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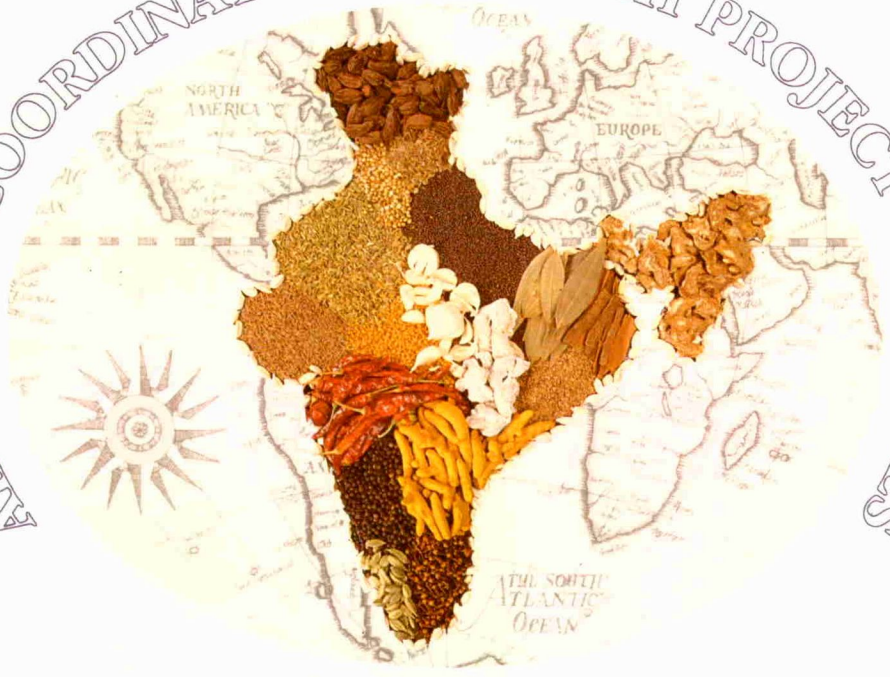
ANNUAL REPORT
1998-99

ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES



INDIAN INSTITUTE OF SPICES RESEARCH
(Indian Council of Agricultural Research)
Calicut - 673 012, Kerala.

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(APRIL 1998 TO MARCH 1999)

INDIAN INSTITUTE OF SPICES RESEARCH

(Indian Council of Agricultural Research)

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CONTENTS

मुख्य सारांश

मसाले फसल के अखिल भारतीय समन्वित अनुसंधान परियोजना राष्ट्र के सबसे बडा मसाले फसल अनुसंधान श्रृंखला है जिसमें 13 कृषि जलवायु अंचलों में स्थित 15 कृषि विश्व विद्यालयों पर आधारित 20 समन्वित और 8 स्वैच्छिक केन्द्र आते है। क्यु आर टी के सिफारिशों के अनुसार सितंबर 1999 से बडे इलायची पर कार्य करने के लिए आई सि ए आर गांड़टोक के स्थान पर आई सी आर अई, आर सी (स्पाइसस बोर्ड) को एक स्वैच्छिक केन्द्र के रूप में स्वीकृत किया गया है। ए आई सी आर पी एस अब 12 मसाले फसलों पर काम करते है - काली मिर्च, इलायची, बडे इलायची, अदरक, हल्दी, लौंग, जायफल, दालचीनी, धनिया, जीरा, सौफ और मेंथी। इसमें 53 वैज्ञानिकों द्वारा मार्गदर्शित और 32 तकनीकी सहायक कर्मचारियो द्वारा पोषित 85 परियोजनाएं आती हैं। इसका वार्षिक बजट 120 लाख रूपए है, जो 75:25 आधार पर आइ सी ए आर और एस ए युस द्वारा आपस में बांटा है। वर्ष 1998-1999 की अनुसंधान उपलब्धियां इस रिपोट में प्रस्तुत किया है।

ए आई सी आर पी एस केन्द्रों ने काली मिर्च के 99, अदरक के 20, हल्दी के 106, वृक्ष मसालों के 27, धनिया के 122, जीरा के 144, सौफ के 178 और मेंथी के 136 अधिमिलनों को मिलाकर आनुवंशिक स्रोतों को मजबूत किया है।

जर्मप्लाजम मूल्यांकन से पन्नियूर केन्द्र काली मिर्च के 3 अधिमिलनों को सूचीबद्ध किया है (पैदावर 5.0, 5.8 और 7.7 कि. ग्राम प्रति बेल) सोलन में अदरक के तीन पंक्तियां (पैदावर 7.5 से 7.7 कि ग्राम/3 मीटर^2) और हल्दी के चार पंक्तियां (पैदावर 8.1 से 8.3 कि. ग्राम/3 मीटर^3) पोटांगी में अदरक के पांच पोक्तियं (पैदावर 7.2 से 7.8 कि ग्राम/3 मीटर^2) हल्दी के तीन पंक्तियां (14.0 से 15.0 कि. ग्राम/3 मीटर^2)और करक्यूमा अरोमटिका दीर्धावधि के दो पंक्तियां (9.5 और 11.5 कि. ग्राम/ 3 मीटर^2) जगटियाल से दीर्धावधि हल्दी के चार (8.2 से 9.0 कि. ग्राम/3 मीटर) मध्यम अवधि के पांच (7.3 से 12.5 कि. ग्राम/3 मीटर^2) और अल्पावधि के तीन (11.5 से 13.0 कि. ग्राम/3 मीटर^2) और जोबनर केन्द्र से धनिया की तीन पंक्तियां सूचीबद्ध किया गया है। इसके अलावा इलायची, अदरक, हल्दी, धनिया, जीरा, सौफ और मेंथी के कई रोग/कीट सहिष्णु अधिमिलन को भी पहचान कर लिया गया है।

विभिन्न केन्द्रों मे 13 समन्वित विभेद परीक्षण अब बढ रहा है और सी वी टी के आधार पर निम्नलिखित पंक्तियां सूचीबद्ध किया है :-

अदरक : पोटांगी - 2 पंक्तियां (10.1 & 11.6 कि. ग्राम/3 एम^2

पुंडीबारी - 1(12.1 कि. ग्राम/3 एम^2)

राईगर - 1 (17.4 कि. ग्राम/3 एम^2)

हल्दी : पोटांगी - 1 (12.7 कि. गाम/3 एम^2)

राईगर - 1 (33.8 टन/हे)

धनिया : जोबनर - 1 (885 कि. ग्राम/हे)

जीरा : जोबनर - 1 (237 कि. ग्राम/हे)

सौंफ : जगुदान - 1 (2720 कि. ग्राम/हे)

मेंथी जोबनर - 2 (2116 & 2321 कि. ग्राम/है)

गुणता विश्लेषण अध्ययन के आधार पर दो उच्च करक्युमिन हल्दी पंक्तियां पहचान किया गया है (6.3% करक्युमिन) और सुखे रिकवरीं (20.3 से 26.6%) केलिए तीन अधिमिलनें भी।

बीज मसालों के चार नए किस्मों को आगामी XV ए आई सी आर पी एस कार्यशाला के निमोचन के लिए प्रभावित किया गया है। इनमें धनिया के आर सी आर - 20 (जोबनर आर ए जे यु) गुजरात जीरा - 3 (जगुदान - जी ए यु) और मेंथी के दो किस्म यानी सी ओ -2 (कोयम्बत्तूर - टी एन ए यु) और गुजरात मेंथी 1 (जगुदान जी एयु) अदरक के पांच अधिमिलन 2.0 से 2.8% तेल और 8.3 से 8.7% तेलीय राल वाले चार पंक्तियं पहचान कर लिया गया है। हिसार में धनिया के तीन अधिमिलन जिसमें 0.4% तेल भी पहचान कर लिया है।

कालीमिर्च (छ:प्रविष्टियां) धनिया (सात प्रविष्टियां (जीरा) छ:प्रविष्टियां सौंफ (तीन प्रविष्टियां) और मेंथी (3 प्रविष्टियां) में सी वी टी शुरु करने के लिए विभिन्न केन्द्रों से प्रस्ताव मिला है।

फसल उत्पादन के क्षेत्र में मडीगेरी केन्द्र ने इलायची के लिए उर्वरक की नई मात्रा 75:75:15 कि. ग्राम एन पी के/है (माध्य पैदावर 684 कि. ग्राम/है) राईगर केन्द्र ने हल्दी की उन्नत पैदावर के लिए उस क्षेत्र में 150:125:125 कि. ग्राम/एन पी के/हे की जरूरत महसूस किया है। जोबनर केन्द्र में ऐसा पाया कि जीरा के 15 अक्तूबर के दौरान बुआई करने से जीरा मुरझान कम हो जाता है। और धनिया के नवंबर 4 की बुआई से सबसे अधिक पैदावर मिलता है। कोयम्बत्तूर की स्थितियों में अक्तूबर में 15 ×10 से. मी. का अंतर छोडना धनिया के लिए सबसे अच्छा सिद्ध हुआ है। लौंग और जायफल के लिए ड्रिप सिंचाई 8 लिटर/दिन/वृक्ष और उर्वरक की मात्रा 400:350:1200 एन पी के 100 कि. ग्राम एफ वाई एम 50 ग्राम असोसपिरिल्लम और फोस्फो बाक्टिरिया प्रति वृक्ष उत्तम पाया गया है।

सिरसी क्षेत्र में फाईटोफतोरा रोग के प्रबंध के लिए पोटासियम फोसफोनेट 0.3% के दर में छिडकाव (3 लिटर/बेल) और दो बार दवाई - मात्रा देना प्रभापूर्ण सिद्ध हुआ है। पन्नियूर केन्द्र में 1 कि. ग्राम नीम खली/फोरेट के 3 ग्राम सक्रिय अंश, 1% बोर्डो मिश्रण का मनसून पूर्व छिडकाव और 0.2% अकोमिन का मानसून के बाद में छिडकाव रोग निवारण केलिए फलप्रद है। इलायची में थ्रिप्स की बाधा

इसके पैदावर के 15.3 कि. ग्राम/ है. का (250 कि. ग्राम/हे. का पैदावर) नाश कर डालता है, इसके अलावा तेल के अंश और बाजार भाव में कमी होती है। अदरक में, सोलानम में बीज प्रकन्दों में डाइथेन एम 45 (0.25%) बाविस्टिन (0.1%) 10 ग्राम थिमेट (12 कि ग्राम/है) मिट्टी में प्रयोग करने से प्रकन्द्र गलन रोग को कम कर सकता है। कालीमिर्च और अदरक में इस रोग के नियंत्रण के लिए ट्राइकोडेर्मा हरजियानम प्रभावपूर्ण सिद्ध हुआ है। हल्दी के टाफ्रीना पत्ते ब्लोच रोग 1% बोर्डो मिश्रण के छिडकाव और 200 पी पी एम रिडोमिल (राइगर) का छिडकाव से नियंत्रण कर सकता है। बिहार में धनिया के तने गाल अधिक पाया जाता है, और कोयम्बत्तूर में धनिया मुरझान को ट्राईकोडेर्मा थायोफिनेट मिथैल के पत्तों पर छिडकाव करने से नियंत्रण कर सकता है।

सभी ए आई सी आर पी एस केन्द्रों में पौध सामग्री के उत्पादन का कार्य हो रहा है, इन केन्द्रों ने काली मिर्च के 1,13912, इलायची के 3502 क्लोन और 6.5 कि. ग्राम बीज, अदरक के 90 कि. ग्राम हल्दी के 645 कि. ग्राम और बीज मसालों के 15.9 टन पैध सामग्रियों का उत्पादन एवं वितरण किया गया है।

इस रिपोर्ट में मसाले फसल पर चालू कार्यरत और बन्द परियोजनाओं के साथ 18 आई सी ए आर तदर्थ अनुसंधान परियोजनाओं की उपलब्धि का सांराश भी निहित है।

आगामी दशकों में मसाले उत्पादन और उत्पादकता में भविष्य के लक्ष्य की पूर्ति के लिए आवश्यकता आधारित और क्रिया आधारित अनुसंधान परियोजनाओं का रूपीकरण के लिए ए आई सी आर पी एस के अनुसंधान कार्यक्रमों का आलोचनात्मक समीक्षा की जा रही है।

EXECUTIVE SUMMARY

The All India Coordinated Research Project on Spices (AICRPS) is the largest spices research network in the country, comprising of 20 coordinating and eight voluntary centres, based at 15 Agricultural Universities in 13 agroclimatic zones. As per the recommendations of the QRT 1998, ICRI, R.C (Spices Board), Gangtok is also identified as a voluntary centre since September 1999 to work on large cardamom, in place of ICAR R.C Gangtok. AICRPS now works on 12 spices - black pepper, cardamom, large cardamom, ginger, turmeric, clove, nutmeg, cinnamon, coriander, cumin, fennel and fenugreek. There are 85 projects manned by 53 Scientists, supported by 32 technical / auxillary staff. The annual budget is Rs 120 lakhs, shared by ICAR and SAU's in 75:25 basis. The research achievements for the year 1998-1999 are presented in this report.

The AICRPS centres strengthened the genetic resources base by adding 95 accessions of black pepper, 20 of ginger, 106 of turmeric, 27 of tree spices, 122 of coriander, 144 of cumin, 178 of fennel and 136 of fenugreek.

From germplasm evaluation, Panniyur centre shortlisted three accessions of pepper (yield 5.0, 5.8 and 7.7 kg/vine); Solan three lines of ginger (yield 7.5 to 7.7 kg/3m^2) and four lines of turmeric (yield 8.1 to 8.3 kg/3m^2); Pottangi five lines of ginger (yield 7.2 to 7.8 kg/3m^2), three lines of turmeric (14.0 to 15.0 kg/3m^2) and two lines of *Curcuma aromatica* (9.5 and 11.5 kg/3m^2); Jagtial four long duration turmeric (8.2 to 9.0 kg/3m^2), five medium duration (7.3 to 12.5 kg/3m^2) and three short duration (11.5 to 13.0 kg/3m^2); and Jobner centre three lines of coriander. Apart from these a few disease/pest tolerant accessions have been identified in cardamom, ginger, turmeric, coriander, cumin, fennel and fenugreek.

Thirteen coordinated varietal trials are in progress in various centres, and based on the CVTs the following lines have been shortlisted:

Ginger	: Pottangi - 2 lines (10.1 & 11.6 kg/3m^2); Pundibari-1 (12.1 kg/3m^2); Raigarh- 1 (17.4 kg/3m^2);
Turmeric	: Pottangi -1 (12.7 kg/3m^2) Raigarh - 1 (33.8 t/ha);
Coriander	: Jobner - 1 (885 kg/ha);
Cumin	: Jobner - 1 (237 kg/ha)
Fennel	: Jagudan-1 (2720kg/ha)
Fenugreek	: Jobner -2 (2116 & 2321 kg/ha)

Based on quality analysis, two high curcumin turmeric lines have been identified (6.3% curcumin) and also three accessions having high dry recovery (20.3 to 26.6%).

Four new varieties of seed spices were proposed for release in the forthcoming XV AICRPS Workshop. They are RCr-20 in coriander (Jobner - RAJU), Guj.cumin - 3 (Jagudan - GAU) and two fenugreek varieties viz Co-2 (Coimbatore-TNAU) and Guj.Methi-1 (Jagudan - GAU). In ginger, five accessions having 2.0 to 2.8% oil and four lines having 8.3 to 8.7% oleoresin have been identified. At Hisar, three coriander accessions having above 0.4% oil, have been identified.

Proposals have been received from various centres for starting CVT in pepper (six entries), coriander (seven entries), cumin (six entries), fennel (three entries) and fenugreek (three entries).

In the area of crop production, Mudigere centre came up with the new fertilizer dose of 75:75:150 kg NPK/ha for cardamom (mean yield 684 kg/ha); Raigarh centre found that 150:125:125 kg/NPK/ha is required for high yield in turmeric in that area; Jobner centre found that sowing cumin during 15 October reduced cumin wilt; while in coriander November 4 sowing gave the best yield. Under Coimbatore condition, sowing at 15 x 10 cm spacing in October was best in coriander. For clove and nutmeg, drip irrigation of 8 l/day/tree and fertilizer dose of 400:350:1200 NPK + 100 kg FYM + 50 gm each of *Azospirillum* and Phosphobacteria per tree is found ideal.

For managing *Phytophthora* disease in Sirsi area, Potassium phosphonate @ 0.3% as spray (3 l/vine) and drench (5 l/vine) twice was effective. At Panniyur centre application of 1 kg neem cake + 3 g ai of Phorate, 1% Bordeaux mixture as premonsoon spray and 0.2% Akomin spray as post-monsoon was good for containing the disease. In cardamom, thrips infestation caused an yield loss of 15.3 kg/ha (for a yield of 250 kg/ha) in addition to reduction in oil content and market price. In ginger, at Solan seed rhizome treatment with Dithane M-45 (0.25%) + Bavistin (0.1%) along with soil application of Thimet 10 g (12 kg/ha) minimised rhizome rot disease. *Trichoderma harzianum* was found effective in checking the disease in pepper and ginger. *Taphrina* leaf blotch control in turmeric could be achieved with 1% Bordeaux mixture spray (Pundibari) and by 200 ppm Ridomil spray (Raigarh). Stem gall of coriander is reported to be very severe in Bihar. In Coimbatore, coriander wilt could be controlled by seed treatment with *Trichoderma* + Thiophenate methyl foliar spray.

In cumin and fenugreek *Trichoderma* + fungicide + neem cake were helpful in controlling wilt disease.

All AICRPS centres took up actively planting material production. The centres produced and distributed 1,13,912 cuttings of black pepper, 3502 cardamom clones and 6.5 kg seeds, 90q ginger, 645q turmeric and 15.9 tonnes of seed spices.

This report also contains summary of achievements of ICAR *ad hoc* research projects on spices currently operating as well as projects concluded during 1998-99.

The research programmes of AICRPS are being critically reviewed for formulating need based and action based research projects for meeting the future targets and challenges in spices production and productivity in the emerging decade.

INTRODUCTION

From the dawn of modern civilization, India is regarded as the legendary land of spices. India is still the largest producer of spices and also exporter; the annual production is to the tune of around 27 lakh tonnes valued approximately at Rs.13000 crores and her share in world trade is about 35% in terms of volume and 13% in value. During the financial year 1998-99, our country registered a 17% increase in export value of spices and spice products, from Rs.1408 crores in 1997-98 to Rs.1650 crores. In this period the export earnings in terms of US Dollars shot up from 378.72 million to 393.90 million, recording an increase of four per cent. Pepper continued to be the leader in export earnings with a share of 38% followed by spice oils and oleoresins (18%) and chillies (13%). The export of cardamom, chilli, turmeric, celery, fenugreek, other spices, and spice oils and oleoresin have increased both in terms of quantity and value compared to last year, whereas, export of pepper and curry powder is higher in terms of value only.

The VIII Plan period witnessed increase in production and productivity for most spices. During the period 1991 - 92 to 1996-97, productivity in pepper has gone up from 282 to 308 kg/ha, cardamom from 61 to 149 kg/ha, large cardamom from 129 to 197 kg/ha, ginger from 2958 to 3278 q/ha, turmeric from 3102 to 4052 q/ha , coriander from 453 to 590 kg/ha, fenugreek from 992 to 1298 kg/ha. On the other hand in the case of celery, cumin, and fennel there were marginal reduction in productivity. The increase in productivity is marginal, and is not comparable with that in other producing countries, mainly because of many production constraints facing these crops. However, the production and productivity increase during the past three decades has been remarkable and is mainly due to the R&D efforts initiated in the 1970s onwards. The AICRP (Spices) has played a significant role in this productivity enhancement.

