24 November 1996, National Academy of Agricultural Sciences, New Delhi - *Peter K V, Sarma Y R* and *Sivaraman K*
- National Symposium on Horticultural Biotechnology, 28-30 October 1996, HSI and IIHR, Bangalore - *Peter K V, Ravindran P N, Nirmal Babu K, Ravindra Mulge, Minoo D, Geetha S P, Sajina A* and *Indulekha P*
- One day seminar on "Internet and Inet", 30 January 1997, Malabar Palace, Calicut- *Prasad M V*
- Seminar on Technology Assessment and Refinement for Diverse Risk Prone Agriculture, 25-26 May 1996, University of Agricultural Sciences, Bangalore, and

  International Conference on 'Creativity and Innovation at Grass roots for Sustainable Natural Resource Management', 14-15 January 1997, Indian Institute of Management, Ahemedabad - *Rajeev P*
- International Symposium on Biodiversity, Dehradun, March 1997 - *Ravindran P N*

11. Membership in committees

Devasahayam S - Editor, Journal of Spices and Aromatic Crops

Edison S - President, Indian Society for Spices Executive Councillor, Indian Society for Plantation Crops

Korikanthimath V S - Executive Councillor, Indian Society for Spices

Peter K V - Member, Spices Board, Cochin; Member, Kerala Biodiversity Board, Trivandrum; Member, Project Monitoring Committee of DBT, Govt. of India; Member Central Subcommittee on Seed Standards, Release & Notification of Hort. Crops; Councillor, Indian Society of Plant Genetic Resources; Member, General Council, Kerala Agricultural University; Fellow, National Academy of Agricultural Sciences, New Delhi; Fellow Indian Society for Vegetable Science, Varanasi; Member (official side), CJSC, ICAR, New Delhi; Executive Councillor, Indian Society for Vegetable Science

Ramana K V - Secretary, Indian Society for Spices

Ravindran P N - Chief Editor, Journal of Spices and Aromatic Crops

Sadanandan A K - General Convener, National Seminar on Water and Nutrient Management for Sustainable, Production and Quality of Spices (to be held at Appangala during Sept. 24-25, 1997); Member,Technology Mission on Black Pepper, Govt.of Kerala; Member, KVK Advisory Committee; Member, Advisory Committee on Production & Export of Organic Spices, Spices Board, Cochin; Member, Task Force for Research, Education & Training under the Steering, Committee of Agriculture, State Planning Board, Govt. of Kerala

12. Personnel & budget

A. Staff position (as on 31 march 1997)

Category	Sanctioned		Filled		Vacant	
	IISR	KVK	IISR	KVK	IISR	KVK
Scientific	41	1 (CTO)	3 6	-	5	1
Technical	37	15	36	8	1	7
Administrative	22	3	22	3	-	-
Supporting	67	7	64	5	3	2

B. NEW APPOINTMENTS

Calicut

Mr. V V Padmanabhan Computer Programmer cum Operator (T-II-3)

Mr. Kishore B Patil, Artist cum Photographer (T-II-3)

Ms. N Beena, Research Associate, ICAR Adhoc Scheme

Ms. K L Gayathri, Research Associate, ICAR Adhoc Scheme

Mr. P P Rajan, Research Associate, ICAR Adhoc Scheme

Ms. P Indulekha, Senior Research Fellow, ICAR Adhoc Scheme

Mr. K Vinaya Gopal, Senior Research Fellow, DBT Scheme

Appangala

Ms. P Indulekha, Senior Research Fellow, ICAR Adhoc Scheme

Mr. G M Hiremath, Research Associate, ICAR Adhoc Scheme

Mr. D M Javoor, Research Associate, ICAR Adhoc Scheme

C. TRANSFERS

Dr. G N Dake, Sr. Scientist (Plant Pathology) IISR, Calicut to Mahatma Phule Krishi Vishwa Vidyapeth, Rahuri, Maharashtra on being selected as Professor, Plant Pathology

Dr. K Sivaraman, Sr. Scientist (Agronomy) from IISR Calicut to SBI, Coimbatore

Mr. K V Saji, Scientist (Economic Botany) from Directorate of Oilseeds Research, Hyderabad to IISR Experimental Farm, Peruvannamuzhi

Ms. S S Veena, Scientist (Plant Pathology) from Sugarcane Breeding Institute, Coimbatore to IISR Calicut

Mr. K A Somanna, Farm Asst (T-II-3), IISR Experimental Farm, Peruvannamuzhi to CRC, Appangala

Mr. K Jayarajan, Computer Operator cum Programmer (T-II-3) from CPCRI, Kasaragod to IISR, Calicut