The All India Coordinated Research Project on Spices (AICRPS) is the largest research network on Spices operating in our country , playing a major role in the area of spices research and development. Initiated in 1971 as a combined project on cashewnut and spices with its headquarters at CPCRI, Kasaragod , it was bifurcated into two independent projects in 1986

and since then it has been working as AICRP on spices with its headquarters at Indian Institute of Spices Research, Calicut, Kerala.

At the time of inception in the fourth Plan (1971), AICRPS had four mandate crops (black pepper, cardamom, ginger and turmeric) and four centres (Panniyur, Pampadumpara, Mudigere, and Solan). The project was gradually strengthened by additional centres as well as crops during the subsequent Plan periods. At present, there are 20 coordinating and eight voluntary centres based at 15 Agricultural Universities under 13 agroclimatic zones of India . There are 12 mandate spices viz., black pepper, cardamom, large cardamom, ginger, turmeric, tree spices (clove, nutmeg, cinnamon) and seed spices (coriander, cumin, fennel and fenugreek).

The objectives of AICRPS are:

- Evolving high yielding, high quality varieties suitable for various agro-ecological situations, and that are tolerant /resistant to diseases and pests.
- Standardising agro-techniques for different agro-climatic conditions
- Evolving measures for management of major pests and diseases
- Working as an interface between SAUs, Indian Institute of Spices Research (IISR) and Indian Council of Agricultural Research (ICAR).

The AICRP on Spices provides the technology base for national level planning and management of spices research in the country and provides the much needed coordinating mechanism between ICAR, IISR and the State Agricultural Universities, other research and development organisations.

The research programmes are executed under three major divisions viz,. Crop improvement (including genetic resources and biotechnology), Crop production (including post harvest technology) and Crop protection. As on today there are 85 projects supported by 53 scientific and 32 technical/supporting staff. In addition, the AICRPS is also monitoring the *ad-hoc* research projects on spices located in various ICAR and SAU organisations.

This report summarises the progress of work under the various AICRPS research and *ad-hoc* projects during 1998-99.

I am sure this report will give the readers an insight into the spectrum of research activities of AICRPS and the critical role it is playing in sustaining and improving production and productivity of spices in the country.

While bidding good bye to the present century (and the millennium), I take this opportunity to dedicate this report to the spices workers of this great country. To achieve the goals set forth by the nation, what we need is work, work and more work. I hope the Scientists under the AICRPS will gear up and rise to the occasion to meet the challenges ahead, and to achieve the goals and aspirations of our beloved country. Let us welcome the new century with this resolve.

(P N RAVINDRAN)
Project Coordinator

PROJECT COORDINATOR'S REPORT

The All India Coordinated Research Project on Spices (AICRPS) was initiated in 1971 during the IV Five Year Plan as a combined project on spices and cashewnut with headquarters at Central Plantation Crops Research Institute (CPCRI), Kasaragod. In order to intensify spices research and development, the original project was bifurcated in 1986 and the present All India Coordinated Research Project on Spices (AICRPS) came into existence. Its headquarters is at Indian Institute of Spices Research, Calicut.

The AICRPS was the first ever major attempt to conduct organised research on spices which was initiated with four crops (black pepper, cardamom, ginger and turmeric) in four centres (Panniyur, Pampadumpara, Mudigere and Solan) during IV Plan (1971). During Vth Plan, the project was extended to seed spices (coriander, cumin, fennel and fenugreek) by including five additional centres viz., Jobner, Jagudan, Guntur, Coimbatore and Pottangi. During VI Plan, four more centres (Sirsi, Vellanikkara, Chintapalli and Yercaud) were added to further intensify the work on pepper, ginger and turmeric. Two new centres viz., Gangtok and Jagtial were also added during VII Plan to work on large cardamom and turmeric respectively. Further, during VIII Plan, six more centres viz., Dholi, Hisar, Kumarganj, Raigarh, Dapoli and Pundibari were added mainly to emphasise research on seed spices, turmeric and tree spices and also to cover the northern region of the country. Eight voluntary / cooperating centres were also added under AICRPS, during this period.

Thus, AICRPS comprises of 20 coordinating and eight voluntary centres based at 15 Agricultural Universities in 13 agroclimatic zones. AICRPS now work on 12 major spices viz., black pepper, cardamom, large cardamom, ginger, turmeric, clove, nutmeg, cinnamon, coriander, cumin, fennel and fenugreek. AICRP on Spices is the largest research network on spices operating in our country, providing technology base for national level planning and management of spices research.

The Quinquennial Review Team (QRT) that reviewed the progress of work of AICRPS, has recommended to close the Gangtok centre (as it is non-performing) and to shift the work to ICRI (Spices Board), Tadung, Gangtok, so that that centre can act

as the nodal Research and Development centre for large cardamom.

Research Activities

It is heartening to see that production and productivity of spices have gone up over the past three decades, in which AICRPS played a major role by extending all its assistance and co-operation for boosting up the spices production and productivity. The AICRPS is vested with the following mandates :

- Evolving high yielding high quality varieties suitable for varying agro-climatic locations, and that are tolerant/resistant to diseases and pests.
- Standardisation of agrotechniques for different agroclimatic conditions
- Evolving control measures for the major pests and diseases
- Working as an interface between SAUs, Indian Institute of Spices Research and Indian Council of Agricultural Research (ICAR).

The research activities are focussed through three major disciplines: crop improvement (including genetic resources and biotechnology), crop production (including post harvest technology) and crop protection. As on today there are 85 projects distributed under different disciplines viz., 40 in crop improvement, 20 in crop production and 25 in crop protection. The crop wise distribution of the projects are 13 in black pepper, 12 in cardamom, 6 in ginger, 11 in turmeric, 7 in tree spices, 10 in coriander, 10 in cumin, 7 in fennel and 9 in fenugreek. Research on paprika (zero pungent capsicum as a source of colour) and highly pungent chillies (for extraction of capsaicin) are also being planned.

The AICRP on Spices is supported by 53 scientists and 32 technical / supporting staff. The annual budget of Rs.120 lakhs, is shared by ICAR (75%) and SAUs (25%).

Monitoring

The location specific and need based research programmes are formulated and finalised during the Workshop / Group Meetings of spices workers organised biennially. The research programmes after approval by the Group are implemented in the AICRPS centres. The Project Coordinator is responsible for monitoring, reviewing, guiding and funding of the projects. The project coordinator makes periodical visits to the centres for review and assessment of the work, and he renders the required guidance and advice to the workers. Besides this, periodical discussions are held with higher officials at ICAR headquarters in connection with AICRPS for smooth running of the project.

Apart from this, the Project cordinator is also monitoring the ICAR *ad-hoc* research projects on spices operating under various Institutions / SAUs and other organisations.

It gives me immense pleasure to present the biennial report of the progress of work and achievement accomplished by the coordinating centres / voluntary centres during 1997-98 to 1998-99.

Genetic Resources

The genetic resource bases of all the crops were further strengthened during the past two years. In the case of black pepper the Panniyur centre added 62 indigenous collections and one wild collection. Ten cultivars were added at Sirsi. Chintapalli centre added 13 new cultivars and two wild collections while, Yercaud centre collected eight new accessions and one related species. The Pundibari centre also added two new collections.

In cardamom, Pampadumpara centre added one cultivated accession. In ginger, five new accessions at Pottangi and 15 at Pundibari were included in the germplasm. In turmeric, Pottangi has added three, Raigarh 37, Pundibari 10, Chintapalli 23 and Kumarganj 13 new accessions. The Coimbatore centre added two exotic lines rich in curcumin from Indonesia apart from 18 cultivated accessions.

In tree spices, Yercaud centre collected two varieties of cinnamon and two species of nutmeg, Pechiparai five new collections of clove, Thadiyankudisai and Dapoli 6 accessions and 12 accessions of cinnamon respectively.

As regards coriander, 21 collections were added at Jobner, 51 at Coimbatore, 13 at Raigarh and 37 at Kumarganj centres. In cumin, 29 accessions were added at Jobner, 103 at Jagudan and 12 at Kumarganj. The fennel accessions were added in the order of 34 in Jobner, 121 in Jagudan and 23 in Kumarganj. In fenugreek, 27 accessions were added at Jobner, 70 at Coimbatore and 39 at Kumarganj.

Germplasm Evaluation

Evaluation of germplasm followed by selection forms the basis for most crop improvement programmes in spices. Some of the achievements during the past two years are given below.

At Panniyur, based on the two years mean data, the following accessions of black pepper were short listed (green yield/vine)

PRS 22 (Karimunda III) - 7.65 kg

PRS 61 (Valli) - 5.78 kg

PRS 21 (Karimunda III) - 4.98 kg

Similarly the following accessions of different crops are short listed for

further evaluation by the various coordinating centres.

Crop Improvement

There are 13 coordinated varietal trials (CVT) that are in progress at various centres besides many comparative yield trials. The CVTs include two in black pepper, three in cardamom, one each in ginger, turmeric, cumin and fennel and two each in coriander and fenugreek. The salient achievements are highlighted below.

The new coordinated varietal trials (CVT series IV) initiated during 1995-96 on ginger and turmeric are progressing well at all the centres. Based on the mean performance of

Spice	Centre	Accessions	Yield
Ginger (8)	Solan (3)	SG-700, BDJR-1226, SG 705	7.5 to 7.7 kg rhizome/3m^2
	Pottangi (5)	V2E4-5 and PGS-43	7.8 kg/3m^2
		V5E5-4, PGS-17 and V1E7-1	7.2 to 7.7 kg/3m^2
Turmeric (22)	Solan (4)	BDJR 1258, Armoor, ST 624 and BDJR 1210	8.1 to 8.3 kg/3m^2
	Jagtial (12) Long duration (4)	Acc. 361, TC-4, JTS-6 and JTS-8	8.2 to 9.0 kg/3m^2
	Medium duration (5)	PTS-10, PTS-19	12.5 kg/3m^2
		JTS-306, CLI 367/II and CLI 370	7.3 to 11.0 kg/3m^2
	Short duration (3)	PCT-10, JTS-604, PCT-14	11.5 to 13.0 kg/3m^2
	Pottangi (6) (*C. longa*) (3)	PTS-5, STS-10 and PTS-28	14.0 to 15.0 kg/3m^2
	(*C. aromatica*) (3)	Chayapasupu II Kalarmanar and CAS-59	9.5 to 11.5 kg/3m^2
Coriander (3)	Jobner (3)	UD-207	Late flowering type (>90 days)
		UD-60 and UD-5	High yielder

The following disease/pest tolerant accessions have also been identified

Spice	Centre	Accession	Disease/pest tolerance
Cardamom (2)	Pampadumpara	Acc.PS-7 Cul. 679	Moderately resistant to thrips Less susceptible to thrips
Ginger (3)	Solan (3)	BDJR 1226, Jamaica and BLP-6	Less susceptible to rhizome rot
Turmeric (20)	Raigarh (5)	Bataguda, Hardaguda, Rashmi, PTS-55, PTS-20	Resistant to leaf blotch (*Taphrina maculans*)
	Dholi (6)	Kohinur, GL Puram, R.Sonia, RH-5 G L Puram, Kohinur	Resistant to leaf blotch (*Taphrina maculans*) Resistant to leaf spot (*Colletotrichum capsici*)
	Jagtial (5)	Armoor, Duggirala	Resistant to leaf blotch (*Taphrina maculans*)
		PCT-13 and PCT-14 PCT culture	Resistant to rhizome rot Resistant to leaf spot (*Colletotrichum capsici*)
	Coimbatore (10)	CL-31 CL-125, CL-30 and CL-154	Free from leaf blotch Tolerant to rhizome scale
Coriander (10)	Jobner (3)	RCr-20, RCr-41 and RCr-435	Moderately resistant to root knot nematode
	Jagudan (2)	JCo-331 and Jco-334	Moderately resistant to root knot nematode
	Dholi (3)	Pant Haritima UD 646 and M1	Resistant to stem gall disease
	Coimbatore (2)	CC.462 CC.496	Less susceptible to wilt
Cumin (6)	Jobner (1)	EC-232684	Less susceptible to wilt
	Jagudan (5)	Sel.75-1, Sel.73-1 and Sel.74-1	Resistant to *Fusarium* wilt
		JC-94-23 and JC-94-57	Moderately resistant to root knot nematode
Fennel (4)	Jagudan (4)	JF-376, JF-377, JF-379 and JF-421	Moderately resistant to root knot nematode
Fenugreek (16)	Dholi (7)	HM-103, R.kanti, UM-306, UM-9, RM-5 and UM-29	Resistant to *Cercospora* leaf spot
	Jagudan (1)	Kasuri methi	Resistant to powdery mildew
	Jobner (8)	UM-32, UM-34, UM-464 UM-117, UM-127, UM-128, UM-129 and UM-305	Resistant to root knot nematode Moderately resistant to root knot nematode

two/three years data the following accessions have been shortlisted.

- New varieties viz., CO-2 fenugreek at Coimbatore and RCr-20 coriander at Jobner have been released through state variety release committee for cultivation in the respective states.
- Vegetative propagation of nutmeg viz., grafting using two leaved stage root stock with both orthotropic and plagiotropic scions recorded highest success at Yercaud.

Crop Production

In cardamom, the Mudigere centre has come up with an optimum fertilizer schedule of 75:75:150 kg NPK/ha for obtaining high yield (684 kg/ha). Micronutrients application

Spice	Centre	Accession	Yield (Rhizomes)
Ginger (4)	Pottangi	V_1E_8-2	11.6 kg/3m^2
		V_3S_1-8	10.1 kg/3m^2
	Pundibari	Gurubathan	12.1 kg/3m^2
	Raigarh	V_3S_1-8	17.4 t/ha
Turmeric (2)	Pottangi	Acc.JTS.2	12.7 kg/3m^2
	Raigarh	Acc.RH.5	33.8 t/ha

The CVT on seed spices is also functioning well and the following accessions are the best yielders based on two / three years data.

Centre	Crop	Accession	Yield (kg/ha)
Jobner	Coriander (1)	UD-684	885
	Cumin (1)	UC-223	237
	Fenugreek (2)	UM-303	2321
		HM-114	2116
Jagudan	Fennel (1)	JF-200	2720

The following accessions have been proposed for CVT in different spices from different centres.

Spice	Centre	Accessions	Yield* (kg/ha)
Black pepper	Panniyur	PRS 22 (Karimunda III)	6.46
		PRS 61 (Valli)	5.10
		PRS 17 (Kalluvally IV)	4.27
		PRS 21 (Karimunda II)	4.00
		Cul.5489 (OP of Cheriakaniakadan)	4.23
		Cul.5695 (OP of Uthirankotta)	4.23

*green berry yield/vine

The seed spices proposals received are given below:

Coriander	Coimbatore(3)	UD-446	529 kg/ha
		ATP-77	518 kg/ha
		DH-48	512 kg/ha
	Jobner (2)	UD-743	972 kg/ha
		UD-744	972 kg/ha
	Jagudan (2)	J.Cor-283	1505 kg/ha
		J.Cor-387	1509 kg/ha
Cumin	Jobner (2)	UC-230	243 kg/ha
		UC-310	264 kg/ha
	Jagudan (4)	JC-94-37	651 kg/ha
		JC-94-128	578 kg/ha
		JC-94-148	586 kg/ha
		JC-94-262	627 kg/ha
Fennel	Jagudan (3)	JF-234	2976 kg/ha
		JF-237	3142 kg/ha
		JF-303	2876 kg/ha
Fenugreek	Jobner (3)	UM-305	2187 kg/ha
		UM-321	2183 kg/ha
		UM-322	1904 kg/ha

significantly increased capsule yield, while pure organic manuring was on par with control which indicates that pure organic manuring cannot replace inorganic fertilizer, which is necessary for obtaining higher productivity.

- At Raigarh, a fertilizer schedule of 150:125:125 kg NPK/ha has been found to be optimum for obtaining higher yield (26.6 t/ha) in turmeric.
- Studies on the volatile oil pattern of cumin accessions at Jobner, revealed that cuminaldehyde and cuminyl alcohol are responsible for wilt resistance and the accession EC 232684 recorded the highest ratio (0.84) of oxygenated compounds to hydrocarbons responsible for wilt resistance.
- Studies on date of sowing on wilt incidence of cumin showed that 15 October is the most appropriate for reducing the disease incidence (1.82%).
- The Jobner centre standardised the date of sowing as 4 November for getting higher yield (1198 kg/ha) in coriander with the highest net return of Rs.16,367/ha with

a B:C ratio of 1.96. The seed rate was optimised as 14 kg/ha under Jobner for the variety RCr-41. The initial leads indicate that micronutrients significantly influence the grain yield of coriander. The Hisar accessions viz., CC.745, CC.748 and Jco-327 are promising for quality (E. oil 0.4%).

- In fenugreek, the ideal spacing (15x10cm) and date of sowing (October) were standardised for getting higher yield under Coimbatore condition.

From the quality studies carried out at Solan, the following high quality accessions are shortlisted.

Turmeric	CL 67 and CL 18	6.3% curcumin
	SG 54, Lajhan, No.45/95	20-26.6% dry recovery
Ginger	BLP.6, SG 723, BDJR 1054, SG 55 and Maran	2.0 to 2.8% essential oil
	V_1S_1-8, BDJR 1226 and Chanog II	8.3 to 8.7% oleoresin

- At Yercaud, in the drip irrigation trial on tree spices, dripping of water @ 8 l/day/plant continues to perform well. As in the biofertilizer trial, recommended dose (100 kg FYM + 400:350:1200 g NPK for clove and 100 kg FYM + 400 : 350:1200g NPK/tree/year for nutmeg along with 50g each of *Azospirillum* and Phosphobacteria resulted in higher yields.

Crop Protection

At Sirsi, application of potassium phosphonate @ 0.3% as spray (3 l/vine) and drench (5 l/vine) twice (just before the onset of monsoon (June) and second at 35-45 days after first spray) was very effective in checking the spread of *Phytophthora* disease incidence. The Panniyur centre has come up with the following recommendation to control *Phytophthora:* Application of one kg neem cake + 3g ai of Phorate/vine together with 1% Bordeaux mixture as pre-monsoon spray and Akomin 0.2% as second spray during monsoon.

- Studies carried out at Mudigere on the quantitative and qualitative loss due to thrips, showed that the loss in damage due to thrips was 15.3 kg/ha for an average capsule yield of 250 kg/ha. In addition, the capsule weight, husk weight, number of healthy seeds/capsule and oil content were also reduced as a result of thrips damage.

- At Solan, seed rhizome treatment with Dithane M-45 (0.25%) + Bavistin (0.1%) along with soil application of Thimet 10G (12 kg/

ha) resulted in reducing the disease incidence and increased the rhizome emergence.

- The initial lead on biocontrol of *Phytophthora* foot rot of pepper at Chintapalli and rhizome rot of ginger at Solan showed that *T. harzianum* was effective in checking the disease.
- Studies on the control of rhizome rot of ginger at Raigarh indicated that Neem cake (5%) and Mahua cake (5%) were effective in control of rhizome rot besides giving higher yield.
- As per the survey report of Dholi, the leaf blotch *(Taphrina maculans)* was more severe compared to leaf spot caused by *Colletotrichum capsici.*
- At Pundibari, 1% BM spray and at Raigarh Ridomil spray were effective in checking the *Taphrina* leaf blotch.
- In coriander, the stem gall disease caused by *Proteromyces macrosporous* was more severe in the coriander growing areas of Bihar. At Coimbatore, biocontrol studies indicated that *Trichoderma* + Thiophenate methyl combination was very effective in checking the wilt disease of coriander.
- In cumin, application of *T. harzianum* as seed treatment along with fungicides spray and neem oil reduced the wilt incidence at Jobner. Soil solarisation also reduced the disease spread.
- In the biocontrol study on the control of root rot of fenugreek, seed treatment with *T. viride* + soil application of neemcake was very effective in reducing the disease spread.

Production and Distribution of Planting Material

All the Coordinating Centres took active participation in the planting material production programme and produced 1,13,912 cuttings of black pepper, 3502 cardamom clones and 6.5 kg seeds, 9.0 and 64.5 quintals of ginger and turmeric and 15.9 tonnes of seed spices and distributed the same to growers.

Future Thrust Areas

The following areas have been identified taking into account the QRT recommendations

- Developing descriptors for all the spices. The IISR has already prepared the draft document for ginger and turmeric
- Germplasm enrichment of seed spices through introduction. Survey and collection from hitherto unexplored areas of India (such as the Bastar area of MP for ginger)
- Development of production technology for spices - based cropping system

- Nutrient and water requirement for sustainable spices production and for targeted yield.
- Management technology for production of organic spice
- Standardisation of management technology using biofertilizer, biocontrol agents and biopesticides in sustainable spices production
- Development of integrated pest and disease management for major diseases of spices
- Initiating research/development programmes in paprika and high pungent chillies
- Initiating research programmes on black pepper and pepper based cropping system for Mohitnagar (West Bengal) and Kahikuchi (Assam) and for the Andamans for meeting the requirements of these regions.

A TRIBUTE

I would like to place on record in this last annual report of the AICRPS in the century, the yeomen services rendered by the past Project Coordinators.

Dr. M C Nambiar, the first Project Coordinator of the unified All India Coordinated Research Project on Cashew and Spices was responsible for laying a strong foundation for the project and his contributions to the cause of the AICRP on Spices and Cashew will be long remembered. On behalf of all the Scientist working under the AICRPS, I would like to place on record our deep appreciation to Dr. Nambiar. Dr. S Edison, the first Project Coordinator of the bifurcated All India Coordinated Research Project on Spices has served in that capacity for almost twelve years. During this period he had built up this project to a magnificent level and the present status of the project is due to his untiring efforts. All of us in the AICRPS are deeply indebted to his services to the cause of the spices. For a short period Dr. A K Sadanandan was holding the charge of Project Coordinator and he continued with the legacy that was built up by Dr. Edison, and we are thankful to him also. Apart from the Project Coordinators, the progress of AICRPS was also due to the unstinted support received from the former Directors of CPCRI; Dr. K V Ahamed Bavappa, Dr. N M Nayar and Dr. M K Nair and the present Director of IISR, Dr. K V Peter. I would also like to place on record the holistic support that the AICRPS received from Dr. K L Chadha, the former DDG and Dr. P Rethinam, the former ADG. It was their vision finally took shape in the form of the present AICRPS.

The present status of the project and the smooth way that it functions is due to the present DDG, Dr. S P Ghosh, who has given all the support, guidance and advice for me in running the AICRPS properly. Similarly, Dr. R N Pal, ADG is playing a

vital role in the running of the project by giving all support and advice. Let me thank both DDG and ADG on behalf of all the staff of AICRPS for the whole-hearted cooperation and support that they are extending. I would also like to add a line of appreciation about Dr. K V Peter, Director, IISR who is giving me all logistic support and technical advice at every step and that makes my functioning much easier. I am very thankful to him for this.

As we are stepping into the new century, let me for a moment look back and record our indebtedness to some of the stalwarts who worked in the AICRPS. Some of them are not with us now and a few have retired from service but their efforts will go a long way and will be remembered. Dr. Venugopalan Nambiar, the former Head of the Panniyur Research Station will be remembered for the variety that he has developed, Panniyur-1, and for the strong foundation that he has laid down for crop improvement in pepper. He is no more, but his contributions will live till pepper cultivation exists in this country. Dr. D C Mohanty of RRS, Pottangi and Prof. Sukumara Pillai, PRS, Panniyur have retired from service and I would like to place on record in this august house, our appreciation for the rich contributions made by them Dr. R.K. Sharma of Rajasthan Agricultural University is retiring from service soon and Dr. H M Chandrappa has shifted his talents to another area from cardamom research. Their contributions to seed spices and cardamom research respectively have laid down strong foundations for the crop improvement work in these crops and I would like to place on record our deep appreciation for them.

I may also add here a word of gratitude to the Scientists of IISR who have given ample technical support and inputs for the functioning of AICRPS for the last 14 years. It would not have been possible to draw up sound technical programmes but for the enthusiasm and support extended by the IISR Scientists. On behalf of the AICRPS, I would like to thank all of them and I hope that the Project will be getting the benefits of their service in the years to come.

The XV Workshop of AICRPS is meeting at a very momentous time when one Century and a millenium are retreating to the past and a new dawn is rising, a new century is unfolding before us. This Workshop of AICRPS will take note of this particular moment and I hope, will be successful in drawing up technical programmes that will take care of interests of spices research and development in the country for the coming century.

I place before the readers this Annual Report for 1998-99 to give a glimpse of the project and achievements that we have made in the past year in the area of spices research and development under the AICRPS.

TECHNICAL PROGRAMMES (1999)

Note: From this year onwards a new Project Code numbering system is introduced. Please indicate these numbers invariably in all reports and documents dealing with the projects.

Project code	Title	Centre
BLACK PEPPER		
PEP/CI/1	**Genetic resources**	
PEP/CI/1.1	Germplasm collection, characterization, evaluation and conservation	Panniyur, Sirsi, Chintapalli, Yercaud and Dapoli
PEP/CI/2	**Hybridization trial**	
PEP/CI/2.1	Inter varietal hybridization to evolve high yielding varieties	Panniyur
PEP/CI/3	**Coordinated varietal trial (CVT)**	
PEP/CI/3.1	CVT 1987 – Series III	Panniyur and Sirsi
PEP/CI/3.2	CVT 1991 – Series IV	Panniyur, Chintapalli, Ambalavayal, Yercaud and Pampadumpara
PEP/CM/1	**Irrigation trial**	
PEP/CM/1.1	Irrigation-cum-fertilizer requirements of black pepper and arecanut in a mixed cropping system	Sirsi
PEP/CM/1.2	Trial on drip irrigation in black pepper	Panniyur
PEP/CP/1	**Disease management trial**	
PEP/CP/1.1	*Phytophthora* foot rot disease management in black pepper	Sirsi
PEP/CP/1.2	Biological control of *Phytophthora* foot rot of black pepper – nursery trial	Chintapalli
PEP/CP/1.3	Studies on the control of nursery disease of black pepper including biocontrol	Panniyur
PEP/CP/1.4	Control of *Phytophthora* disease of black pepper in farmers' field – observational trial	Panniyur
PEP/CP/1.5	*Phytophthora* foot rot incidence in black pepper under different density in an arecanut garden	Sirsi

Project code	Title	Centre
PEP/CP/2	**Pest management trial**	
PEP/CP/2.1	Control of scale insects in black pepper	Pampadumpara
PEP/CP/2.2	Survey for the incidence of insect pests in black pepper at high altitudes	Pampadumpara
CARDAMOM		
CAR/CI/1	**Genetic resources**	
CAR/CI/1.1	Germplasm collection, characterization, evaluation and conservation	Mudigere and Pampadumpara
CAR/CI/2	**Hybridization and selection**	
CAR/CI/2.1	Evaluation of synthetics	Mudigere
CAR/CI/3	**Coordinated varietal trial (CVT)**	
CAR/CI/3.1	CVT 1998 – Series II	Pampadumpara
CAR/CI/3.2	CVT 1991 – Series III with Malabar Type	Mudigere, Appangala and Saklespur
CAR/CI/3.3	CVT 1991 – Series III with Mysore Type	Mudugere, Appangala, Saklespur and Myladumpara
CAR/CI/4	**Varietal / evaluation trial**	
CAR/CI/4.1	Yield evaluation of promising cardamom selection – 1997	Mudigere
CAR/CM/1	**Nutrient management trial**	
CAR/CM/1.1	Effect of fertilizer on the yield of cardamom	Mudigere and Pampadumpara
CAR/CM/1.2	Influence of micronutrients on the yield of cardamom	Mudigere and Pampadumpara
CAR/CM/1.3	Trial on integrated nutrient management	Mudigere and Pampadumpara
CAR/CP/1	**Pest management in cardamom**	
CAR/CP/1.1	Evaluation of plant based insecticides for the control of thrips and borer in cardamom	Mudigere
CAR/CP/1.2	Estimation of quantitative and qualitative loss due to thrips damage in cardamom	Mudigere
CAR/CP/1.3	Bioecology of natural enemies of major pests of cardamom	Mudigere

Project code	Title	Centre
GINGER		
GIN/CI/1	**Genetic resources**	
GIN/CI/1.1	Germplasm collection, characterization, evaluation and conservation	Solan, Pottangi, Pundibari, Kumarganj, Dholi and Raigarh
GIN/CI/2	**Coordinated varietal trial (CVT)**	
GIN/CI/2.1	CVT 1996 – Series IV	Pottangi, Chintapalli, Solan, Pundibari and Raigarh
GIN/CI/3	**Varietal / Evaluation trial**	
GIN/CI/3.1	Comparative yield trial (CYT I&II)	Pottangi and Solan
GIN/CI/4	**Quality evaluation trial**	
GIN/CI/4.1	Evaluation of germplasm for quality	Solan
GIN/CP/1	**Disease management trial**	
GIN/CP/1.1	Integrated management of rhizome rot of ginger	Solan, Dholi, Pundibari and Raigarh
GIN/CP/1.2	Biocontrol studies on rhizome rot of ginger	Solan
TURMERIC		
TUR/CI/1	**Genetic resources**	
TUR/CI/1.1	Germplasm collection, characterization, evaluation and conservation	Solan, Pottangi, Pundibari, Jagtial, Dholi, Kumarganj, Raigarh and Coimbatore
TUR/CI/2	**Coordinated varietal trial (CVT)**	
TUR/CI/2.1	CVT 1996 – Series IV	Pottangi, Dholi, Pundibari, Kumarganj and Raigarh
TUR/CI/3	**Varietal / evaluation trial**	
TUR/CI/3.1	Comparative yield trial (CYT)	Pottangi, Dholi and Jagtial
TUR/CI/4	**Quality evaluation trial**	
TUR/CI/4.1	Quality evaluation of germplasm/ varieties	Solan and Coimbatore
TUR/CI/4.2	Impact of environment on quality of turmeric	Solan, Pottangi, Kumarganj, Coimbatore and Dholi

Project code	Title	Centre
TUR/CM/1	**Nutrient management trial**	
TUR/CM/1.1	Response of Nitrogen and spacing on growth and yield of turmeric	Kumarganj
TUR/CM/1.2	Response of fertilizer on the yield of turmeric	Raigarh
TUR/CP/1	**Disease management trial**	
TUR/CP/1.1	Survey and identification of disease causing organisms in turmeric and screening of turmeric germplasm against diseases	Dholi, Jagtial and Coimbatore
TUR/CP/1.2	Chemical control of *Taphrina* leaf spot disease of turmeric	Jagtial, Raigarh and Pundibari
TUR/CP/1.3	Effect of seed treatment on leaf blotch of turmeric / effect of fungicides on leaf spot disease	Dholi
TUR/CP/1.4	Investigations of the causal organism of rhizome rot of turmeric and screening of biocontrol agents for the management	Jagtial
TREE SPICES		
TSP/CI/1	**Genetic resources**	
TSP/CI/1.1	Germplasm collection, characterization, evaluation and conservation of clove, nutmeg and cinnamon	Yercaud, Pechiparai, Thadiyankudisai and Dapoli
TSP/CI/2	**Coordinated varietal trial (CVT)**	
TSP/CI/2.1	CVT 1992 in clove	Yercaud, Pechiparai and Dapoli
TSP/CI/2.2	CVT 1992 in cinnamon	Yercaud, Thadiyankudisai Pechiparai, Ambalavayal,
TSP/CM/1	**Propagation / multiplication trial**	
TSP/CM/1.1	Vegetative propagation in nutmeg, clove and cinnamon	Yercaud, Thadiyankudisai, Pechiparai and Dapoli
TSP/CM/2	**Irrigation trial**	
TSP/CM/2.1	Drip irrigation in clove and nutmeg	Yercaud
TSP/CM/3	**Nutrient management trial**	
TSP/CM/3.1	Biofertilizer trial in tree spices	Yercaud

Project code	Title	Centre
TSP/CM/4	**Physiological studies**	
TSP/CM/4.1	Studies on fruit drop of nutmeg	Dapoli
CORIANDER		
COR/CI/1	**Genetic resources**	
COR/CI/1.1	Germplasm collection, description, characterization, evaluation, conservation and screening against diseases	Jobner, Jagudan, Guntur, Kumarganj, Coimbatore, Hisar, Dholi and Raigarh
COR/CI/2	**Coordinated varietal trial (CVT)**	
COR/CI/2.1	CVT 1993 – Series II	Jagudan, Jobner, Guntur, Dholi and Hisar Coimbatore,
COR/CI/2.2	CVT 1996 – Series III	Jobner, Jagudan, and Raigarh, Coimbatore, Dholi
COR/CI/3	**Varietal / evaluation trial**	
COR/CI/3.1	Comparative yield trial	Dholi and Coimbatore
COR/CI/4	**Quality evaluation trial**	
COR/CI/4.1	Quality evaluation in coriander	Jobner
COR/CM/1	***Nutrient management trial***	
COR/CM/1.1	Response of fertility levels and plant spacing on yield of coriander	Kumarganj
COR/CM/1.2	Response of coriander to micronutrients	Jobner
COR/CP/1	**Disease management trial**	
COR/CP/1.1	Survey to identify the disease incidence, collection and identification of casual organism	Dholi
COR/CP/1.2	Studies on wilt and powdery mildew management in coriander. Biocontrol of wilt in coriander.	Coimbatore
COR/CP/1.3	Studies on stemgall disease management of coriander by different fungicides	Dholi
CUMIN		
CUM/CI/1	**Genetic resources**	
CUM/CI/1.1	*Germplasm collection, characterization,* evaluation conservation and screening against diseases	Jobner and Jagudan

Project code	Title	Centre
CUM/CI/2	**Hybridisation trial**	
CUM/CI/2.1	Mutation studies and hybridisation programme in cumin	Jagudan
CUM/CI/3	**Coordinated varietal trial (CVT)**	
CUM/CI/3.1	CVT 1994 – Series II	Jobner and Jagudan
CUM/CI/4	**Quality evaluation trial**	
CUM/CI/4.1	Quality evaluation in cumin	Jobner
CUM/CI/4.2	Evaluation of essential oil of cumin	Jobner
CUM/CM/1	**Irrigation trial**	
CUM/CM/1.1	Irrigation schedule for cumin with reference to yield and blight disease	Jagudan
CUM/CM/2	**Nutrient management trial**	
CUM/CM/2.1	Integrated nutrient management in cumin	Jagudan
CUM/CP/1	**Disease management trial**	
CUM/CP/1.1	Blight disease control by manipulation of agronomic practices	Jagudan
CUM/CP/1.2	Epidemiological study of *Alternaria* blight of cumin	Jobner and Jagudan
CUM/CP/2	**Pest management trial**	
CUM/CP/2.1	Integrated management of pests and disease of cumin	Jobner and Jagudan
FENNEL		
FNL/CI/1	**Genetic resources**	
FNL/CI/1.1	Germplasm collection, characterization, evaluation, conservation and screening against diseases	Jobner, Jagudan, Hisar, Dholi
FNL/CI/2	**Hybridization trial**	
FNL/CI/2.1	Mutation studies and crossing programme in fennel	Jagudan
FNL/CI/3	**Coordinated varietal trial (CVT)**	
FNL/CI/3.1	CVT 1994 – Series II	Jobner, Hisar and Jagudan
FNL/CI/4	**Quality evaluation trial**	
FNL/CI/4.1	Quality evaluation studies in fennel	Jobner
FNL/CM/1	**Irrigation trial**	
FNL/CM/1.1	Response of *rabi* fennel to irrigation, nitrogen & phosphorus	Jagudan

Project code	Title	Centre
FNL/CM/2	**Spacing / sowing trial**	
FNL/CM/2.1	Effect of different inter and intra row spacings on yield of fennel	Jagudan
FNL/CM/3	**Nutrient management trial**	
FNL/CM/3.1	Studies on organic and inorganic source of fertilizer for sustainable productivity in fennel	Jagudan
FENUGREEK		
FGK/CI/1	**Genetic resources**	
FGK/CI/1.1	Germplasm collection, characterization, evaluation conservation and screening against diseases	Jobner, Jagudan, Coimbatore, Guntur, Hisar, Dholi and Kumarganj
FGK/CI/2	**Hybridization trial**	
FGK/CI/2.1	Evolving varieties resistant to powdery mildew through mutation breeding and crossing programme	Jagudan
FGK/CI/3	**Coordinated varietal trial (CVT)**	
FGK/CI/3.1	CVT 1995 – Series III	Coimbatore, Jobner, Guntur, Hisar, Jagudan, Dholi and Kumarganj
FGK/CI/4	**Varietal / evaluation trial**	
FGK/CI/4.1	Comparative yield trial	Coimbatore and Hisar
FGK/CM/1	**Spacing /Sowing trial**	
FGK/CM/1.1	Effect of time of sowing and spacing in fenugreek	Coimbatore
FGK/CM/2	**Nutrient management trial**	
FGK/CM/2.1	Response of fenugreek varieties to row spacing and date of sowing	Jobner
FGK/CM/2.2	Response of fertility levels and spacing on growth and yield of fenugreek	Kumarganj
FGK/CM/2.3	Response of fertilizer on the yield of fenugreek	Jagudan
FGK/CP/1	**Disease management trial**	
FGK/CP/1.1	Biocontrol of root rot in fenugreek	Coimbatore

ACRONYMS

PEP	:	Black pepper	CUM	:	Cumin
CAR	:	Cardamom	FNL	:	Fennel
GIN	:	Ginger	FGK	:	Fenugreek
TUR	:	Turmeric	CI	:	Crop Improvement
TSP	:	Tree spices	CM	:	Crop Management
COR	:	Coriander	CP	:	Crop Protection

Discipline / Crop wise distribution of technical programmes of AICRPS (1998-99)

Crop	Crop Improvement	Crop Production	Crop Protection	Total projects
Black pepper	4	2	7	13
Cardamom	6	3	3	12
Ginger	4	-	2	6
Turmeric	5	2	4	11
Tree Spices	3	2	2	7
Coriander	5	2	3	10
Cumin	5	2	3	10
Fennel	4	3	-	7
Fenugreek	4	4	1	9
Total projects	**40**	**20**	**25**	**85**

PROGRESS OF WORK AND ACHIEVEMENTS

BLACK PEPPER

PEP/CI/1 Genetic Resources

PEP/CI/1.1 Germplasm collection, characterisation, evaluation and conservation

Panniyur, Sirsi, Chintapalli, Yercaud and Dapoli

The Panniyur centre maintains 105 accessions of black pepper as field gene bank. Among these, 52 accessions flowered in the current year and 12 accessions recorded yield of above 3.5 kg/vine. The cv. *Valli* (PRS 61) registered highest berry yield (7.1 kg/ vine, green) followed by *Kottanadan* I (PRS 27, 5.9 kg.) and *Mundi* (PRS 36, 5.7kg.). In comparison, the best yielders during the past year (1997-98) were *Karimunda* III (10.2 kg/vine), *Kaniakkadan* (7.1 kg/vine) and *Kalluvally* IV (6.5 kg/ vine).

At Sirsi centre 96 accessions are being maintained including 75 cultivated and 21 wild. During the current year 23 accessions were evaluated. The lines have just commenced flowering in the current year.