Shri C Ramesh Babu, Jr.Stenographer from ICAR Research Complex for NEH region to CRC, Appangala

Sri. B T Velayudhan, SS Gr.II (Watchman) from Peruvannamuzhi Farm to Calicut

Sri. K T Mohammed, Tech. Asst. (T-II-3) from Peruvannamuzhi Farm to Calicut

Sri. Jaimon Thomas, JTA (T-I), from CTRI, Regional Station, Hunsur to Experimental Farm, Peruvannamuzhi

Sri. D K Eswara, JTA (T-1) Experimental Farm, Peruvannamuzhi to CTRI, RS, Hunsur

D. RESIGNATIONS

Calicut

Mr. N Sreejith, Computer Operator cum Programmer (T-II-3)

Mr. V V Padmanabhan, Computer Programmer cum Operator (T-II-3)

Mr. Kishore B Patil, Artist cum Photographer

Ms. A Sajina, Senior Research Fellow, ICAR Adhoc Scheme

Ms. T P Sreeja, Senior Research Fellow, ICAR Adhoc Scheme

Ms. K L Gayathri, Research Associate, ICAR Adhoc Scheme

Appangala

Ms. P Indulekha, Senior Research Fellow, ICAR Adhoc Scheme

Mr. John C Zechariah, Senior Research Fellow, ICAR Adhoc Scheme

KVK, Peruvannamuzhi

Mr. A Sakeer Hussain,Technical Officer (Ag.Extn.)

Ms. C S Kavitha,Training cum Technical Asst.(T-II-3)(Home Science)

Mr. M S Sivadasan, SS Gr.I (Village Attendant)

Mr. P D Jose, SS Gr.I (Animal Attendant)

E. PROMOTIONS

Calicut

Sri. S Hareendrakumar Jr. Clerk as Sr. Clerk (ad hoc)

Sri. T Balakrishnan, Sri. V P Ramachandran, Sri. P T Madhavan, Sri. P Soman, Sri. V Balakrishnan, Sri. K Balakrishnan Nair and Sri. P Prabhakaran Nair - SS Gr.I to SS Gr. II

Sri. B T Velayudhan and Sri. K P Vijayan Nair - SS Gr.II to SS Gr. III

Sri. N Ayyappan and Sri. K Keeran - SS Gr.III to SS Gr. IV

Peruvannamuzhi Farm

Sri. P Sadanandan, SS Gr.I as Jr.Clerk(adhoc)

Sri. M Balakrishnan, SS Gr.I as Jr. Clerk

Sri. N K Raghavan, Sri. M Choikutty, Sri. V K Sankaran, Sri. M Balakrishnan, Sri. K Gangadharan Nair and Sri. P Sreedharan - SS Gr.I to SS Gr. II

Sri. C Bhaskaran, Sri. P Damodaran and Smt.N K Girija - SS Gr.II to SS Gr. III

Sri. E K Nanu - SS Gr.III to SS Gr. IV

Appangala

Smt. H B Gangu and Smt. B L Seethu -SS Gr.III to SS Gr. IV

Smt. P K Manikka, Smt. Marinanjamma, Smt. B R Janaki, Sri. B M Seshappa and Sri. P K Belliappa -SS Gr.II to SS Gr. III

F. RETIREMENTS

Dr. M Aravindan, Principal Scientist and Chief Training Organizer, KVK retired on super annuation.

G. BUDGET FOR THE YEAR 1996-97

Particulars	Actual Expenditure (Rs. in lakhs)		
	Plan	Non Plan	Total
Establishment charges	2.98	102.47	105.45
Travelling Allowance	2.00	3.50	5.50
Works	14.97	-	14.97
Other charges including equipments	69 .99	14.00	83.99
Total	**89.94**	**119.97**	**209.91**
OTHER SOURCES			
AP Cess fund schemes			36.88
KVK			35.64
NARP			5.00
AICRP Spices			45.46
DBT Schemes			6.09
IPDS			9.84
Pension & Gratuity			4.94
Total			143.85

13. Distinguished visitors

Calicut

Dr. M S Swaminathan, Chairman, Dr.M S Swaminathan Research Foundation, Madras

Dr. Jayant Patil, Member(Agri), Planning Commission, Govt. of India

Dr. K L Chadha, DDG(Hort.) ICAR, New Delhi

Prof. V L Chopra, National Professor (Bio technology), NRC Plant Biotechnology, New Delhi

Dr. R N Pal, ADG (PC), ICAR, New Delhi

Dr. I S Yadav, Director, IIHR, Bangalore

Dr. S Nagarajan, Director, Directorate of Wheat Research, Karnal

Dr. B K Tripathi, Director, SBI, Coimbatore

Dr. C K George, Executive Director, Spices Board, Cochin

Dr. N Mohanakumaran, Director of Research, KAU, Trichur

Dr.V K Gupta, Professor & Head, Plant Pathology, YSPUHF, Solan

Dr. R P Sapkota, Director, Nepal Agricultural Research Council, Nepal

Dr. S K Shrestha, Project Coordinator, Secondary Crop Development Project, Nepal

Dr. P K Koshy, Head, CPCRI Regional Station, Kayangulam

Dr. K V Ahamed Bavappa, former Director, CPCRI, Kasaragod

Mr. V R Nimbecker, Under Secretary, Krishi Bhavan, New Delhi

Dr. S D Lal Mishra, Director (Hort.), Govt.of Uttar Pradesh

Dr. R D Sharma, Director (P&I), ICAR, New Delhi

Mr. K P G Menon, Director (Marketing), Spices Board, Cochin

Appangala

Mr. M C Nanaiah, Minister for Law & Parliamentary Affairs, Govt. of Karnataka

Dr. K L Chadha, DDG(Hort.), ICAR, New Delhi

Prof. V L Chopra, National Professor (Bio technology), IARI, New Delhi

Justice C V N Shastri, Judge, High Court of A.P., Hyderabad

Prof. G Mehta, Vice Chancellor, Univertsity of Hyderabad, Hyderabad

Dr. I S Yadav, Director, IIHR, Bangalore

Prof. G S R Subba Rao, Dean, Faculty of Science, Indian Institute of Science, Bangalore

Dr. P V Shenoy, Formerly Director, Institute for Social and Economic Change, Bangalore

Dr. R D Iyer, Head (Gen. & Plant Breeding) Retd., CPCRI, Kasaragod

Dr. S K Shreshta, Department of Agriculture, Kathmandu, Nepal

Peruvannamuzhi

Mr. V K Rajan, Minister for Agriculture, Govt.of Kerala

Dr. K L Chadha,DDG(Hort.), ICAR, New Delhi

Dr. Jayant Patil, Member(Agri.), Planning Commission, Govt. of India

Dr. V L Chopra, B P Pal National Professor, NRC Plant Bio Tech., ICAR, New Delhi

Dr. R D Sharma, Director (P&I), ICAR, New Delhi

Dr. R P Sapkota, Director, Crops & Hort, Nepal Agril.Council, Nepal

Dr. S K Shrastha, Project Co-ordinator &

Secretary Crops Development Project, Nepal

Dr. R B L Bhaskar, Joint Director (Bio), Directorate of Plant Protection, Quarantine & Storage, Ministry of Agriculture, Faridabad.

14. TECHNICAL PROGRAMME

Sl. No.	Programme	Project No.	Page No.
1	Enrichment and maintenance of spices germplasm	Gen I (813)	19
		Gen II(813)	19
		Gen VI(813)	22
		Gen IX(813)	19
		Gen XIII(813)	25
		Hort III(813)	35
		Biotech V(813)	35
2	Evaluation of spices germplasm for high quality, high yield and resistance to pests and diseases	Gen II(813)	19
		Gen VI(813)	22
		Hort III(813)	35
		Crop Prot I.1, I.2 & I.3(813)	64
3	Breeding for high yield, high quality and disease resistance in black pepper ond cardamom	Gen VII. 1(813)	25
		Gen VII. 2(813)	26
		Gen X(813)	26
4	*Developmental morphology, cytogenetics and* repraductive biology of ginger and turmeric	Gen VII. 1(813)	25
		Gen XIV(813)	31
		ICAR adhoc project 1	38
5	Vegetative propagation of tree spices	Hort I(813)	33
6	Micropropagation of elite lines of cardamom, black pepper and tree spices	Biotech I(813)	36
		Biotech III(813)	37
		Biotech VI(813)	38
		ICAR ad hoc project 3	39
7	Developing somaclones of block pepper, ginger and cardamom for high yield and disease resistance	Biotech II(813)	36
		Biotech IV(813)	37
		ICAR ad hoc project 2	39
8	Irrigation requirements of black pepper	Agr VI(813)	42
		Agr XVI(813)	46
		ICAR ad hoc project 3	59
9	Studies on spices based cropping/farming systems	Agr XIV(813)	44
		Agr XIX(813)	48
		ICAR ad hoc project 1	58