The Chintapalli centre maintains 41 accessions which includes 16 cultivated and 25 wild. Among the cultivated accessions, Panniyur-1 registered the highest berry yield (8 .0 kg/vine, green).

At Yercaud, 106 accessions are being maintained. During the current year, fruit set was observed in 40 accessions and the yield was very negligible.

The Dapoli centre is maintaining nine accessions of pepper. During the year, the varieties Sreekara and Subhakara were added to the germplasm.

PEP/CI/2 Hybridisation Trial

PEP/CI/2.1. Inter varietal hybridisation to evolve high yielding varieties.

Panniyur

The trial was initiated with the objective of evolving varieties having superior yield, quality and resistance to pest and disease along with other desirable traits. The progenies obtained after sowing open pollinated and hybrid seeds are primarily screened for vegetative traits and later for reproductive traits and resistance to biotic and abiotic stress.

At present, a total of 490 OP/ hybrids, varying in age from one to

ten years, are being maintained and evaluated under this trial. During the current year, yield was recorded from 250 cultures. Culture 6797 (OP of *Uthirankotta*) gave the highest berry yield (6.3 kg/vine, green) followed by cul. 4879 (OP of *Uthirankotta*) and cul. 4847 (OP of *Uthirankotta*) with an yield of 5.6 and 4.7 kg/vine respectively .

PEP/CI/3 Coordinated Varietal Trial (CVT)

P E P/CI/3.1. CVT 1987 - Series III

Panniyur and Sirsi

This trial was laid out at Panniyur and Sirsi, to compare the performance of promising cultures with released varieties.

At Panniyur, this trial was laid out in 1990 with eight cultures/varieties and two checks. In 1998-99, *Panniyur-1* recorded the highest berry yield (5.0 kg/ vine, green) followed by *Panniyur-2* and *Panniyur-3* with 3.6 and 3.0 kg /vine respectively. During 1997-98 the highest yielder was *Karimunda* (4.7 kg /vine).

At Sirsi, the trial was laid out as an intercrop in arecanut garden during 1993 with 10 entries *viz.*, *Karimalligesara*, KS-27, KS-88, cul. 956, cul. 812, *Panniyur-1*, cul. 141, cul. 331, cul.239 and *Uddakare*. The plants have just started flowering and the yield recorded was negligible. Among the cultivars, the yield was high (626g/vine) in cul. 239, followed by *Panniyur-1* and *Uddakare*.

PEP/CI/3.2 CVT 1991 - Series IV

Panniyur, Chintapalli, Ambalavayal, Yercaud and Pampadumpara

The trial was laid out at the above mentioned centres with nine released varieties [*Sreekara* (KS.14), *Subhakara* (KS.27), *Panchami* (Acc.856), *Pournami*, *Panniyur* 1,2,3,4 and 5], four promising cultures [*Kottanadan* (Acc.2426 and 2445), cul. 1558 (OP *Kalluvally*) and cul. 5128 (OP *Cheriyakaniyakadan*)] and a check (*Karimunda*) with the objective of testing the performance of promising cultures *vis-a-vis* released varieties and local check

At Panniyur, among the 13 promising cultures planted during 1993, cul.1558 (OP *Kalluvally*) showed superiority with respect to berry yield (4.98 kg /vine) followed by *Panniyur*-4, acc. 2445, *Panchami*, *Panniyur*-5, *Panniyur*-2 and cul.5128 which were on par with cul.1558.

At Chintapalli, the trial was laid out in 1996. Nine entries started yielding during current year. Among them *Malligessara* recorded high yield (0.42 kg/vine).

At Ambalavayal ,the trial was started during 1992. The entries started yielding and *Panchami* recorded high yield (0.50 kg/vine).

At Yercaud, the trial was initiated during 1992. Six entries started yielding and yield ranged from 0.28(local) to 1.5 kg /vine (*Panniyur*-3).

At Pampadumpara, the trial was laid out in1992.The cul. 239 recorded the highest yield (1.1kg /vine) followed by *Pournami*. The cul.5128 recorded more volatile oil (4.6%) and was significantly superior to other entries.

PEP/CM/1 Irrigation Trial

PEP/CM/1.1 Irrigation cum fertilizer requirements on black pepper and arecanut in a mixed cropping system.

Sirsi

The Sirsi centre laid out a trial during 1992-93 with three irrigation levels and four fertilizer levels to study their effect on pepper and arecanut in a mixed cropping system. The treatments were imposed during May 1995 on three year old vines.

During current year, the flowering and spike setting were very poor. There was also no significant difference for yield under different irrigation levels. Whereas, significant difference in yield was observed for fertilizer levels. A fertilizer schedule of 150:60:210g NPK /vine resulted in high yield (583g/vine, green). The lack of response for irrigation is probably due to the nature of experimental plot in low-lying arecanut area and due to the shade effect.

PEP/CM/1.2 Trial on drip irrigation in black pepper

Panniyur

In order to find out the efficacy of drip irrigation on black pepper varieties, the trial was laid out during 1996 with three irrigation levels (I_o-No irrigation, I_1-Drip irrigation @ 2 l/vine/day and I_2-Drip irrigation @ 4 l/vine/day) with three varieties (*Panniyur* 1,3,5) in a factorial RBD.

The vine establishment was good under I_2 (Drip irrigation @ 4 l/vine/day). The irrigation levels did not show any remarkable effect on initial yield. However, *Panniyur*-1 registered higher yield than *Panniyur*-3 and 5.

PEP/CP/1 Disease Management Trial

PEP/CP/1.1 *Phytophthora* foot rot disease management in black pepper.

Sirsi

The Sirsi centre laid out a new trial for the management of *Phytophthora* foot rot at six locations in farmers' fields during 1996-97. There were five treatments with different fungicides and bioagents. The fungicides were applied as spray/drench and bioagents as basal.

The results from Table 1 revealed that Potassium phosphonate @ 0.3% as spray (3 l/vine) and drench (5 l/vine) twice during the season (just

before the onset of monsoon, i.e., June and second round at 35-45 days after first spray) showed least disease incidence (6.7 %) compared to control (34.4%). The next best treatment was spraying 1% Bordeaux mixture (3 l/vine) and drenching with 0.3% copper oxychloride which recorded 7.2% disease incidence.

The three years (1996 to 1999) pooled mean revealed that Potassium phosphonate @ 0.3% as spray and drench was very effective in checking the disease. The mean incidence of disease was only 5.9% as against 28.7 % in control.

PEP/CP/1.2 Biological control of *Phytophthora* foot rot of black pepper - nursery trial

Chintapalli

The Chintapalli centre laid out a biocontrol trial of *Phytophthora* during 1996-97 with four treatments *viz.*, *Trichoderma harzianum* as both soil application and spray, *T. harzianum* as soil application alone, drenching with copper oxy chloride (COC) and a control.

During the year 1998-99, the least disease incidence (4.4% in sterilised and 5.2% in unsterilised soil) was noted in plants receiving *T. harzianum* as both soil application and spray as against control (17.6% in sterilised and 20.0% in unsterilised soil).

PEP/CP/1.3 Studies on the control of nursery disease of black pepper including biocontrol.

Panniyur

To develop an effective control measure for nursery disease, an ex-

Table 1 *Phytophthora* foot rot management in black pepper at Sirsi

Treatment	Per cent disease incidence			Mean
	1996-97	1997-98	1998-99	
Control	33.9	17.8	34.4	28.7
Bordeaux mixture 1% spray and Copper oxy chloride 0.3% drench twice	8.9	6.1	7.2	7.4
Potassium phosphonate 0.3% spray and drench twice	6.7	4.4	6.7	5.9
Bioagent (*Trichoderm a viride* @ 50g/ vine + 1 kg of neem cake and 5 kg of FYM/vine	20.6	7.2	10.6	12.8
Potassium phosphonate (0.3%) spray twice and bioagent (*Trichoderma viride*) @ 50g along with 1 kg of FYM/vine	17.8	5.0	8.9	10.6
CD at 5%	2.5	3.8	3.5	3.3

periment with five treatment combinations was laid out during 1997. The treatments were T_1 - 1% Bordeaux spray and drench, T_2 - dipping in *T. harzianum*, T_3 - dipping in *T. viride*, T_4 - soil solarisation of potting mixture, T_5 -control.

During the current year, the treatments T_2 and T_3 (dipping in *T. harzianum*, *T.viride* respectively) recorded minimum rotting percentage of cuttings (7.5 and 9.0% respectively) and were on par with T_1 ie.,1% Bordeaux mixture spray and drench(12.0%).

PEP/CP/1.4 Control of *Phytophthora* disease of black pepper in farmers' field - observational trial.

Panniyur

The trial was laid out during 1996-97 at two locations *viz.*, Pepper Research Station, Panniyur and at Kunnoth Estate, Payam with the objective of developing effective and economic management practices to control *Phytophthora* disease in pepper.

There were five treatments *viz.*, T_1 - Akomin 3ml/l as spray and drench, T_2 - T_1 + biocontrol agent (*T. harzianum*) T_3 - biocontrol agent (750 g / vine) alone, T_4 - 1% Bordeaux Mixture spray and T_5 - control. The disease intensity based on leaf and branch infection and wilting of vines was recorded.

During 1998-99 all the treatments were on par at both locations and did not show any significant difference for disease incidence and wilting. The disease incidence during the year was in general insignificant.

PEP/CP/1.5 *Phytophthora* foot rot incidence in black pepper under different density in an arecanut garden

Sirsi

The Sirsi centre laid out an experiment involving different densities of black pepper (25, 50, 75 and 100% of black pepper population) in an arecanut garden during 1996-97 using the variety *Malligessara*. During the current year *Phytophthora* incidence was not observed in any of the treatments.

PEP/CP/2 Pest Management Trial

PEP/CP/2.1 Control of scale insects in black pepper

Pampadumpara

The trial could not be carried out due to scanty incidence of the pest.

PEP/CP/2.2 Survey for the incidence of insect pests in black pepper at high altitudes

Pampadumpara

This study was initiated in 1996 to survey various *Panchayats* in Idukki district. Three gardens in each *Panchayat*, with 25 vines in each

garden, were to be surveyed. The observations to be recorded are, the incidence of various insect pests, their nature of damage, severity of infestation and seasonal occurrence. During the current year survey was not conducted due to the lack of an Entomologist in position.

Closed project

PEP/CP/1.1 Management of *Phytophthora* foot rot and slow decline of black pepper

Panniyur

The experiment was laid out at Pepper Research Station, Panniyur during 1992, with the objective of evaluating newer fungicides and soil amendments for *Phytophthora* foot rot management.

There were nine treatments including control. The details are as follows:

T_1 - Absolute control without any cultural practice

T_2 - Package of practices of KAU + 1 kg neem cake + 3g a.i. Phorate / vine

T_3 - Package of practices of KAU + 1% Bordeaux mixture (BM) spray + drenching with 0.2% Copper oxychloride as first round + Ridomil MZ 72 WP (100 ppm as metalaxyl) as second round

T_4 - T_2 + Ridomil spray first + 1% BM as second round

T_5 - T_2 + 0.2% Akomin first (spray + drench) + BM spray as second round

T_6 - T_2 + BM spray first + 0.2% Akomin as second spray

T_7 - T_2 + BM spray + 0.2% Copper oxychloride drench

T_8 - T_2 + first round BM + second round Akomin + third round Ridomil

T_9 - Kavach 0.2% drench and spray (three rounds)

The experiment was laid out in RBD with three replications. There were 10 vines/plot in each replication. The treatments were imposed during pre-monsoon and post-monsoon periods. Observations on the incidence of the disease were taken as defoliation, foliar yellowing and death of vines.

The pooled data for five years with respect to defoliation, foliar yellowing and death of vines are presented in Table 2a. It is clear from the data that all the treatments included in the trial were significantly superior to absolute control (T_1). Even though treatments T_6 and T_7 recorded minimum defoliation (7% each), they were on par with T_3, T_5 and T_8.

With regard to foliar yellowing T_6, T_7 and T_5 were on par and T_6 recorded the least infection of 4.4%. Treatments T_6 and T_7 recorded the minimum vine death and they were on par. From

Table 2a *Phytophthora* foot rot and nematode disease management in black pepper at Panniyur (pooled data from 1991-92 to 1995-96)

Treatment	Defoliation (%)	Foliar yellowing (%)	Death of vines(%)
T_1	20.5	11.9	2.07(1.60)
T_2	15.8	11.3	0.67(1.08)
T_3	9.2	7.5	0.67(1.08)
T_4	11.3	8.5	0.93(1.20)
T_5	9.9	5.8	0.60(1.05)
T_6	7.0	4.4	0.13(0.79)
T_7	7.0	4.5	0.07(0.75)
T_8	9.9	6.4	0.40(0.95)
T_9	11.7	9.4	0.93(1.20)
CD at 5%	2.9	1. 5	0.10

Values in parenthesis are transformed ones

these results it may be inferred that application of 1 kg neem cake + 3g a.i. of Phorate/vine + application of 1% BM as pre-monsoon spray and spraying 0.2% Akomin as second round during the monsoon period were effective in minimising the incidence of *Phytophthora* foot rot and slow decline diseases of pepper. This may be accountable to the higher organic matter, providing a more complex biological antagonism to host pathogen. This might have resulted in the reduction of inoculum level and thereby reduced incidence of the disease.

The cost, benefit ratio of the treatments T_6 and T_7 are shown in Table 2b. It could be noted that the

Table 2b Cost of application of chemicals

Treatment	Inputs (Rs)	Cost of input (Rs)	Cost of application (Rs)	Sub total
T_6	Cultural practices	-	3.00	
	Neem cake 1 kg	6.00/vine	0.75	
	Phorate 30g/vine	3.00/vine	0.75	
	Bordeaux mixture1.5 l/vine	1.00/vine	2.00	
	Akomin 3 ml/1.5 l	0.90/vine	2.00	
	Total	10.90	8.50	19.40
T_7	Cultural practices	-	3.00	
	Neem cake 1 kg	6.00	0.75	
	Phorate 30g/vine	3.00	0.75	
	Bordeaux mixture 1.5 l/vine	1.00	2.00	
	Copper oxychloride 3 l/vine	2.40	2.00	
	Total	12.40	8.50	20.90

Cost of inputs :

Copper oxychloride/kg	= Rs.98/-	Copper sulphate/kg	= Rs.60/-
Neem cake/kg	= Rs.6/-	Lime/kg	= Rs.6/-
Phorate/kg	= Rs 48/-	Akomin 100 ml	= Rs.35.60

treatment T_6 is more economical than T_7 and from the present study it is concluded that application of 1kg neem cake + 3g a.i. of Phorate/vine together with first round spraying of 1% BM + 0.2% Akomin as second spray has resulted in minimum incidence of both *Phytophthora* foot rot and slow decline of black pepper.

CARDAMOM

CAR/CI/1 Genetic Resources

CAR/CI/1.1 Germplasm collection, characterisation, evaluation and conservation

Mudigere and Pampadumpara

The Mudigere centre maintains 245 accessions of cardamom. Based on the analysis of pooled data over seven years, the following lines have been shortlisted : EB 1277-7, P17, P8, Cl.728, Cl.692, P12, Cl.730, Cl.757 and P20. These are being multiplied for further testing under yield trials (Table 3).

At Pampadumpara, 91 accessions comprising of 77 cultivated and 14 wild types are being maintained and were evaluated for yield and quality traits (Table 4). Among the accessions, PS.29 recorded highest yield (892 g/clump, fresh wt), followed by *Manjirabad* (797g), S-1 (668g), MBP (642g) and PS-12 (627g). As regards quality, maximum volatile oil (8.0%) and oleoresin (12.2%) was observed in PS-12 followed by PS-5. With respect to pest tolerance, the acc. PS.7 showed lowest infestation to thrips (5.0%), while MCC.34 was highly susceptible (53.0%). In case of cap-

Table 3 Yield and related data of promising entries (Mudigere)

Sl.	Entries	Plant height (cms)	Number of bearing suckers	Number of panicles/ clump	Panicles length (cms)	Green capsule yield, g/clump
1.	EB 1277-7	183.3	12.0	29	55	936
2.	P-17	227.0	18.8	29	73	821
3.	P-8	196.0	17.4	24	50	539
4.	CL-728	293.0	24.0	17	73	521
5.	CL-692	291.0	18.8	26	75	512
6.	P-12	224.0	18.2	24	74	496
7.	CL-730	296.5	9.7	24	43	487
8.	CL-757	290.0	20.0	25	79	486
9.	P-20	348.0	16.0	32	55	435
10.	M-1 (ch)	220.0	10.0	19	50	389
11.	M-2 (ch)	237.0	11.0	25	66	388

Table 4 Germplasm evaluation of cardamom at Pampadumpara (1998-99)

Accession	Yield/clump		Thrips	Borer	Volatile oil	Oleoresin
	Wet weight (kg)	Dry weight (kg)	incidence (%)	infestation (%)	(%)	(%)
PS-29	0.89	0.17	32.0	0.0	7.7	10.8
Manjirabad	0.80	0.13	10.0	0.0	6.6	10.2
S-1	0.68	0.13	22.0	0.0	6.8	10.5
MBP	0.64	0.13	10.0	0.0	6.2	10.0
PS-12	0.63	0.13	22.0	0.0	8.0	12.2
PS-7	0.62	0.12	5.0	0.0	6.7	10.5
MCC-34	0.65	0.12	53.0	0.0	6.7	10.5
PS-27	0.57	0.12	22.0	2.0	6.3	10.2
Veeraputhran	0.49	0.09	18.0	1.0	7.8	11.2
PS-5	0.46	0.09	9.0	0.0	8.0	12.0

sule borer, except PS-27 and *Veeraputhran* none of the accessions had the infestation.

CAR/CI/2 Hybridisation and Selection

CAR/CI/2.1 Evaluation of synthetics

Mudigere

Earlier studies carried out at Mudigere revealed that improvement in yield of cardamom could be more effectively achieved by utilising the promising clones in a polycross and selecting the progeny with better performance by conducting polycross progeny test. Thus a trial was planned to grow promising clones in a polycross, and on the basis of general combining ability, to lay out a restricted progeny test to isolate progenies with higher yield. Seven promising clones were thus planted in 1996 in a polycross system. The clones are Cl-691, Cl-692, Mudigere-1, Mudigere-2, SKP-14, Sel.800 and HS-1. Based on the general combining ability as reflected in yield, a restricted polycross nursery was made to isolate the progenies with higher yield potential through subsequent progeny testing.

During the current year seeds (Syn.I.) were collected from the clones and nursery had been raised. The vigorous seedlings selected from this nursery will be planted in the next season for yield testing.

CAR/CI/3 Coordinated Varietal Trial (CVT)

CAR/CI/3.1 CVT 1998 - Series II

Pampadumpara

The trial was relaid out during 1994 with 10 accessions *viz.*, Cl.679,

Sel.800, M.1, Sel.112, Sel.262, Cl.726, Cl.683, SKP.51, SKP.14 and PV.1 as per the decision of XII AICRPS Workshop.

During the current year, the variety M-1 recorded more capsule yield (301g/clump, fresh) than other accessions. The Cul.679 was less susceptible to thrips (3.6% incidence) and SKP-51 was highly susceptible (13.0%).

CAR/CI/3.2 CVT 1991- Series III with Malabar Type

Mudigere, Appangala and Sakleshpur

As per the decision of XI AICRPS Workshop at Trivandrum, the Coordinated Varietal Trial of promising cardamom clones of Malabar type with 14 entries was laid out during 1992 at the above mentioned centres. As the trials were vitiated, due to damages caused by wild animals, it was decided (in the XIV AICRPS Workshop) to relayout the trial at Mudigere and Sakleshpur.