10	Vermicomposting and biofertilizers	Agr XVII(813)	46
		Agr XVIII(813)	48
11	Nutritional requirements of spice crops	SSc II(813)	49
12	Drought management in black pepper and cardamom	Phy V(813) & Phy VI(813)	53
13	Biogenesis of pigments in spice crops	Biochem I(813)	56
14	Quality evaluation in spices	PHT I(813)	56
15	Epidemiology and management of *Phytophthora* foot rot in black pepper	Path I.1(813)	75
		Poth II.3(813)	63
		DBT adhoc project 1	73
		Hort II(813)	35
16	Viral diseases of black pepper and cardamom	Poth X(813)	63
		Path XII(813)	64
		ICAR adhoc project 3	72
17	Bacterial wilt of ginger	Path XI(813))	64
18	Studies on mechanism of resistance to pests and pathogens of spice crops	Crop Prot II(813)	65
19	Integrated control of insect & nematode pests of spices	Ent X(813)	66
		Nema III(813)	67
		ICAR adhoc project 1	70
20	Integrated management of rhizome rot of ginger	ICAR adhoc project 4	73
21	Biological control of pests, nematodes and diseases of spice crops	Biocontrol I.1, I.2 & I.3(813)	68
		ICAR adhoc project 2	71
		DBT Project 2	74
22	Economics of black pepper cultivation	Stat V(813)	90
23	Demonstration of high production technologies	Ext I(813)	90
24	Constraint analysis in black pepper and cardamom production	Ext II(813)	92
		Ext III(813)	93
25	Training of research and extension workers	Ext I(443)	91
26	Multiplication and distribution of nucleus planting materials	Agr XX(813)	49

15. Publications & presentations

a. Reviews

Devasahayam S 1996 Biological control of insect pests of spices. In: Anandaraj M and Peter K V (Eds.) Biological Control in Spices (pp.33-45). Indian Institute of Spices Research, Calicut.

Eapen S J and Ramana K V 1996 Biological control of nematodes of spices. In: Anandaraj M and Peter K V (Eds.) Biological Control in Spices (pp.20-32). Indian Institute of Spices Research, Calicut.

Kandiannan K, Sivaraman K, Thankamani C

K and Peter K V 1996 Agronomy of ginger (*Zingiber officinale* Rosc.). J Spices & Aromatic Crops 5: 1 -27.

Peter K V 1996 Major spices. In: Paroda R S and Chadha K L (Eds.) Fifty Years of Crop Science Research in India (pp. 771-788). ICAR, New Delhi.

Peter K V 1996 Spices research and development in India. In: Proc. PLACROSYM - XI (pp. xiv-xxii). ISPC, Kasaragod.

Ravindran P N, Nirmal Babu K, Rema J and Peter K V 1996 Plant biotechnology in improvement of spices. The Botanica 46: 44-50.

Sarma Y R and Anandaraj M 1997 *Phytophthora* foot rot of black pepper. In: Agnihotri V P, Sarabhoy A K & Singh D V (Eds.) Management of Threatening Diseases of National Importancee (pp. 237-248). Malhotra Publishing House, New Delhi.

Sarma Y R, Anandaraj M and Venugopal M N 1996 Biological control of diseases of spices. In: Anandaraj M and Peter K V (Eds.) Biological Control in Spices (pp 1 - 18). Indian Institute of Spices Research, Calicut.

B. RESEARCH PAPERS

Abdulla Koya K M, Devasahayam S, Selva Kumaran S and Mini Kallil 1996 Distribution and damage caused by scale insects and mealy bugs associated with black pepper (*Piper nigrum* Linn.) in India. J ent.Res. 20: 129 - 136.

Anandaraj M, Ramana K V and Sarma Y R 1996 Role of *Phytophthora capsici* in the etiology of slow decline disease of black pepper. J Plantn Crops 24 (suppl): 166-170.

Anandaraj M, Ramana K V and Sarma Y R 1996 Sequential inoculation of *Phytophthora capsici, Radopholus similis* and *Meloidogyne incognita* in causing slow decline of black pepper. Indian Phytopath. 49: 297-299.

Anandaraj M and Leela N K 1996 Toxic effects of some plant extracts on *Phytophthora capsici,* the foot rot pathogen of black pepper. Indian Phytopath. 49: 181-184.

Dake G N, Anandaraj M, Raju C A and Rohini Iyer 1996 Effect of seed treatment and lining material on rhizome rot of ginger in storage. J Plantn Crops 24 (Suppl): 233-239.

Eapen S J 1995 (published in 1996) A note on the incidence of *Rotylenchulus reniformis* in cardamom plants. Indian J Nematol. 25: 213 - 214.

John Zachariah T 1995 (published in 1996) Essential oil and its major constituents in selected black pepper accessions. Plant Physiol. & Biochem. 22: 151 - 153.

Jose Abraham, Anandaraj M, Ramana K V and Sarma YR 1996 A simple method for indexing *Phytophthora* and nematode infection in black pepper *(Piper nigrum* L.). J Spices & Aromatic Crops 5: 68-71.