At both centres, the trial was relaid out with 14 entries *viz.*, Cl.679, Cl.726, Cl.683, HSI.1, M.1, CCS-800, CCS-872, CCS-893, SKP-14, SKP-21, SKP-72, SKP-100, MCC-34 and PV-1during 1992. The trial is in progress. The observations on growth characters did not show any significant difference among the clones .

CAR/CI/3.3 CVT 1991-Series III with Mysore Type

Mudigere, Appangala, Sakleshpur and Myladumpara

This trial was also decided (in the XIV AICRPS Workshop) to relayout at the centres where it got vitiated.

At Mudigere, the trial was relaid out with five entries *viz.*, MCC-12, MCC-21, MCC-61, MCC-85 and SKP-51 along with local check in 1998. The crop growth is satisfactory.

At Sakleshpur, the trial was planted in 1996. Growth and morphological characters were recorded and were mostly non-significant, except in the case of plant height for which MCC-85 was superior to others. Yield was negligible. Capsule characters were recorded. In MCC-12, 39.3% of capsules fall in > 8mm class.

At Myladumpara, the trial was laid out in 1992. Pooled data indicated that MCC-21 performs well with regard to yield contributing characters such as number of bearing tillers, panicles/clump and racemes/ panicle. The projected yield is highest for MCC-85 (380 kg/ha) closely followed by MCC-21 (375 kg/ha). The other clones are poor performers. The inference that can be drawn is that the Malabar types in general are less suitable to the Idukki conditions.

CAR/CI/4 Varietal / Evaluation Trial

CAR/CI/4.1 Yield evaluation of promising cardamom selections – 1997

Mudigere

To improve the yield of cardamom through evaluation of open pollinated seedling progenies of promising clones, a diallel cross was carried out at this centre, but did not yield better hybrids. From the progenies, 23 promising clumps were identified and they were multiplied. The best four clones were planted during July 1997 along with Mudigere 1 and 2. As the trial was damaged by wild animals, it was relaid out with 14 promising seedling progenies during July 1998. The crop growth is satisfactory.

CAR/CM/1 Nutrient Management Trial

CAR/CM/1.1 Effect of fertilizer on the yield of cardamom.

Mudigere and Pampadumpara

The trial was initiated for evaluating the response of cardamom to various levels of NPK.

At Mudigere, the trial was laid out during 1992 using Mudigere-1 and with graded levels of fertilizer (T_1-0:0:0, T_2-38:38:75, T_3-75:75:100, T_4-100:100:175, T_5-125:125:200, T_6-150:150:225 kg NPK/ha).

The results from Table 5 indicated that fertilizer application significantly influenced the yield. Increasing dose of fertilizer resulted in increased capsule yield. However, the yield (684 kg/ha) recorded under recommended dose (75:75:150 kg NPK/ha) was on par with other dozes. Similar trend was observed during last year also.

Table 5 Effect of different levels of NPK on capsule yield in cardamom at Mudigere

Treatment	Yield kg/ha		
	1997	1998	Mean
T_1 0:0:0	163	464	315
T_2 38:38:75	181	572	378
T_3-75:75:150	284	684	484
T_4 100:100:175	294	742	513
T_5-125:125:200	302	734	518
T_6-150:150:225	280	786	533
CD at 5%	41	93	

At Pampadumpara, the experiment was laid out in 1994 with six levels of fertilizer (T_1 - 0:0:0, T_2 - 75:75:150, T_3 - 100:100:175, T_4 - 125:125:200, T_5 - 150:150:225, T_6 - 75:75:150 + 0.5 kg neem cake/clump) and using cv. PV-1.

The plants that received NPK @ 75:75:150 kg/ha + 0.5 kg neem cake /clump recorded higher yield (210 g/ clump, fresh wt) than T_2 and T_3 treatments. Last year, the best yield (938.3 g) was given by the treatment 100:100:175 kg/ha NPK. The number

of panicle and length of panicle were highest in plants receiving NPK @ 125:125:200 kg/ha.

CAR/C M/1.2 Influence of micronutrients on yield of cardamom

Mudigere and Pampadumpara

To study the influence of micronutrients (Boron, Zinc and Molybdenum) on yield of cardamom, this trial was laid out at Mudigere and Pampadumpara.

At Mudigere, the trial was laid out in 1992 using M1 suckers with seven treatments *viz*, Borax @ 10 and 20 kg/ha as soil application, 0.2% foliar spray, Molybdenum @ 0.25 and 0.5 kg/ha as soil application, Borax 10kg + Molybdenum 0.25 kg/ha and control.

Response of cardamom to micronutrients was significant. Both Boron and Molybdenum independently and in combination increased capsule yield. A higher yield of 476 kg/ha (fresh wt) was obtained under Borax 20 kg/ha as soil application compared to control (376 kg/ha). However, among the varieties there was no significant difference as in the previous year.

At Pampadumpara, the trial was laid out during 1996 with various levels of Boron, Molybdenum and Zinc (Borax @ 10 and 20 kg/ha as soil application, 0.2% spray, Molybdenum @ 0.25 and 0.5 kg/ha as soil application, Borax 10kg + Molybdenum 0.25 kg/ha, Zinc sulphate 0.25% spray, Borax 10 kg/ha + Molybdenum 0.25 kg/ha + Zinc sulphate 0.25% spray, and control) using *cv.* PV1.

As the trial was vitiated due to drought during last year (1997-98), it was relaid out during the current year in a new area having irrigation facility.

CAR/CM/1.3 Trial on integrated nutrient management

Mudigere and Pampadumpara

At Mudigere, this trial was laid out in 1994 with six treatments (Table 6). During the first year harvest (1996) there was no significant difference among treatments, and it was concluded to be due to the inherently high soil fertility. In 1997 and 1998, 100% inorganic fertilizer (T_5) gave highest yield (707 and 760 kg/ha respectively) and were significantly above the 100% organic fertilization. 100% organic manuring (534 kg/ha) was on par with control (480 kg/ha). The results indicated that pure organic manuring cannot replace inorganic fertilizer application and that for higher productivity inorganic fertilizer application is necessary.

Table 6 Effect of organic and inorganic manures on yield of cardamom at Mudigere

Treatment	Capsule yield (green) kg/ha			
	1996	1997	1998	Mean
T_1 –100% organic manure (OM)	708	479	534	574
T_2 75% OM + 25% inorganic manure (IM)	765	624	606	665
T_3 50% OM + 50% IM	710	602	684	665
T_4 25% OM + 75% IM	716	609	744	688
T_5 –100% IM	840	707	760	769
Control (no manure)	685	400	480	522
CD at 5%	NS	81	189	

CAR/CP/1 Pest Management in Cardamom

CAR/C P/1. 1 Evaluation of plant based insecticides for the control of thrips and borer in cardamom

Mudigere

Two trials were carried out to study the efficacy of plant based (neem) insecticidal formulations. In the first trial, five neem based formulations (Neem cake, NSKE, Neemgold, Nimbecidin, Bioneem) were tested in combination with Monocrotophos (one spray). Here Monocrotophos was the first spray followed by the various neem formulations and an absolute control. In the second trial, each treatment consists of three applications each of the neem based formulations (NSKE, Neem cake, Neemgold, Nimbecidin, Bioneem, Neemark) and the efficacy was compared with Monocrotophos - Phosalone-Phosalone (recommended practice) and an absolute control. In both trials, the results were very inconsistent during the current year and also as in the previous years. All neem based products were on par, and they in turn were on par with the recomm-ended treatment schedule (Table 7a, b).

CAR/CP/1.2 Estimation of quantitative and qualitative loss due to thrips damage in cardamom.

Mudigere

To assess the capsule damage and yield loss due to thrips, the harvested and dried capsules were grouped into four categories based on the extent of surface area scabbed as 0=no damage, 1=upto 10% scabbed area, 2=11 to 33% scabbed area and 3=>33% scabbed area.

The weight of 100 capsules in each category indicated a significant loss in weight with increase in

Table 7a Evaluation of plant based insecticides for the control of thrips and borers in cardamom

Sl.No.	Treatments	%thrips damage	Green capsule yield (g/plot)	Green capsule yield (g/plant)
1.	Monocrotophos-Neemcake-Neemcake	6.960	1364.7	113.7
2.	Monocrotophos-Phosalone-Phosalone	4.673	958.8	79.8
3.	Monocrotophos-Phorate-Phosalone	6.420	1175.3	97.9
4.	Monocrotophos-Endosulfan-Endosulfan	4.097	1487.5	123.9
5.	Monocrotophos-KSKE-Neekgold	9.860	17.8	118.1
6.	Monocrotophos-Bioneem-Neemgold	8.187	1363.2	113.6
7.	Monocrotophos-NSKE-Nimbecidin	6.197	1488.2	124.0
8.	Monocrotophos-Neemgold-Nimbicidin	6.467	1497.2	124.8
9.	Monocrotophos-Bioneem-Nimbicidin	6.563	1636.0	136.3
10.	Control	6.830	1369.5	114.1

Note : 12 plants per plot.

Table 7b Evaluation of plant based insecticides for the control of thrips and borers in cardamom

Sl. No.	Treatments	% thrips damage	Green capsule yield (g / plot)	Green capsule yield (g / plant)
1.	Monocrotophos-Neemcake-Neemcake	15.462	510.0	63.7
2.	NSKE-NSKE-NSKE	18.077	212.9	26.6
3.	Nimbicidin- Nimbicidin- Nimbicidin	21.915	194.2	24.3
4.	Neemgold- Neemgold- Neemgold	16.915	208.4	26.0
5.	Neemark-Neemark-Neemark	17.187	281.1	35.1
6.	Bioneem-Bioneem-Bioneem	23.107	173.6	21.7
7.	Monocrotophos-Phosalone-Phosalone	14.953	218.7	27.3
8.	Control	13.512	117.5	14.7

Note : 8 plants per plot.

thrips damage. A random sample of harvested produce would have 20.3% capsule in the category-1, 7.8% in the category -2, and 7.5% in category-3 amounting to nearly 35% of the produce. From the study it was worked out that for an average yield of 250 kg/ha of dry capsule, the loss in weight due to thrips damage would amount to 15.3 kg/ha in addition to the market price loss. Reduction in capsule weight, husk weight, number of healthy seeds/capsule and oil content were also reduced as a result of thrips damage.

CAR/CP/1.3 Bioecology of natural enemies of major pests of cardamom

Mudigere

Thrips, shoot and capsule borers are the major insect pests of cardamom crop, and the present project was proposed for studying the natural enemies of the above insect pests under the cardamom ecosystem existing in the Mudigere region. Thrips occupy a concealed niche between leaf sheath and hence become unavailable for common predators. However, spiders in the cardamom ecosystem, larvae of *Chrysopa* sp. and certain unidentified predatory insects were observed to be the feeders on mites, but they seem to have little value as biocontrol agents. No parasites have been recorded.

The larvae of *Conogethus punctiferalis* under field condition was parasitised by an ichneumonid parasite *Xanthopimpla sp.* A bacterium was found to infect the larvae of *C. punctiferalis.* This bacterium was isolated and is being studied in detail.

GINGER

GIN/CI/1 Genetic Resources

GIN/CI/1.1 Germplasm collection, characterisation, evaluation and conservation

Solan, Pottangi, Pundibari, Kumarganj, Dholi, and Raigarh

The Solan centre maintains 176 germplasm accessions and were evaluated for growth and yield performance. During the year, the yield of promising collections ranged from 4.5 to 7.5 kg/3m^2 bed. The accessions *viz.*, BDJR.1226, Jamaica and BLP.6 recorded highest yield with less disease incidence (Table 8&9).

Fifteen accessions are being maintained at Pundibari centre. Out of 11 entries evaluated, Acc. GCP. 12, GCP.1, GCP. 8, GCP. 15 and GCP.9 are promising for yield.

At Dholi, 27 acc. are being maintained and evaluated for yield and various agronomic traits. The Kumarganj centre maintains 10 accessions and Raigarh maintains 18 accessions.

The Pottangi centre is maintaining 165 accessions. During the reported year, five new collections from Khandamal and Koraput areas were added to the germplasm. Out of 155 accessions evaluated, the accessions PGS-433 (7.8 kg/3m^2), V_5E_5-4 (7.7kg/3m^2) and PGS-17 (7.7kg/m^2) were the top yielders.

GIN/CI/2 Coordinated Varietal Trial

GIN/CI/2.1 CVT 1996 - Series IV

Pottangi, Chintapalli, Solan, Pundibari and Raigarh

The CVT 1996, consisting of six entries (V_1E_8-2, V_1S_1-8, V_3S_1-8, Suprabha, SG-554 and Acc.64) from Pottangi, Solan, Jagtial and IISR

Table 8 Performance of ginger germplasm at Solan

Character	Range	Name & value of the promising collection
Survival %	33.3-97.7	*Juggijan* (97.7), BLP-5(95.5), 24/95(95.5), BLP-1(93.3), SG-726(93.3), *Ern a d* (91.1), SG-672(91.1), MNCH/95 (91.1), V_1S_1-2 (91.1) and BDJR 1226 (88.8)
Tillers per plant	2.8-5.7	SG-690 (5.7), SG-721 (5.6), SG-711(5.5), *Ern a d* (5.4), BDJR 1088 (5.2), SG 703(5.0), BLP-3(4.8), SG-670 (4.7), SG-706(4.6) and SG-54(4.4).
Pseudostem length (Plant height)cm	20.2-58.6	*Charn a* (58.6), SG-690 (58.0), SG-670 (57.3), Jamaica (56.6), BDJR 1080 (56.5), BDJR 1226 (56.6), BDJR 1142 (55.1), SG 61(54.9), SG-672 (54.1) and BDJR 1018 (53.4).
Yield per plant(g)	62-145	BDJR 1142 (145), BLP-6(145), BDJR 1088 (143), China 3(138), 40/95(138), SG-724 (136), Jamaica (135) SG723 (135), *Ern a d* (133) and BDJR 1026 (132)
Yield per plot (kg)	1.2-7.5	BDJR 1226 (7.5), Jamaica (6.8), BLP-6(6.2), BLP-1(5.5), SG 706 (5.2), SG 723 (5.1), 40/95 (5.0), SG 718 (4.6), BLP-5(4.5) and SG 701 (4.5).

Table 9 Performance of promising collection for disease resistance and quality attributes at Solan

Collection	Disease incidence (%)	Dry matter (%)	Essential oil (%)	Oleoresin (%)
BDJR 1226	10.5	17.0	2.0	8.1
Jamaica	12.4	17.6	1.0	5.4
BLP-6	12.0	20.0	2.8	7.5
BLP-1	16.4	20.0	2.8	7.5
SG-706	16.4	24.0	1.5	5.4
SG-723	17.0	19.0	2.8	7.4
40/95	17.0	22.0	2.0	6.8
SG 718	20.5	20.0	2.0	5.6
BLP-5	21.0	22.4	2.0	5.5
SG-701	22.4	16.8	1.5	8.0

Calicut was laid out at the above co-ordinating centres (Table 10).

The Pottangi centre laid out the trial with the above mentioned accessions in an RBD with four replications during 1998-99. The yield difference was not significant. The accession V_1E_8-2 registered the highest yield (18.2kg/3m^2) followed by V_3S_1-8 (13.4kg) and V_1S_1-8 (13.2kg). The mean performance of accessions evaluated for three years presented in Table 11 revealed that the accession V_1E_8-2 was the best yielder (11.6kg/3m^2) followed by V_3S_1-8 (10.1kg/3m^2).

At Solan, the trial was laid out for the second time with six accessions during 1998. The acc.V_3S_1-8 recorded highest yield (5.2 kg /3m^2) and was

Table 10 *Comparative yield performance of ginger varieties under CVT (1998-99) at AICRPS Centres*

Variety	Yield kg/3m^2			
	Solan	Chintapalli	Pundibari	Raigarh
SG-554	4.9	5.0	*	11.5
Suprabha	4.4	*	*	*
V3S1-8	5.2	8.0	7.3	16.0
V1S1-8	4.7	2.8	9.6	16.0
V1E8-2	5.0	6.3	*	11.1
Acc.64 (Varada)	4.8	7.5	9.1	14.8
Check			11.0 (Garubathan)	8.5 (Local)
CD at 5%	0.49	NS	1.7	22.1

*complete data not provided

Table 11 Performance of ginger accessions under CVT at Pottangi (1996-97 to 1998-99)

Sl.No.	Cultivars	1996-97	1997-98	1998-99	Mean yield (kg/3m^2	Projected yield (t/ha)
1	V_3S_1-8	3.920	12.889	13.448	10.086	25.21
2	V_1E_8-2	6.388	10.202	18.247	11.612	29.03
3	ACC-64	5.188	9.324	12.361	8.958	22.39
4	V_1S_1-8	4.125	10.347	13.222	9.231	23.08
5	Suprabha	5.416	8.622	8.313	7.450	18.63
6	SG-554	5.572	7.322	11.475	8.123	20.31
	CD at 5%	N.S.	1.47	N.S		

Results : V_1E_8-2 (29.03 t/ha) was the highest yielder followed by V_3S_1-8 (25.21 t/ha)

on par with SG-554, V_1E_8-2 and Varada (Acc.64). The top positions were occupied by the following accessions: best dry recovery (23.4%) in V_1E_8-2; essential oil (2.0%) in SG-554 and acc.64; oleoresin content (6.7%) in V_1S_1-8. During the first year of this trial highest yield was recorded for SG-554 (5.5 kg/3m^2) which was on par with Varada (Acc.64).

The Pundibari centre laid out the trial with five accessions *viz*., SG-536, V_1S_1-8 , Acc.64, V_3S_1-8 and *Garubathan* as check during 1998-99. During the year, the check recorded significantly higher yield (11.0 kg/3m^2) than all other accessions tested. The pooled mean over three years (1996-97 to 1998-99) also showed that the check recorded significantly higher yield (12.1 kg/3m^2) than other accessions.

At Chintapalli, the trial was laid out with five collections (SG.554, Acc.64, V_3S_1-8 , V_1E_8-2 and V_1S_1-8). The acc. V_1S_1-8 registered highest yield (8.0 kg/3m^2) followed by Acc.64 (7.5 kg/3m^2). The number of tillers per clump was high (4. 7) in V_1S_1-8 followed by V_3S_1-8 (4.1). However, the results are non-significant.

The Raigarh centre laid out the trial with six accessions in 1996. During current year, the accessions such as V_1S_1-8 and V_3S_1-8 registered significantly higher yield (16.0 t/ha). The local check recorded 8.5 t/ha. The mean yield performance over two years (1997 and 1998) indicated that the acc.64 (Varada) was the highest yielder (17.5 t/ha) followed by V_3S_1-8 (17.4 t/ha) and V_1S_1-8 (13.5 t/ha).

GIN/CI/3 Varietal Evaluation Trial

GIN/CI/3.1 Comparative yield trial (CYT I & II)

Pottangi and Solan

At Solan, this trial included six collections (SG.711, PGS.23, SG.695, BDJR.1130, BDJR.1179 and check – SG.666) and was laid out for the second time. The yield difference was not significant among the collections. However, two collections *viz*., BDJR.1130 and BDJR.1179 gave comparatively higher yield (6.8 and 6.4 kg/3m^2 respectively) than check (6.1 kg/3m^2). With respect to quality parameters highest oleoresin (8.0%), dry matter (21.5%) and essential oil (2.0%) were recorded in SG.711, PGS.23 and BDJR.1179 respectively.

In CYT-II at Solan, six collections *viz*., SG.699, SG.682, *Thaffingiva*, SG.680, SG 710 and SG.666 were evaluated. The pooled mean over two years showed that *Thaffingiva* recorded slightly higher yield (6.5 kg/3m^2) than check (6.0 kg/3m^2) but the yield differences were non significant. The acc. SG.682 and SG.699 performed better for quality.