Korikanthimath V S 1996 Spurt in cardamom yield and income by switching over from conventional management to high production technology. J Plantn Crops 24 (Suppl):840-847.

Krishnamoorthy B, Rema J, John Zachariah T, Jose Abraham and Gopalam A 1996 Navashree and Nithyashree - two high yielding and high quality cinnamon (*Cinnamomum verum* Bercht & Presl.) selections. J Spices & Aromatic Crops 5: 28 -33.

Krishnamoorthy B, Sasikumar B and Rema J 1996 Genetic variability and segregation of sex in nutmeg. J Plantn Crops 24 (Suppl): 468- 472.

Nirmal Babu K, Rema J, Zecharia J C, Samsudeen K and Ravindran P N 1996 Plant regeneration from tissue cultures of *Piper colubrinum* Link. J Plantn Crops 24(Suppl): 594-596.

Nirmal Babu K, Samsudeen K, Ratnambal M J and Ravindran P N 1996 Embrygonesis and plant regeneration from ovary derived callus cultures of *Zingiber officinale*. J Spices & Aromatic Crops 5: 134-138.

Nirmal Babu K, Rema J, Sree Ranjine Devi P, Samsudeen K and Ravindran P N 1996 Micropropagation of an endangered species of *Piper, P.barberi* Gamble and its conservation. J Plant Gen. Resources 9: 179-182.

Prabhakaran Nair K P, Sadanandan A K, Hamza S and Jose Abraham 1997 The importance of Potassium buffer power in the growth and yield of cardamom. J Plant Nutrition 20: 987 - 997.

Rao T G N, Sasikumar B and Johnson K George 1995 (Published in 1996) Field reaction of ginger germplasm to *Phyllosticta zingiberi*. Indian Phytopath. 48: 463 - 465.

Ravindran P N, Balakrishnan R and Nirmal Babu K 1996 Numerical taxonomy *of Piper* species of Western Ghats II. Principal component analysis. Rheedea 6: 75-86.

Sadanandan A K, Bhargava B S and Hamza S 1996 Leaf nutrient norms for black pepper *(Piper nigrum* L.) using DRIS. J Plantn Crops 24 (Suppl): 53-59.

Sadanandan A K and Hamza S 1996 Response of four turmeric *(Curcuma longa* L.) varieties to nutrients in an oxisol on yield and curcumin recovery. J Plantn Crops 24 (Suppl): 120-125.

Sasikumar B, George J K and Ravindran P N 1996 IISR Varada- a high yielding ginger *(Zingiber officinale* Rosc.) variety. J Spices & Aromatic Crops 5: 34- 40.

Sasikumar B, George J K, Zachariah T J, Ratnambal M J, Nirmal Babu K and Ravindran P N 1996 IISR Prabha and IISR Prathibha - two new high yielding and high quality turmeric *(Curcuma longa* L.) varieties. J Spices & Aromatic Crops 5: 41- 48.

Sasikumar B and Veluthambi K 1996Transformation of black pepper(*Piper nigrum* L.) using *Agrobacterium* Ti plasmid based vectors. Indian Perfumer 40: 13 - 16.

Sivaraman K and Palaniappan S P 1996 Turmeric - maize and onion intercropping system. II. Leaf area index and dry matter production. J Spices & Aromatic Crops 4: 145 -155.

Sreeja T P, Eapen S J and Ramana K V 1996 Occurrence of *Verticillium chlamydosporium* Goddard in a black pepper *(Piper nigrum* L.) garden in Kerala, India. J Spices & Aromatic Crops 5: 143 - 147.

c. Presentations in seminars/symposia

Anandaraj M and Sarma Y R 1996 Epidemiology of *Phytophthora* foot rot of black pepper. Symposium on Epidemiology and Plant Disease Control, 21-22 Nov. 1996, University of Agricultural Sciences, Dharwad, Karnataka.

Dake G N 1996 Characterization of the isolates of *Pseudomonas solanacearum* to biotypes and their interaction in ginger *(Zingiber officinale).* Ninth International Conference on Plant Pathogenic Bacteria, August 1996, Centre for Advanced Studies in Botany, University of Madras, Madras.

Eapen S J, Ramana K V and Sarma Y R 1996 Evaluation of *Pseudomonas fluorescens* isolates for control of *Meloidogyne incognita* in black pepper *(Piper nigrum* L.).

National Seminar on Biotechnology of Spices and Aromatic Plants, 24 - 25 April 1996, Calicut, Kerala.

Edison S and Johny A K (Eds.) 1996 Report of AICRP on Spices: 1994-95 & 1995-96. ICAR Regional Committee Meeting, 26-27 June 1996, Bangalore, Karnataka.

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15. Staff list

A. Indian Institute of Spices Research, Calicut

Managerial

K V Peter Ph.D., Director

S Edison Ph.D., Project Coordinator, AICRP Spices

Scientific

Division of Crop Improvement & Biotechnology

P N Ravindran Ph.D., Principal Scientist (Plant Breeding) and Head in Charge

B Krishnamoorthy M.Sc.(Ag.), Senior Scientist (Plant Breeding)

B Sasikumar Ph.D., Scientist Sr. Scale (Plant Breeding)

I Rema Ph.D., Scientist Sr. Scale (Horticulture)

K Nirmal Babu M.Phil., Scientist Sr. Scale (Plant Breeding)

K Johnson George M.Sc., Scientist Sr.Scale (Gen.& Cytogen.) (On study leave)

K P M Dhamayanthi M.Sc., Scientist Sr. Scale (Gen. & Cytogen.)

R Ramakrishnan Nair M.Sc., Scientist (Gen. & Cytogen.) (On study leave)

Division of Crop Production and Post Harvest Technology

A K Sadanandan Ph.D., Principal Scientist (Soil Science) and Head in Charge

K Sivaraman Ph. D., Senior Scientist (Agronomy) (upto 18.03.1997)

T John Zachariah Ph.D., Scientist Sr.Scale (Biochemistry)

N K Leela M.Sc., Scientist Sr.Scale (Organic Chemistry)(On study leave)

C K Thankamani M.Sc.(Ag.), Scientist (Agronomy) (On study leave)

B Chempakam Ph.D., Sr.Scientist (Biochem.)

K Kandiannan M.Sc.(Ag.), Scientist (Agronomy)

K S Krishnamurthy Ph.D., Scientist (Plant Physiology)

Division of Crop Protection

Y R Sarma Ph.D., Principal Scientist (Plant Pathology) and Head in Charge

K V Ramana Ph.D., Principal Scientist (Nematology)

G N Dake Ph.D., Senior Scientist (Plant Pathology) (upto 16. 11. 1996)

M Anandaraj M.Sc., Senior Scientist (Plant Pathology)

S Devasahayam M.Sc., Senior Scientist (Entomology)

K M Abdulla koya M.Sc.(Ag.), Scientist Sr. Scale (Entomology)

Santhosh J Eapen M.Sc. Scientist Sr. Scale (Nematology)

S S Veena M.Sc.(Ag.), Scientist (Plant Pathology)(w.e.f. 23.12.1996)

Social Science Section

Jose Abraham M.A., M.Sc., Senior Scientist (Statistics)

M V Prasad Ph.D., Scientist (Agri. Extension)

Technical

Johny A Kallupurackal Ph.D., Sr. Technical Information Officer (T7)

P Azgar Sheriff M.LIS, Technical Officer (T5)(Lib.)

Hamza Srambikkal M.Sc., Technical Officer (T5) (Lab)

M M Augusthy, Technical Officer (T5)

V Balakrishnan, Technical Officer (T4)

K Samsudeen M.Sc., Technical Assistant (T4)

N Sreejith, Tech. Asst. (T-II-3), Computer Progr.cum Operator (upto 12.04.1996)

V Sivaraman, Tech. Assistant (T-II-3)

Kishore B Patil, Artist cum Photographer (T-II-3) (From 15.06.1996 to 26.02.1997)

K Jayarajan, Computer Operator cum Programmer (T-II-3) (w.e.f. 26.03.1997)

K T Muhammed, Tech. Asst. (T-II-3) (w.e.f. 5 June 1996)

P K Chandravally, Jr. Tech. Assistant (T2)

K Krishnadas, Mechanic cum Pump Operator (T2)

Administration and Accounts

K Usha, Asst. Administrative Officer

T Gopinathan, Asst. Finance & Accts. Officer

M K Sachidanandan M.A., Superintendent(A&A)

A P Sankaran, Assistant

C Padmanabhan, Assistant

V Vijayan, Assistant

V Radha, Assistant

C Sunanda M.Com., Senior Clerk

P K Janardhanan, Senior Clerk

K S Sreekumaran M.A, Senior Clerk (On deputation)

C Venugopalan, Senior Clerk

S Hareendrakumar, Senior Clerk (ad hoc)

R N Subramanian, Junior Clerk

K Padminikuty, Junior Clerk

N Prasannakumari M.A, Hindi Translator

V C Sunil, Jr. Clerk (Hindi Typist)

S M Chettiar, Senior Stenographer

P V Sali, Stenographer

Alice Thomas, Stenographer

C K Beena, Junior Stenographer

Technical (Workshop group)