At Pottangi, the CYT was laid out with six accessions viz., V_1E_8-2, V_1S_1-8, V_1C-8, V_3S_1-8, SG.666 and Suprabha in RBD with four replications during 1998-99. The accessions differed significantly for yield and related traits. During the current year the best yielder was V_1S_1-8 with 19.8 kg/3m^2 followed by V_1E_8-2 (18.8 kg/3m^2). The mean yield performance for three years is given in Table 12. The projected yield is highest for V_1E_8-2 (32.8 t/ha) closely followed by V_3S_1-8 (29.1 t/ha).

GIN/CI/4 Quality Evaluation Trial

GIN/CI/4.1 Evaluation of germplasm for quality

Solan

Sixtytwo collections were analysed for quality parameters like dry matter, oleoresin and essential oil contents. The results indicated that dry matter content varied from 17.1% (SG.80) to 26.0% (*Lajhan*), essential oil from 1.25% (SG.710 and PGS.23) to 2.75% (SG.723 and BLP.6) and oleoresin from 4.5% (*Kindi*) to 8.3% (*Chanog* II). Accessions *Lajhan*, No.45/95 and *Shilli Bangi* (for dry matter content), BLP.6, SG.723 and SG.687 (for essential oil), and *Chanog* II, BDJR.1126 and BDJR.1262 (for oleoresin) are promising for quality. (Table 13).

GIN/CP/1 Disease Management Trial

GIN/CP/1.1 Studies on control of rhizome rot of ginger.

Solan, Dholi, Pundibari and Raigarh

At Solan, an experiment consisting of eight treatment combinations was laid out during 1997 in RBD with three replications. Observations on rhizome emergence, incidence of rhizome rot and yield were recorded.

The results from Table 14 indicated that the sprouting was highest (97.1%) during 1997, when they were treated

Table 12 Comparative yield performance of ginger in CYT at Pottangi

Sl.No.	Cultivars	1996-97	1997-98	1998-99 yield	Mean yield (kg/3m^2)	Projected yield (t/ha)
1	V_1E_8-2	7.45	13.11	18.84	13.14	32.84
2	V_1S_1-8	6.42	10.33	11.30	9.35	23.38
3	V_1C-8	4.99	10.58	8.90	8.16	20.39
4	V_3S_1-8	5.16	9.91	19.79	11.62	29.06
5	SG-666	3.46	8.54	8.61	6.87	17.17
6	Suprabha	3.61	8.16	9.60	7.12	17.81
	CD at 5%	2.52	1.16	8.22	3.97	9.92

Table 13 Evaluation of ginger germplasm for quality at Solan

Accession	Dry matter(%)	Essential oil (%)	Oleoresin (%)
Thaffingiva	17.5	1.5	7.0
No.45/95	25.2	2.0	6.4
SG-666	17.3	1.3	5.3
BDJR-1134	15.0	1.5	7.3
SG-672	20.2	1.5	5.7
SG-682	20.2	1.5	7.1
SG-695	18.6	1.5	7.3
BDJR-1149	18.0	2.0	6.1
Kali Chanog	17.6	2.3	7.0
Shilli Bangi	24.8	2.0	6.0
Ernad	21.2	2.0	6.0
BDJR-1230	18.5	1.5	5.6
BLP-8	20.4	1.8	7.2
SG-723	19.0	2.8	7.8
BLP-6	20.0	2.8	7.5
V_1E_4-4	18.8	2.3	6.3
Kindi	22.0	2.0	4.5
Juggigan	22.0	2.5	6.8
V_1E_8-2	23.4	1.5	6.0
R4	18.0	1.5	5.1
SG-711	17.8	1.5	8.0
Lajhan	26.0	1.5	7.3
BDS-9/93	21.0	2.0	7.6
SG-710	18.0	1.3	7.6
R3P3	24.6	2.0	8.0
SG-69	19.0	1.5	7.7
Chanog-II	19.0	2.5	8.3
No.12/95	20.0	2.0	7.1
No.22/95	20.0	1.8	7.4
Wynad	23.6	2.0	7.4
PGS-23	21.5	1.3	5.1
BDJR-1191	21.6	1.5	6.0
BLP-5	22.4	2.0	5.5
BDJR-1179	20.8	2.0	5.5
SG-680	17.1	1.3	5.1

Accession	Dry matter(%)	Essential oil (%)	Oleoresin (%)
SG-692	22.4	2.0	6.7
SG-706	24.0	1.5	5.4
SG-62	21.6	1.5	5.2
BDJR-1267	23.0	2.0	6.2
SG-686	18.8	2.0	7.2
SG-503	21.2	1.5	5.2
BDJR-1226	17.0	2.0	8.1
Jamaica	17.6	1.0	5.4
SG-700	20.0	1.8	5.8
Chanan	24.0	1.5	6.1
SG-687	23.0	2.8	7.4
BDJR-1262	23.6	2.5	8.0
SG-724	23.6	1.8	6.7
SG-707	20.8	2.5	7.0
SG-704	20.0	2.0	6.7
SG-709	23.6	1.8	6.4
V_1S_1-3	23.0	1.5	6.7
SG-713	22.0	2.0	6.6
No.44/95	19.2	2.0	7.4
SG-568	24.0	2.0	7.5
SG-683	20.0	1.5	6.2
C2T2	22.0	2.0	7.6
SG-624	22.4	2.5	7.1
Acc.64	20.0	2.3	6.1
SG-688	22.0	2.0	6.2

with Dithane M.45 (0.25%) + Bavistin (0.1%) for 60 minutes along with soil application of Thimet 10g (12 kg/ha). Whereas, during the current year, the treatment T_4 (Farmers' practice + Rhizome treatment with Dithane M.45 (0.25%) + Bavistin (0.1%) + Chlorpyriphos (0.2%) + Chlorpyriphos spray (0.1%) two months after planting) recorded the highest sprouting (98.2%).

Mean data of two years revealed that the treatment T_2 (Dithane M.45 (0.25%) + Bavistin (0.1%) + Thimet 10G @ 12 kg/ha) recorded the highest sprouting (92.5%) with less disease incidence (9.9%) and was on par with T_4 for yield (10.5 kg/3m^2).

At Dholi, to study the effect of seed treatment in control of soft rot of ginger, a trial was laid out with five treat-

ments (Ridomil MZ @ 3g/l , Indofil M.45 2g/l, Bavistin 1g/l, Indofil M.45 2g + Bavistin 1g/l, Blitox 2g/l) along with a control.

The results showed that the disease incidence was lowest (13.5%) in rhizomes treated with Ridomil MZ @ 3g/l for one hour. The next best treatment combination was Indofil M.45 @ 2g + Bavistin 1g/l which recorded a disease incidence of 26.6%.

At Pundibari a trial with 10 treatment combinations [Indofil M.45 2g, Ridomil 1.5g, Akomin 2.0ml, Sun Agro Monas (*Pseudomonas fluorescens*) 2g, Aliette (Fosetyl AL) 1g, Bordeaux mixture 1.0%, Sun Agro Dema (*Trichoderma viride*) 2g, seed treated control and control without seed treatment] was laid out during 1997-98 for the management of rhizome rot of ginger. The lowest disease incidence (7.5%) was recorded under Indofil M.45 treatment. During the current year the experiment was abandoned as the pathogenicity of the disease occurring in the region could not be established.

At Raigarh, a trial having seven treatment combinations was laid out during *kharif* 1997 and 1998 in RBD with three replications, for the management of rhizome rot of ginger. The results from Table 15 revealed that in both the years fungicide applications significantly reduced the disease incidence and higher yield was recorded in treated plots. During current year the yield recorded was very low compared to last year. The treatment neem cake (5%) recorded high yield (3.0 kg/3m^2) which was followed by Mahua cake @ 5% (1.7 kg/3m^2) as against (0.46 kg/3m^2) in control. The same treatment recorded the lowest disease incidence (11.0%) as against control (24.3%). The mean performance of two years data also indicated that the treatments *viz*., Neem cake @ 5% and Mahua cake @ 5% were not only effective in control of rhizome rot (7.3 and 8.8% incidence respectively) but recorded highest yields (7.5 and 6.5 kg/3m^2 respectively) in contrast to control plots (27.7% incidence and yield of 2.2 kg/3m^2).

GIN/ CP/1.2 Biocontrol studies on rhizome rot of ginger

Solan

The objective of this trial is to develop a suitable control measure using biocontrol agents in combination with chemical fungicides such as Dithane and Bavistin for the control of ginger rhizome rot. The trial was laid out during 1998 with seven treatment combinations [T_1 - *T. harzianum* - cow dung slurry rhizome treatment (0.5%); T_2 - cow dung slurry treatment alone (0.7%), T_3 - T_1 + *Trichoderma* soil application (250g/plot); T_4 - T_1 + Dithane M.45 (0.25%) + Bavistin (0.1%) slurry treatment; T_5-

Table 14 Integrated management of rhizome rot of ginger at Solan

Treatment	Emergence (%)			Disease incidence(%)			Yield/plot(kg)			Mother rhizome recovery	
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998
T_1	83.1	80.3	81.7	19.1	27.3	23.2	7.3	8.4	7.9	0.9	1.1a
T_2	97.1	87.9	92.5	5.6a	14.1	9.9	10.8	10.2	10.5	1.6a	1.4a
T_3	90.5	79.3	84.9	9.3c	30.2	19.8	10.1c	8.5	9.3	1.2	1.2
T_4	83.1	98.2	90.7	17.6	17.8a	17.7	9.9	11.1	10.5	0.9	1.5
T_5	82.2	91.1	86.7	18.5	15.0b	16.8	11.8	9.2	10.5	0.9	1.2
T_6	73 8	86.9	80.4	28.4	15.0b	21.7	8.1	7.9	8.0	0.7	1.1
T_7	83.1	85.9	84.5	18.4	16.7	17.6	9.4	9.0	9.2	1.0	1.2
T_8	94.3	88.0	91.2	6.5b	18.0	12.3	9.8c	8.7	9.2	0.8	1.1
CD at 5%	3.7	0.7		0.4	0.5		0.5	0.6		0.2	0.2

T_1 - Farmers' practice (control but rhizome selection)

T_2 - T_1 + rhizome treatment with Dithane M45 (0.25%) + Bavistin 0.1% + Thimet 10G soil application (12 kg/ha)

T_3 - T_1 + Rhizome treatment with Chloropyriphos (0.2%) + Chloropyriphos (0.1%) spray after two months of planting

T_4 - T_1 + Rhizome treatment with Dithane M45 (0.25%) + Bavistin 0.1% + Chloropyriphos (0.2%) + Chloropyriphos (0.1%) spray two months after planting

T_5 - T_4 + 50% N (50 kg/ha)

T_6 - T_4 + 100% N (100 kg/ha)

T_7 - T_4 + 50% NPK (50:25·25 kg/ha, ½ N, full P and K as basal and remaining ½ dose of N as top dressing in two splits)

T_8 - T_4 + 100% NPK (100:50:50 kg/ha ½ N, full P and K as basal and remaining ½ dose of N as top dressing in two splits)

Table 15 Effect of fungicides on control of rhizome rot of ginger at Raigarh

Treatment	Rhizome rot incidence (%)			Yield (kg/3m²)		
	1997	1998	Mean	1997	1998	Mean
Control	31.1	24.3	27 7	3.8	0.5	2.2
Blitox-50 (0.3%)	13.3	25.3	19.3	5.6	1.3	3.5
Mancozeb (0.3%)	14.4	22.0	18.2	8.0	1.3	4.7
Ridomil (200ppm)	11.1	21.7	16.4	8.4	0.9	4.6
Topsin (0.1%)	11.1	22.7	16.9	8.9	1.0	4.9
Neem cake (5%)	3.3	11.3	7.3	12.5	3.0	7.5
Mahua cake (5%)	6 7	11.0	8.8	11.4	1.7	6.5
Saw dust (5%)	7.8	13.3	10.5	6.9	0.9	3.9
CD at 5%	5.7	6.6		2.5	1.2	

Table 16 Biocontrol on rhizome rot of ginger at Solan

Treatment	Emergence %	Disease incidence %	Rhizome yield kg/3m²	Mother rhizome recovery
T_1	86.5	10.4	5.4[a]	0.92[a]
T_2	83.5	19.3	2.8	0.72
T_3	77.6	12.4	4.5[b]	0.88
T_4	78.7	18.8	3.0	0.68
T_5	83.5	11.3	5.2	0.92[a]
T_6	74.2	14.6	3.3	0.72
T_7	79.2	20.9	2.6	0.62
CD at 5%	0.29	0.02		

Glomus mosseae soil application; T_6 - *G. heterosporum* soil application; T_7 - control].

The results from Table 16 showed that *T. harzianum* - cow dung slurry rhizome treatment recorded highest rhizome emergence (86.5%) with least disease incidence (10.4%) and with more yield (5.4 kg/3m²). In contrast, the yield was low (2.6 kg/3m²) and disease incidence was high (20.9%) in control plots.

TURMERIC

TUR/CI/1 Genetic Resources

TUR/CI/1.1 Germplasm collection, characterisation, evaluation and conservation

Solan, Pottangi, Pundibari, Jagtial, Dholi, Kumarganj, Raigarh and Coimbatore

The Solan Centre is maintaining 172 accessions and they were evaluated for yield and associated traits. The yield ranged from 2.2 to 8.3 kg/3m² and the yield of promising collections ranged from 4.5 to 7.5 kg/3m². The promising collections for yield are BDJR.1226, Jamaica, BLP-6, BLP-1, SG.706 and SG.723 with above 5.0 kg./3m² (Table 17).

The Pottangi centre maintains 207 turmeric accessions which includes three new collections from Kandhamal and Rayagoda areas of Orissa. One hundred and seventyfive accessions were evaluated during the current year. Among the 155 *Curcuma longa* accessions, PTS-5 (15.1kg/3m²) and STS.10 (14.5kg/3m²); among 17 *C. aromatica* accessions *Chayapasupu* II (11.5kg/3m²) and *Kalarmanar* (10.0kg/3m²) and among three accessions of *C. amada* CAM (16.5kg/3m²) are the best yielders.

At Pundibari, 60 accessions are being maintained. Forty three accessions were evaluated during this year. The accessions showed high variability for growth and yield characters.

The accessions *viz.*, TCP-9, TCP-7, TCP-10, TCP-1, TCP-2 and TCP-8 are promising for yield.

The Jagtial centre maintains 188 accessions of turmeric. New accessions were collected from Adilabad , Kovur, Chintapalli and Anantharajpeta areas. The accessions were grouped into long duration (8-9 months), medium duration (7-8 months), and short duration (6-7 months). The best yielders are : (i) long duration accessions : JTS-6 and JTS-8 (8.8 and 8.2 kg/3m^2 respectively); (ii) medium duration : JTS-306, CLI.367/II and CLI.370 (8.0, 7.5 and 7.3 kg/3m^2); (iii) short duration: JTS-604 and JTS-602 (7.2 and 7.0 kg/3m^2 respectively) (Table 18).

Fiftyseven accessions are maintained at Dholi and are evaluated for morphological and yield characters. The best yielders were Rajendra Sonia (31.0 kg/3m^2) and RH-24 (29.0 kg/3m^2).

The Kumarganj centre is maintaining 28 accessions and were evaluated for agronomic traits and yield. The accessions *viz.*, NDH.14 (53.7 t/ha), NDH.18 (52.8 t/ha), PTS.43 (51.5 t/ha), Rajendra Sonia (53.0 t/ha), NDH.13 (49.8 t/ha) and NDH.12 (48.8 t/ha) are promising for yield.

The Coimbatore centre has been maintaining 196 germplasm accessions. During the current year, survey has been made at Perundurai, Erode, Bhavani and Kodumudi areas

Table 17 Performance of turmeric germplasm at Solan

Character	Range	Name and value of promising collection
Survival (%)	86.6 to 100	BDJR-1182, BDJR-1260, BDJR-1139, BDJR-1216, BDJR-1293, ST-44N, ST-29N, Solan Lord, PCT-8, T.No.262 and Alleppey Finger Turmeric
Tillers per plant	1.2 to 5.6	ST-832 (5.6), Suroma (5.0), ST-41M(4.8), EN-321(4.7), ST- 66(4.6), ST-323(4.4), BDJR-1182(4.4), ST-325(4.0) and BDJR-1216(4.0)
Pseudostem length(cm)	52.3 to 100	PTS-53(100), ST-491(97.5), BDJR-1258(97.2), BDJR-1196 (94.0), BDJR-1005(93.7), ST-447(93.2), ST-34(93.0), PTS-9 (92.6), BDJR-1229 (91.8) and BDJR-1242(88.8)
Yield per plant(g)	91 to 136	BDJR-1267(136), BDJR-1229(130), CO-1(129), BDJR-1229(123), ST-41(122), BDJR-1196 (121), ST-760Y (120), ST-447(119), BDJR-1069(118) and ST-29M (104)
Yield per plot (kg)	2.2 to 8.3	BDJR-1258(8.3), Armoor(8.2), ST-624 (8.2), ST-34(7.5), BDJR-122 (7.5), BDJR-1242(7.4), BDJR-1116(7.2), ST-41 (7.2), BDJR-1250(7.1) and BDJR-1005(7.0)

and 20 new lines were added to the germplasm. Two exotic lines *viz.*, CL-223 (*Curcuma xanthorrhiza*) and CL-224 (*Curcuma longa*) were also introduced from Indonesia. Considerable variation among the accessions has been noted for yield traits. Based on the yield (kg/plant) performance of last two years the following accessions were short listed: CL 2 (1.2), CL 30 (1.2), CL 53 (1.4), CL 68 (1.5), CL 74 (1.6), CL 145 (1.7), CL.147 (1.1) and CL 189 (1.2).

The Raigarh centre holds 43 turmeric accessions. In the evaluation of accessions resistant to *Taphrina* leaf blotch, acc. PTS.62, Acc.360, and JTS.1 were found tolerant and they recorded good yield (>23.0 t/ha) under CVT. And the germplasm accessions viz., *Bataguda, Hardaguda,*

Table 18 Yield performance of promising germplasm accessions at Jagtial and Pottangi

	1997-98		1998-99	
Centre		Yield		
	Promising accession	(kg/3m²)	Promising accession	Yield (kg/3m²)
Jagtial	Long duration type			
	Acc.361	9.0	JTS.6	8.8
	TC.4	9.0	JTS.8	8.2
	JTS.6	8.5		
	Medium duration type			
	PTS.10	12.5	JTS.306	8.0
	PTS.19	12.5	CLT.367/II	7.5
	JTS.306	11.0	CLT.370	7.3
	Short duration type			
	PCT.10	13.0	JTS.604	7.2
	JTS.604	12.0	JTS.602	7.0
	PCT.14	11.5		
Pottangi	*C. longa*			
	PTS.45	9.7	PTS. 5	15.0
	PTS.13	8.2	STS. 10	14.5
	Tur.No.1	7.7	PTS.28	14.0
	C. aromatica			
	Bataguda	7.8	Chayapusupa	11.5
	Haridaguda	7.3	Kalarmanar	10.0
	ChayapusupaII	7.0	CAS.59	9.5
	C. amada			
	CAM.3	6.6	CAM.3	16.5
	CAM.1	6.4	CAM.2	14.8
	CAM.2	5.8	CAM.1	11.1

Rashmi, PTS.55, Tec.No.6, PTS.20, PTS.29, RTS.1, RTS.2 and Ranga were highly tolerant to leaf blotch. CAM.53, *Roma*, RTS-12, CAS.56, *Kasturi*, CAM.3, RTS-4 and RTS-18 showed moderate tolerance.

TUR/CI/2 Coordinated Varietal Trial

TUR/CI/2.1 CVT 1996 - Series IV

Pottangi, Dholi, Pundibari, Kumarganj and Raigarh

The CVT - 1996 consists of ten accessions *viz*., RH-5 and *Rajendra Sonia* from Bihar, PTS-12, PTS-62 and PTS-43 from Pottangi, Acc.360 and 361 from IISR, JTS-1 and JTS-2 from Jagtial (Table 19).

At Dholi, the CVT with nine entries was laid out for the third year. The entry RH-5 recorded highest yield (13.2 kg/3m^2) followed by RH.10 (12.3 kg/3m^2). The lowest yield (3.0 kg/3m^2) was recorded by PTS-12.

At Kumarganj, during 1998-99 the best yield was recorded by *Rajendra Sonia* (54.3 t/ha) followed by Acc.361 (44.1 t/ha) and PTS-43 (43.8 t/ha). The mean performance of accessions evaluated for three years (1996-97 to 1998-99) revealed that R. *Sonia* (check) registered highest yield of 51.0 t/ha (Table 20). The next best accessions were Acc. 361 (46.6 t/ha), RH-5 (44.7 t/ha) and PTS-43 (43.7 t/ha).

Pundibari centre conducted the trial with seven accessions (excluding JTS.1 and 2) during 1996-97 to 1997-98 and with nine accessions during 1998-99. During

Table 19 Comparative yield performance of Turmeric varieties under CVT (1998-99)

Variety	Rhizome yield (kg/3m^2)				Yield (t/ha)	
	Pottangi	Dholi	Pundibari	Jagtial	Kumarganj (t/ha)	Raigarh (t/ha)
R.Sonia (RH-10)	17.4	12.3	13.9	5.3	54.3	31.5
RH-5	15.0	13.2	14.0	7.7	42.7	26.3
PTS-12	15.2	3.0	12.6	6.0	39.1	26.0
PTS-62	11.8	4.6	12.7	4.6	35.5	28.5
PTS-43	13.1	4.2	12.0	6.0	43.8	32.0
Acc.360	10.5	6.0	12.5	5.7	43.0	27.3
Acc.361	10.0	5.8	12.8	8.2	44.1	21.5
JTS-1	17.9	6.3	10.8	8.2	41.9	27.8
JTS-2	16.6	5.3	8.4	8.9	37.8	29.0
Check(s)		-	2.3	8.3 (Duggirala)	-	24.4(RTS-1) 18.5(RTS-2)
CD at 5%	5.2	3.8		0.8	2.7	13.1

Table 20 Yield performance of turmeric accession under CVT at Kumarganj (1996-97 to 1998-99)

	Rhizome yield (t/ha)			
Accession	1996-97	1997-98	1998-99	Mean
PTS-43	44.0	43.3	43.8	43.7
PTS-12	41.0	41.5	39.1	40.5
PTS-62	31.1	31.6	35.5	32.7
JTS-1	42.8	43.6	41.9	42.7
JTS-2	38.6	36.4	37.8	37.6
Acc.360	35.0	35.4	43.0	39.3
Acc.361	47.2	48.4	44.1	46.6
R. Sonia	48.3	50.0	54.3	50.9
RH-5	45.5	46.0	42.7	44.7
CD at 5%	40.3	40.6	27.3	

the current year, significant yield difference was observed among the accessions. Accessions RH.5 and Rajendra Sonia were the best yielders (14.0 kg/3m^2) (Table 21).

The mean performance of accessions evaluated for three years showed that the check (*Rajendra Sonia*) recorded the highest rhizome yield (14.1 kg/3m^2) followed by Acc. 360 and PTS 62 (13.6 kg/3m^2).

Table 21 Yield performance of turmeric accessions under CVT at Pundibari

Accession	Yield (kg/3m^2)			
	1996-97	1997-98	1998-99	Mean
RH-5	14.3	12.0	14.0	13.4
Acc.361	10.3	16.7	12.8	13.3
PTS-62	11.3	16.9	12.7	13.6
PTS-12	8.2	15.9	12.6	12.2
PTS-43	12.7	13.4	12.0	12.7
Acc.360	12.1	16.3	12.5	13.6
R.Sonia	14.4	13.9	13.9	14.1
JTS-1	-	-	10.8	10.8
JTS-2	-	-	8.4	8.4
CD at 5%	2.9	2.4	2.3	

At Raigarh, among the 11 accessions evaluated, accessions PTS-43 (32.0 t/ha) and *Rajendra Sonia* (31.5 t/ha) recorded significantly higher rhizome yield compared to other accessions. Mean yield performance of accessions evaluated for three years presented in Table 22 revealed that acc. RH.5 (33.8 t/ha), *Rajendra Sonia* (29.7 t/ha) and PTS-43 (28.0 t/ha) were the top yielders than local checks (22.0 and 15.6 t/ha in RTS.1 and RTS.2 respectively).

TUR/CI/3 Varietal Evaluation Trial

TUR/CI/3.1 Comparative yield trial

Pottangi, Dholi and Jagtial

In Pottangi this trial was laid out using long and medium duration cultivars. In the long duration trial out of the six cultivars evaluated, the cultivar PTS.22 registered significantly higher yield (16.6 kg/3m^2) closely followed by PTS.55 (16.0 kg/3m^2) and PTS.62 (15.1 kg/3m^2). The mean performance of accessions evaluated for three years indicated that PTS.62 was the best yielder (11.6kg/3m^2) closely followed by PTS.55 (11.3 kg/3m^2). In the short duration trial also there were six accessions. During the current year, though the yield difference was not significant, the accession PCT.8 registered the highest yield (14.0 kg/3m^2) closely followed by PTS.15 (13.8 kg/3m^2). The mean performance of cultivars evaluated for three years (Table 23) showed that PTS.59 was the best yielder (11.9 kg/3m^2) followed by PTS.15 (10.8 kg/3m^2) and PCT.8 (10.2 kg/3m^2).

Table 22 Yield performance of turmeric varieties under CVT at Raigarh

Cultivar	Yield (t/ha)			
	1996-97	1997-98	1998-99	Mean
R. Sonia	37.3	20.4	31.5	29.7
RH-5	52.4	22.6	26.3	33.8
PTS-43	30.2	22.0	32.0	28.0
PTS-12	21.5	13.6	26.0	20.4
PTS-62	30.7	18.0	28.5	25.7
Acc.360	23.5	27.3	27.3	26.1
Acc.361	31.7	22.3	21.5	25.2
JTS-1	31.9	18.3	27.8	26.0
JTS-2	23.2	25.6	29.0	25.9
Checks (RTS-1)	-	19.6	24.4	22.0
(RTS-2)	11.8	16.6	18.5	15.6
CD at 5%	19.0	6.6	13.1	-

At Dholi, a CYT was laid out with seven accessions *viz*., PCT-8, PCT-11, *Sonali, Sugandham, Manipuri, Morangia* and *Rajendra Sonia* (check). The accessions varied significantly for growth and yield characters. Highest yield was recorded by Rajendra Sonia (29.5 kg/3m^2).

A CYT with long, medium and short duration varieties was laid out at Jagtial. In long duration trial, there were seven accessions (JTS-9, JTS-8, JTS-6, JTS-5, JTS-7, JTS-3 and *Duggirala* - check). Out of this, JTS-6 registered significantly higher yield (8.9 kg/3m^2) followed by JTS-8 (8.0 kg/3m^2) as against check (7.3 kg/3m^2). In medium duration trial out of 13 accessions (JTS-307, JTS-311, JTS-308, JTS-302, JTS-304, JTS-313, JTS-301, JTS-303, JTS-306, JTS-305, JTS-310, JTS-309 and CLI-317) evaluated, the highest rhizome yield (8.4 kg/3m^2) was obtained in JTS- 313 closely followed by JTS-309 (8.2 kg/3m^2). The check (CLI-317) recorded an yield of 7.0 kg/3m^2. With regard to short duration trial, out ofseven accessions (JTS-601, 602 603, 604, 605, 606 and PCT-13) tested, JTS-602 gave higher yield (7.9 kg/3m^2) closely followed by check (7.6 kg/3m^2) (Table 24).

Table 23 Yield performance of Turmeric accession at Pottangi in CYT 1996-97 to 1998-99

Cultivars	Yield kg/3m^2			Mean yield	Projected yield (t/ha)
	1996-97	1997-98	1998-99		
Short duration					
PTS-43	6.8	13.8	12.6	10.9	27.4
PTS-62	6.7	12.9	15.1	11.6	29.0
PTS-55	8.3	9.5	16.0	11.2	28.2
TU.No.1	6.4	11.1	11.1	9.5	23.9
PTS-22	6.2	8.5	16.5	10.4	26.1
Roma	4.7	9.5	11.2	8.4	21.1
CD at 5%	1.98	2.0	4.3	2.7	6.9
Long duration					
PTS-59	11.5	10.9	13.2	18.8	23.7
PTS-15	7.5	11.0	13.8	10.8	27.0
PTS-11	7.4	9.6	12.7	9.9	24.7
PCT-8	7.0	9.8	13.9	10.2	25.6
PTS-52	8.2	8.1	13.4	9.9	24.8
K.Local	5.0	7.3	10.6	7.7	19.2
CD at 5%	2.1	1.7	N.S		

TUR/CI/4 Quality Evaluation Trial

TUR/CI/4.1 Quality evaluation of germplasm / varieties

Solan and Coimbatore

At Solan, the samples harvested during the year are being processed for quality analysis.

At Coimbatore, 65 accessions were evaluated for curcumin content. The curcumin content varied in different accessions from 0.99 to 6.4%. The highest curcumin content (6.4%) was

Table 24 Comparative yield evaluation of turmeric accessions at Jagtial (1998-99)

Accession	Yield (kg/3m^2)	Yield (t/ha)	Curing (%)
Long duration			
JTS-9	7.0	21.9	19.8
JTS-8	8.0	25.0	20.0
JTS-7	5.6	17.6	20.3
JTS-6	8.9	27.7	20.1
JTS-5	6.5	20.3	20.2
JTS-3	6.5	20.2	20.0
Duggirala	7.3	22.8	19.8
CD at 5%	0.7	2.2	-
Medium duration			
JTS-307	6.2	19.3	19.1
JTS-311	6.6	20.5	19.6
JTS-308	8.0	24.9	19.8
JTS-302	8.1	25.5	19.3
JTS-304	7.1	22.1	19.1
JTS-313	8.4	26.4	19.4
JTS-301	6.9	21.7	19.2
JTS-303	7.2	22.6	19.2
JTS-306	6.8	21.4	19.3
JTS-305	6.3	19.8	19.3
JTS-310	6.5	20.2	19.5
JTS-309	8.2	25.7	19.2
JTS-317	7.0	21.8	20.2
CD at 5%	0.65	2.0	-
Short duration			
JTS-604	6.0	18.9	19.2
JTS-605	5.1	16.1	19.0
JTS-601	6.9	19.9	19.0
JTS-602	7.8	24.5	19.0
JTS-603	5.5	17.2	18.8
JTS-606	5.6	17.3	18.7
PCT-13	7.6	23.6	18.3
CD at 5%	0.5	1.6	

recorded in CL-67 followed by CL-18 (6.3%). Eleven accessions (CL-19, CL-67, CL-32, CL-74, CL-18, CL-11, CL-94, CL-80, CL-124, CL-115 and CL-26) recorded more than 5.0% curcumin.

TUR/CI/4.2 Impact of environment on quality of turmeric

Solan, Pottangi, Kumarganj, Coimbatore and Dholi

As per the decision of XIV AICRPS Workshop, a new trial to study the effect of altitude on quality of turmeric was laid out at Solan with four accessions (*Rajendra Sonia,* Acc. 360, BSR-2, JTS-2) along with four local entries (ST-365, ST-148, ST-85, ST-330). Results showed that curcumin content was highest in ACC.360 (4.6%) followed by JTS-2, *Rajendra Sonia* and ST-148. JTS-2 registered highest essential oil (7.0%) while oleoresin content was highest (16.5%) in ST-330.

At Coimbatore, a trial was laid out with five improved varieties (JTS-2, *Roma,* Acc. 360, *Rajendra Sonia* and *Suguna*) to study the effect of environment on quality. The samples harvested are under processing for quality analysis.

TUR/CM/1 Nutrient Management Trial

TUR/CM/1.1. Response of Nitrogen and spacing on growth and yield of turmeric

Kumarganj

To find out the optimum spacing and nitrogen level, a trial was laid out during *kharif* 1997 with four levels of Nitrogen (0, 50, 100, 150 kg/ha) and three spacing (20x20, 30x20, 40x20 cm).

Result showed that increasing levels of Nitrogen increased rhizome yield. Application of 150 kg N/ha recorded the highest rhizome yield (43.0 t/ha). With respect to spacing, medium spacing (30x20cm) recorded higher yield (37.1 t/ha) than other spacing. Interaction effect was also significant and the combination of 150 kg N/ha with 20x20 cm spacing gave the highest yield (50.0 t/ha) of rhizome.

TUR/CM/1.2 Response of fertilizer on the yield of turmeric

Raigarh

An experiment comprising eight treatment combinations (T_1-Control, T_2-FYM @ 25 t/ha, T_3 - 50:25:25, T_4-75:50:50, T_5-100:75:75, T_6-125:100:100, T_7-150:125:125, T_8-175:150:150 kg NPK/ha) was laid out in RBD with three replications during *kharif* 1997 and 1998.

Treatments significantly influenced yield and related traits. The treatments T_7 (150:125:125 kg NPK/ha) and T_8 (175:150:150 kg NPK/ha) recorded significantly higher rhizome yields (21.2 and 21.4 t/ha respectively) as against control (5.2 t/ha). Mean yield performance over two years also revealed that T_7 and T_8 were the best treatments in realising higher yields (26.6 and 26.3 t/ha respectively) com-

pared to control (7.0 t/ha) and other treatments (Table 25).

TUR/CP/1 Disease Management Trial

TUR/CP/1.1 Survey and identification of disease causing organisms in turmeric and screening of turmeric germplasm against diseases

Dholi, Jagtial and Coimbatore

Dholi centre conducted survey in turmeric growing areas of Bihar and found that leaf blotch of turmeric (caused by *Taphrina maculens*) is more severe compared to leaf spot caused by *Colletorichum capsici*. The cultivars Kohinoor, GL Puram, Rajendra Sonia and RH-5 are moderately field resistant to *Taphrina maculans* and Kohinoor and GL Puram showed field resistance to *C.capsici*.

At Jagtial, 48 elite turmeric accessions were tested in sick plot. Eleven accessions (PCT-14, JTS-606, JTS-305, JTS-306, JTS-307, JTS-308, JTS-311, JTS-9, PTS-19, GS & BSR-1) were free from rhizome rot disease and rhizome fly attack, 44 from *Colletotrichum* leaf spot and seven (PCT-14, JTS-606, PCT-10, JTS-604, JTS-605, *Armoor* and *Duggirala*) from *Taphrina* leaf blotch.

At Coimbatore, accession CL-31 is found to be totally free from leaf spot, and low incidence (11-20%) was noticed in 108 accessions. Accessions *viz.*, CL-125, CL-30, CL-154 were found to be tolerant to scale infection.

TUR/CP/1.2 Chemical control of *Taphrina* leaf blotch disease of turmeric

Dholi, Pundibari and Raigarh

Pundibari centre laid out an experiment during 1997 to 1999 with four treatments (BM 1%, Syllit 65 WP 0.1%, Kavach 75 WP 0.1% and control), using PCT-13 (*Suguna*) variety. Results showed that the fungicides

Table 25 Effect of fertilizer on growth and yield of turmeric at Raigarh

Treatment	No. of tillers per plant	Rhizome yield per plant	Rhizome yield (t/ha)		
			1997-98	1998-99	Mean
T_1	1.6	55.4	8.7	5.2	7.0
T_2	1.6	72.8	12.3	7.5	9.9
T_3	2.1	100.8	14.7	9.5	12.1
T_4	2.0	112.3	17.9	12.3	15.1
T_5	1.9	133.3	21.3	16.0	18.7
T_6	2.2	160.0	23.7	17.9	20.8
T_7	2.8	206.7	31.9	21.2	26.6
T_8	2.6	201.7	31.1	21.4	26.3
CD at 5%	0.7	27.9	4.0	2.0	

significantly reduced the disease incidence. Mean data over two years revealed that the per cent disease index (PDI) was the lowest (27.9%) in the treatment received Bordeaux Mixture (1%) spray (30 days interval starting from 120 DAS upto 180 DAS) as against control (59.2%). The mean rhizome yield was also high (6.3 kg/1.2m^2) in the same treatment.

In another trial at Dholi to control leaf blotch caused by *Taphrina maculens,* among the seven treatment combinations, the disease incidence was lowest (21.0%) in Indofil M45 @ 2g/l closely followed by Blitox 50 @ 2.5g/l of water (25.0% incidence).

Raigarh centre laid out a trial on control of *Taphrina* leaf blotch using different fungicides. The trial was laid out in RBD with three replications during *kharif* 1997 and 1998. There were seven treatment combinations. The results (Table 26) revealed that fungicides significantly reduced the disease incidence and led to higher yield. During the current year, lowest disease incidence (31.1%) with highest yield (10.5 kg/ 3m^2) was recorded in plants that received Ridomil @ 200 ppm as against the control (71.5% incidence, 5.3 kg/m^2). The two years mean data also revealed that Ridomil was very effective in control of *Taphrina* leaf spot which recorded 8.3 kg/3m^2 in comparison with control (5.1 kg/3m^2). The next best treatment was Thiophenate Methyl (0.1%) which recorded 8.0 kg/3m^2.

TUR/CP/1.3 Effect of seed treatment on leaf blotch of turmeric / effect of fungicides on leaf spot disease

Dholi

In the experiment to control leaf spot disease caused by *Colletotrichum capsici* there were seven treatments [Ridomil MZ @ 3g/l, Indofil M45 @ 2g/l, Bavistin @ 1g/l, Indofil M45 (2g) + Bavistin (1g), Blitox 50 (2.5g/l), Emisan 6 (1g/l) and a control] laid out Dholi. The minimum disease incidence of 12.5% was recorded in plants treated with Emisan 6 for 15 minutes. In contrast, the disease incidence was high (56.5%) in control plot.

TUR/CP/1.4 Investigations on the causal organism of rhizome rot of turmeric and screening of biocontrol agents for its management

Jagtial

The main objective of the study is to know the etiology of turmeric rhizome rot complex disease in glass house, pot culture and field conditions.

During the year the diseased and infected samples of *Armoor,*

Duggirala and Jagtial local red varieties were studied for the presence of various organisms. The organisms viz., *Rhizopus sp.*, Bacteria (creamy yellow and creamy white) were obtained on PDA, Tomato Juice Agar and Hemp Seed Agar medium. *Curvularia sp.* and Bacterium (creamy white) on PDA + Carbendazim medium and *Rhizoctonia sp.* on carrot agar medium.

In the trial to identify suitable biocontrol agents for the management of rhizome rot using combinations involving *Trichoderma viride*, *Pseudomonas fluorescence*, *Bacillus subtills;* all biocontrol agents reduced the disease incidence.