M Vijayaraghavan, Driver (T-II-3)

N Chandrahasan, Driver (T-II-3)

K Balan Nair, Driver(T-II-3)

Supporting

M Padmanabhan SS Gr. IV (Peon)

K Keeran SS Gr. IV (Lab- attender)

N Ayyappan SS Gr. 1V (Mazdoor)

K P Vijayan Nair SS Gr. III (Mazdoor)

B T Velayudhan, SS Gr. III (Watchman) (w.e.f. 05.06.1996)

K Chandran SS Gr. II (Mazdoor)

N Ravindran SS Gr. II (Mazdoor)

V Balakrishnan SS Gr. II (Mazdoor)

T Balakrishnan SS Gr.II (Mazdoor)

K Balakrishnan Nair SS Gr.II (Mazdoor)

P Prabhakaran Nair SS Gr. II (Mazdoor)

V P Ramachandran SS Gr. II (Mazdoor)

P Soman SS Gr. II (Mazdoor)

P T Madhavan SS Gr. II (Mazdoor)

K Kunhikanaran SS Gr. I (Peon)

I Unni Nair SS Gr. I (Lab attender)

T Ammed Koya SS Gr. I (Watchman)

M Koru SS Gr. I (Watchman)

V P Vijayan Nair SS Gr. I (Mazdoor)

K P Devaki SS Gr. I (Mazdoor)

C M Kamalam SS Gr. I (Safaiwala)

T T Soman SSGr.I (Mazdoor)

K Bhaskaran, Tea Maker

M K Purushu, Wash Boy

Ad hoc Schemes

Shaji Philip M.Sc., Research Associate, DBT scheme

S Selvakumaran Ph.D., Research Associate, ICAR ad-hoc scheme

Minoo Diwakaran M.Sc, Research Associate, ICAR adhoc scheme

Geetha S Pillai M.Sc., Research Associate, ICAR adhoc scheme

A Shamina M.Phil, Research Associate, ICAR ad-hoc scheme

A B Remashree Ph.D., Research Fellow, ICAR ad-hoc scheme

K K Sherlija Ph.D., Research Fellow, ICAR ad-hoc scheme

T P Sreeja M.Sc., Sr. Research Fellow, ICAR ad-hoc scheme (upto 13.12.1996)

A Sajina M.Sc., Sr. Research Fellow, ICAR adhoc scheme (upto 20.11.1996)

Mini Kallil M.Sc., Senior Research Fellow, ICAR ad-hoc scheme

M G Prakash M.Sc., Jr. Research Fellow, DBT scheme

N Beena M.Sc., Research Associate, ICAR ad-hoc scheme (w.e.f. 09.05.1996)

K L Gayathri M.Phil., Research Associate, ICAR ad-hoc scheme (from 12.06.1996 07.03.1997)

P P Rajan M.Sc., Research Associate, ICAR ad-hoc scheme (w.e.f. 16.08.1996)

P Indulekha M.Sc., Sr. Research Fellow, ICAR ad-hoc scheme (w.e.f. 19.12.1996)

K Vinaygopal M.Sc., Sr. Research Fellow, ICAR ad-hoc scheme (w.e.f. 13.01.1997)

Mr. P Prakash, Driver, DBT scheme

Mr. K K Santhosh, Lab. Attender, DBT scheme

B. IISR EXPERIEMENTAL FARM, PERUVANNAMUZHI

Scientific

P A Mathew M.Sc. (Ag.), Senior Scientist (Horticulture) and Scientist in charge

K V Saji M.Sc., Scientist (Eco. Botany) (w.e.f. 16.12.1996)

Technical

V K Abubacker Koya, Farm Superintendent (T6)

K A Somanna, Farm Assistant (T4) (upto 21.01.1997)

K T Muhammed, Jr. Technical Assistant (T-I-3) (upto 04.06.1996)

V P Sankaran, Jr. Technical Assistant (T-I-3)

N A Madhavan, Technical Assistatnt (T-I-3)

N P Padmanabhan, Jr. Technical Assistant (T-I-3)

K Kumaran, Jr. Technical Assistant (T2)

K Chandran, Jr.Technical Assistant (T1)

P Bhaskaran, Jr. Technical Assistant (T1)

D K Eswara, Jr. Technical Assistant (T1) (upto 07.06.1996)

A K Balan, Jr. Technical Assistant (T1)

K P Premachandran, Jr. Technical Assistant (T1)

K K Sasidharan, Jr. Technical Assistant (T2)

E V Ravindran, Jr. Technical Assistant (T1)

Jaimon Thomas, Jr. Technical Assistant (T1) (w.e.f. 07.10.1996)

M Balakrishnan, Jr. Technical Assisatant (T1) (w.e.f. 13.11.1996)

Administration and Accounts

P Sadanandan, Jr. Clerk (ad hoc) (w.e.f. 13.11.1996)

Technical (Workshop group)

T R Sadasivan, Pump Operator

P K Balan, Tractor Driver

Supporting

E Kunhayyappan, SS. Gr. IV (Watchman)

E K Nanu, SS. Gr. IV (Watchman)

B T Velayudhan, SS. Gr.III (Watchman) *(upto 04.06.1996)*

C Bhaskaran, SS. Gr. III (Mazdoor)

P Damodaran, SS. Gr. III (Mazdoor)

N K Girija, SS. Gr.III (Mazdoor)

K Raghavan, SS. Gr. II (Mazdoor)

M Choyikutty, SS. Gr. II (Mazdoor)

K Gangadharan Nair, SS Gr.II (Mazdoor)

N K Raghavan, SS Gr.II (Mazdoor)

V K Sankaran, SSGr. II (Mazdoor)

P Sreedharan, SS Gr. II (Mazdoor)

V P Sarada, SS Gr. I (Mazdoor)

K K Ravindran, Tea Maker

P N Kausalya, Wash woman

Adhoc Scheme

K Rajan, Field Assistant, IPD Scheme

c. Cardamom Research Centre, Appangala

Scientific

V S Korikanthimath Ph.D., Sr. Scientist (Agronomy) & Scientist-in-charge

M N Venugopal Ph.D., Sr. Scientist (Plant Pathology)

Rajendra Hegde Ph.D., Scientist (Agronomy)

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Ravindra Mulge Ph.D., Scientist (Horticulture)

S J Anke Gowda Ph.D., Scientist (Plant Physiology)

Technical

M K Appaiah, Tech.Officer (T-5)

K A Somanna, T-II-3 (Farm Asstt.) (w.e.f.22.01.1997)

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Technical (Workshop group)

H G Nanamaiah, Driver (T-1-3)

Administrative

Enid Savitha, Superintendent

K Vasudevan, Assistant

C Ramesh Babu, Jr.Stenographer (w.e.f.May 1996)

Supporting

B J Lakkaiah, SS Gr.-III (Mali)

H Y Erappa, SS Gr.IV (Watchman)

B L Seethu, SS Gr.IV (Mazdoor)

H B Gangu, SS Gr.IV (Mazdoor)

H B Laxmi, SS Gr.III (Mazdoor)

Mada Shetty, SS Gr.III (Mazdoor)

P K Manikka, SS Gr.III (Mazdoor)

M G Marinanjamma, SS Gr.III (Mazdoor)

B R Janaki, SS Gr.III (Mazdoor)

B M Seshappa, SS Gr.III (Mazdoor)

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K M Chikkasakamma, SS Gr.II (Mazdoor)

B M Cheniappa, SS Gr.II (Mazdoor)

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B M Lalitha, SS Gr.II (Mazdoor3

K M Puttasidhamma, SS Gr.I (Mazdoor)

S Mahadeva, SS Gr.I (Mazdoor)

B K Poovappa, SS Gr.I (Mazdoor)

H B Nagamma, SS Gr.I (Lab.Attendant)

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K V Marigowda, Tea Maker (Canteen) Gr.I

Adhoc schemes

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S Shanmugavel B.V.Sc., Tech.Officer(T6), Veterinary Science

K M Prakash, M.Sc. (Ac.) Tech.Officer(T6), Agronomy

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A Sakeer Hussain M.Sc. (Ag.), Tech.Officer (T6), Agri. Extension (upto17.07.1996)

C S Kavitha M.Sc., Trg. Asst.-cum- Tech. Asst. (T-II-3), Home Science (upto 21.09.1996)

Administrative

V L Jacob, Superintendent (A&A)

S Sunitha, Jr.Stenographer

P Sundaran, Jr.Clerk

Technical (Workshop)

T C Prasad, Driver cum mechanic

Ramanna Gowda, Driver

Supporting

K P Gangadharan, SS Gr.I Watchman

C V Ravindran, SS Gr.I Peon-cum-messenger

B Satheesan, SS Gr.I Horticulture attendant

C Ravindran, SS Gr.I Farm Attendant

P D Jose, SS Gr.I, Animal attendant (upto 30.01.1997)

M S Sivadasan, SS Gr.I, Horticulture attendant (upto 16.12.1996)

L Swaminathan, Cook (w.e.f. 02.09.1996)

PUBLICATIONS AVAILABLE FROM INDIAN INSTITUTE OF SPICES RESEARCH, CALICUT

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