TREE SPICES

TSP/CI/1 Genetic Resources

TSP/CI/1.1 Germplasm collection, characterisation, evaluation and conservation of clove, nutmeg and cinnamon

Yercaud, Pechiparai, Thadiyankudisai and Dapoli

At Yercaud 13 clove accessions are being maintained and evaluated for

Table 26 Effect of fungicides on the control of leaf blotch of turmeric at Raigarh

Sl. No.	Treatment	Taphrina leaf blotch						Yield (kg/3m²)		
		% Diseased leaves			Disease severity					
		1997	1998	Mean	1997	1998	Mean	1997	1998	Mean
1.	Control	80.4	94.9	87.7	70.3	71.5	70.9	4.8	5.30	5.1
2.	Blitox-5	57.2	64.0	60.6	44.3	36.2	40.3	6.0	8.10	7.0
3.	Ridomil (200ppm)	36.9	45.2	41.1	30.8	31.1	31.5	6.0	10.50	8.3
4.	Thiophenate Methyl (0.1%)	35.4	52.5	44.0	29.6	42.2	35.9	8.5	7.40	8.0
5.	Carbendazim (0.1%)	32.7	62.5	48.6	32.6	41.0	36.8	6.4	8.20	7.3
6.	Mancozeb (0.3%)	54.4	80.7	67.6	45.9	50.0	48.0	6.5	7.80	7.2
7.	Antracol (0.3%)	56.2	72.5	64.4	46.0	42.5	44.3	7.6	7.50	7.6
	CD at 5%	11.4	8.97	-	18.4	11.8	-	1.3	1.54	-

growth and yield characters. The accession SA.1 showed vigorous growth. In cinnamon, the centre holds 11 accessions and second coppicing was done during the year. The bark yield ranged from 68 (cv.1) to 144.5 g (cv.5) among the accessions.

Pechiparai centre is maintaining 21 clove accessions. Among them, SA.13 and SA.12 continued to give vigorous growth. Twelve accessions in each of nutmeg and cinnamon are being maintained at the centre. The nutmeg accession MF 2 recorded more number of branches (21) and maximum height (3.3m). In cinnamon, Acc.203 gave high bark yield (3.8 kg) followed by cv.63 (3.4 kg).

At Dapoli, fourteen nutmeg accessions and twelve cinnamon accessions are being maintained and the crop growth is satisfactory. A survey was conducted in Dapoli and Guhagar tahasils of Ratnagiri district, to locate elite mother trees of nutmeg. Ten villages were covered under this survey. Seeds of promising trees collected were sown in the nursery. So far thirteen seedlings of six trees have been obtained. And eight soft wood grafts of seven elite mother trees were successful.

TSP/CI/2 Coordinated Varietal Trial (CVT)

TSP/CI/2.1 CVT 1992 in clove

Yercaud, Pechiparai, and Dapoli

In CVT 1992 at Yercaud, there are six accessions *viz.*, Sel.1,2,3,4,5, and Kallar local. Among them, Sel.1 continues to give vigorous growth and started flowering during the current year.

TSP/CI/2.2 CVT 1992 in cinnamon

Yercaud, Ambalavayal, Pechiparai and Thadiyankudissai

At Yercaud, the CVT (1992) was laid out with five accessions (Sel. 44, 53, 63, 189 and 203 from IISR, Calicut). Among them Sel. 189 recorded high bark yield (990g, fresh wt.) with 46% recovery. Sel. 44 recorded highest leaf oil (4.1%) while Sel. 189 with highest bark oil (4.0%) and Sel. 53 and Sel. 63 with highest bark oleoresin (16.0%).

At Ambalavayal, seven accessions (SL. 44, 53, 63, 189 203 from IISR, and Acc.1 2 from RARS, Ambalavayal) were tested under CVT. Among them, Sel.189 gave highest bark yield (2.4 kg of dry quills/12seedlings) followed by SL.53 (2.2kg).

TSP/CM/1Propagation/Multiplication Trial

TSP/CM/1.1 Vegetative propagation in nutmeg, clove and cinnamon

Yercaud, Thadiyankudissai, Pechiparai and Dapoli

At Yercaud, an experiment was carried out in nutmeg to identify optimum stage of scion and root stock for getting maximum success through grafting. The scions were collected from two types of shoots (orthotropic and plagiotropic) and four types of

root stocks (epicotyl, 2, 4, and 6 leaved stage) were used. The results indicated that grafting using two leaved stage of root stock with both orthotropic and plagiotropic scions recorded the highest percentage of success (53.0 and 50.0 respectively).

At Dapoli, in order to find out the optimum time for air layering, an experiment on air layering in nutmeg and clove was initiated during 1998 August and is in progress.

TSP/CM/2 Irrigation Trial

TSP/CM/2.1 Drip irrigation in clove and nutmeg

Yercaud

The drip irrigation trial was started during 1993 with five irrigation levels (2,4, 6, 8 litres of water/plant/day, control i.e., pot watering @ 8 litres/ week/plant). Observations revealed that dripping of water @ 8 litres/day/plant gave vigorous growth with more number of branches (55.0) and taller plants (231.6 cm) as compared to control plants.

TSP/CM/3 Nutrient Management trial

TSP/CM/3.1 Biofertilizer trial in tree spices

Yercaud

To study the influence of biofertilizer on growth and yield of clove and nutmeg, a trial was laid out at Yercaud during 1992 with five treatments *viz.*, T_1-control i.e., local practice with 50 kg FYM + 5 kg bone meal, T_2-100 kg FYM + 400:350: 1200 g $N:P_2O_5:K_2O$/tree/year for clove and 400:300:1200 g NPK for nutmeg, T_3 - T_2 + 50 kg in each of *Azospirillum* and Phosphobacteria, T_4 - 75% of T_2 + 50 g of biofertilizer/tree/year, T_5 - 50% of T_2 + 50 g of biofertilizer/ tree/year.

The observations from Table 27 showed that recommended dose (100 kg FYM + 400:350: 1200 for clove and 100 kg FYM + 400:350:1200g NPK/ tree/year for nutmeg) along with 50g in each of *Azospirillum* and Phosphobacteria resulted in highest yield in clove (4.9 kg/tree/year) and nutmeg (672 fruits/tree/year).

TSP/CM/4 Physiological Studies

TSP/CM/4.1 Studies on fruit drop of nutmeg

Dapoli

A survey was undertaken in the villages of Dapoli *Tahasil* of Ratnagiri district to find out the causes for fruit drop in nutmeg. It was observed that the fruit drop in the region was very meagre (2.5%) and no fungus was found associated with this disorder.

Table 27 **Effect of biofertilizer on tree spices at Yercaud**

Treatment	Clove				Nutmeg			
	Mean no. of buds/cluster		Mean green bud yield (kg)		Mean fruit wt(g)		Mean fruit yield(Nos.)	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
T_1	20.4	20.6	2.6	3.0	64.4	64.4	438.0	442.4
T_2	21.5	21.6	3.7	4.0	65.7	65.7	568.0	572.0
T_3	21.7	21.7	4.0	4.9	65.6	69.6	484.0	498.2
T_4	20.2	20.3	3.8	3.9	75.0	75.2	648.0	672.4
T_5	21.0	20.8	3.8	3.8	70.4	70.4	546.0	592.0

CORIANDER

COR/CRI/ 1Genetic Resources

COR/CI/1.1 Germplasm collection, description, characterization, evaluation, conservation and screening against diseases

Jobner, Jagudan, Guntur, Kumarganj, Coimbatore, Hisar, Dholi and Raigarh

The Jobner centre maintains 761 coriander accessions which includes 631 indigenous, 112 exotic and 18 new collections. In the evaluation of 154 accessions, 23 accessions yielded higher than the best check (RCr.41). The accessions UD.60, UD.5, UD.62, UD.63 and UD.77 are promising for yield. In the screening for root knot nematode, accessions RCr.20, RCr.41and RCr.435 exhibited moderate resistance.

At Coimbatore, 205 accessions are maintained, including 45 new collections from different coriander growing areas. These accessions were evaluated for yield and other agronomic traits. The mean grain yield per plant ranged from 6.8 g to 20.5 g. Twelve accessions registered higher yield than the ruling variety CO.3. The accession CS. 94 registered the highest yield (20.5 g / plant).

The Jagudan centre maintains 70 coriander accessions, consisting 18 exotic and 52 indigenous collections. In the screening for root knot nematode, accessions JCo.331 and JCo.344 were moderately resistant.

At Dholi, 95 accessions are being maintained and evaluated. Among them, 10 were found promising for growth and yield. In screening of germplasm for disease resistance *Pant Haritima*, UD-646 and M.1 were resistant to major diseases.

The Kumarganj centre holds 67 accessions and they were evaluated for various traits. The accessions RCr.41, *Pant Haritima*, DH.49, DH.53, DH.52, RD.23, DH.28, PHM.5 and

CS.695 are performing better for yield. The acc. RCr. 41 recorded highest yield (1810 kg/ha).

The Guntur centre is maintaining 230 accessions. Among the 110 accessions evaluated during the year, L C C. 227 recorded the highest yield of 917 kg/ha followed by L C C.225 (900 kg/ha) and L C C.174 (883 kg/ha). The check (*Sadhana*) recorded an yield of 667 kg/ha.

The Raigarh centre holds 24 accessions.

At Hisar, sixtyfive accessions of coriander were evaluated in two row plots of 2.5 meter length (2.5 sq.m.) each using *Pant Haritima*, DH.5 and *Narnaul* Selection as checks during 1997-98. The seed yield of the germplasm material ranged from 250g (DH.214) To 660g (DH.234). Thirty two lines gave higher seed yield than DH.5, 46 higher than *Narnaul* Selection and 58 outyielded *Pant Haritima.*

COR/CI/2 Coordinated Varietal Trial (CVT)

COR/CI /2.1 CVT 1993 – Series II

Jobner, Jagudan, Guntur, Coimbatore, Dholi and Hisar

The CVT was laid out at the coordinating centres with 11 accessions from Rajasthan (UD.446, UD.447, RCr. 41), Haryana (DH.36 and 38), Gujarat (J.Cor. 64 and 123), Tamil Nadu (C C. 402 and 964) and Andhra Pradesh (ATP. 77 and 102).

At Jobner, based on the mean performance of three years (1993-94 to 1995-96), the accession UD.446 recorded higher yield (1281 kg/ha) as compared to check (RCr.41, 1272 kg/ha).

At Jagudan, the trial was concluded. Based on the pooled mean data over three years (1993-94 to 1995-96) none of the accession was superior to control (Guj.Cor.2). However, the accessions CC.462, ATP.77 and JCo.123 recorded higher yield (1121, 1108, 1105 kg/ha respectively) than control, though not statistically significant.

At Coimbatore, CO.3 was used as check. Based on two years mean data, the check out yielded (916 kg/ha) other accessions.

At Dholi, the trial with 10 accessions was concluded and UD 446 was the best yielder (2000 kg/ha) compared to check (*Rajendra Swathi*, 1450 kg/ha) as based on pooled data over three years.

COR /CI /2.2 CVT 1996 Series III

Jobner, Jagudan, Coimbatore, Dholi and Raigarh

The CVT consisting of 13/11 accessions was laid out at the above mentioned centres (Table 28).

At Jobner, the trial was laid out with 13 accessions; four from Rajasthan (UD.684, UD.685, UD.686, RCr.41 and

local check), two from Gujarat (J.Cor.327 and J.Cor.331), four from Haryana (DH.13, DH.33, DH.48 and DH.52) and two from Andhra Pradesh (L C C.15 and L C C.32) during *Rabi* 1997-98 in RBD with four replications. The accessions differed significantly for yield and various growth parameters. During the year, the accession UD.684 recorded the highest yield (883 kg/ha) followed by local check (872 kg/ha) and J.Cor.331 (761 kg/ha). The lowest yield of 501 kg/ha was recorded in L C C.32. The mean performance of accessions evaluated during 1996-97 and 1997-98 (Table 29) revealed that UD. 684 was the highest yielder (885 kg/ha) closely followed by DH.13 (733 kg/ha) as against the local check (573 kg/ha).

At Jagudan, the trial consists of 13 accessions *viz.*, UD.684, UD. 685, UD.686, DH.13, DH.48, DH.52, LCC. 15, LCC.32, CC.745, CC.748, JCo.327, JCo.331 and a check (Guj.Cor.2), laid out in RBD with three replications during *Rabi* 1997-98. During the year, significant differences for yield among the accessions were observed, but none was significantly superior to check (Guj.Cor.2;

Table 28 Comparative yield (kg/ha) performance of coriander varieties under CVT

Accession	Jagudan (3 Years)	Jobner * (2 Years)	Coimbatore (2 Years)	Dholi (1998-99)	Guntur (1998-99)	Raigarh (1998-99)	Hisar (1997-98)
UD – 684	1306	885	428	1757	267	**	1730
UD – 685	1267	554	463	1223	367	**	1770
UD – 686	1376	707	445	1910	333	**	1570
DH – 13	1521	733	432	**	383	940	1600
DH – 48	1361	661	512	**	350	880	1500
DH – 52	1303	583	456	1163	300	700	1420
L C C – 15	1103	475	**	938	756	690	1520
L C C – 32	1290	394	**	1424	728	930	1370
C C – 745	1254	_	490	**	**	**	1500
C C – 748	1430	_	470	**	**	**	1630
J C o – 327	1514	543	**	**	483	500	1770
J C o – 331	1492	609	**	**	517	880	1650
R.C r-41	_	664	**	**	**	**	**
L.Check(1)	1663	573	477	1371	600	1000	1990[1]
L.Check(2)	G.Cor.2		CO. 3				1440[2]
CD at 5%	NS	2.4	19.0	2.1	119.2	2.0	

* 1998-99 data not provided

** Entries are not uniform

[1]Hisar Anand

[2]Narnaul Sel.

1933 kg/ha). The mean performance of accessions (Table 30) over three years (1996-97 to 1998-99) revealed that the check (Guj.Co.2) recorded the highest yield (1663 kg/ha) followed by DH.13 (1521 kg/ha) and J.Co.327 (1514 kg/ha).

The CVT at Coimbatore consists of nine accessions *viz*., UD.684, UD. 685, UD.686, CC.745, CC.748, DH.13, DH.52, DH.48 and CO.3 as check. The trial was laid out in RBD with three replications during *Kharif* 1998. The accessions differed significantly for growth and yield traits. During current year the accession DH.48 recorded maximum yield (510 kg/ha) among the accessions tested. The pooled data over two years (1996-97 to 1997-98) showed that the accession DH.48 was the highest yielder (512 kg/ha) followed by CC.745 (490 kg/ha) and CC.748 (469.5 kg/ha). The yield recorded by the check was 476. 5 kg/ha (Table 31).

The Dholi centre laid out the trial for the second year in 1998 with 11 accessions [(DH.52, LCC.15, LCC.32, UD.684, UD.685, UD.435, UD.436, RD.23, RD.120 and *Rajendra Swathi* (check)] in RBD with three replications. The accessions varied significantly for yield and other traits. During the year, UD.686 registered the highest grain yield of 1910 kg/ha followed by 1757 kg/ha in UD.684. In contrast, the check gave 1371 kg/ha.

Table 29 Mean performance of coriander accessions under CVT at Jobner

Accession	Yield (kg/ha)			Umbel/	Umbellets/	Grains /
	1996-97	1997-98	Mean	Plant	Umbel	Umbel
UD – 684	885	885	885	34	5.0	34.8
UD – 685	547	560	554	35.1	4.9	36.8
UD – 686	873	540	707	31.7	5.5	33.7
DH – 13	742	723	733	41.9	5.5	27.0
DH – 48	691	631	661	39.9	5.0	30.9
DH – 52	639	527	583	28.6	5.1	44.4
L C C – 15	370	579	475	40.4	3.7	13.6
L C C – 32	286	501	394	34.3	4.1	14.5
J C o – 327	481	605	543	29.8	4.5	19.4
J C o – 331	456	761	609	39.6	5.2	23.7
RC r – 41	599	729	664	29.5	5.8	33.0
Check	274	872	573	48.1	4.7	24.4
CD at 5%	2.0	NS	2.4	NS	0.6	8.6

Table 30 Mean performance of coriander accessions under CVT at Jagudan

Accession	Yield (kg/ha)			
	1996-97	1997-98	1998-99	Mean
UD – 684	1470	925	1672	1306
UD – 685	1307	953	1541	1267
UD – 686	1388	1062	1677	1376
DH – 13	1742	1062	1759	1521
DH – 48	1361	1171	1552	1361
DH – 52	1236	969	1704	1303
L C C – 15	1105	1307	896	1103
L C C – 32	1290	1443	1138	1290
C C – 745	1176	1252	1334	1254
C C – 748	1334	1203	1819	1430
J C o – 327	1465	1307	1770	1514
J C o – 331	1552	1307	1617	1492
Check (Guj. Co.2)	1666	1388	1933	1663
CD at 5%	3.2	3.0	2.5	NS

At Guntur, among the 11 accessions evaluated, L C C.15 recorded significantly higher yield (756 kg/ha) followed by L C C.32 (728 kg/ha) as against the check (600 kg/ha).

At Raigarh, the trial was laid out with 15 accessions during 1996. There was significant difference in yield among the accessions tested. During current year the accession DH.36 registered significantly higher yield (1220 kg/ha) than all others.

At Hisar the trial was laid out with 15 entries in 1995. Significant differences were noted for all the growth and yield parameters. Highest seed yield was recorded in Hisar Anand, followed by CO3, JCO.327 and UD.685. Plant height ranged from 46.8 to 83.0 cm; number of branches from 6.4 to 7.9, umbels per plant from 47.9 to 70.7, umbellets per umbel 5.3 to 6.5 and seeds per umbel 26.0 to 45.0.

On the basis of average yield for three years (1995-96 to 1997-98) at Hisar, Hisar Anand recorded the highest yield of 20.7q/ha which was 41.8% higher over *Narnaul* Selection (check) followed by UD.685 (26.7%) and UD.684 (24.0%) (Table 32).

COR/CI/3 Varietal / Evaluation Trial

COR/CI/3.1 Comparative yield trial

Dholi and Coimbatore

The Dholi centre laid out the trial with 10 accessions *viz.*, DH.36,

Table 31 Yield performance of coriander accessions under CVT at Coimbatore

Accessions	Number of Umbels /plant			Yield (kg/plot, 9.6 m²)			Yield
	1996-97	1997-98	Mean	1996-97	1997-98	Mean	(kg/ha)
UD – 684	16.7	21.5	19.1	0.46	0.40	0.43	427.5
UD – 685	17.1	22.5	19.8	0.46	0.47	0.46	462.5
UD – 686	15.4	26.0	20.7	0.41	0.48	0.44	444.5
C C – 745	19.0	27.1	23.1	0.53	0.45	0.49	490.0
C C – 748	14.6	21.4	18.0	0.49	0.45	0.47	469.5
D H – 13	14.1	25.0	19.5	0.41	0.45	0.43	432.0
D H – 52	16.4	13.2	14.8	0.41	0.50	0.46	456.0
D H – 48	16	25.6	20.8	0.45	0.51	0.51	512.0
CO.3	16.9	33.0	25.0	0.45	0.50	0.48	476.5
CD at 5%	NS	2.6	-	0.2	0.2	-	-

DH.38, DH.52, UD.446, UD.447, Jco.123, Jco. 462, ATP.77, ATP.102 and Rajendra Swathi (check) during 1998 in RBD with three replications. The data showed that the accession DH.52 recorded the highest grain yield of 1615 kg/ha as against the check (1306 kg/ha) followed by DH.36 (1202 kg/ha).

At Coimbatore, the trial was laid out with 10 accessions *viz*., DH.36, DH.38, ATP.102, ATP.77, CC.462, C C.964, UD.446, UD.447, JCo.123 and C O.3 (check) in RBD with three replications during *kharif* 1998. Significant difference for yield was observed among the accessions, but the check recorded the highest yield (500 kg/ha). Whereas, the mean performance of two years data (1996-97 and 1997-98) revealed that UD.446 was the highest yielder (529 kg/ha) followed by ATP.77, C C.462, DH.36 and UD.447 (517.5, 506, 493.5 and 490 kg/ha respectively). The check recorded an yield of 476.5 kg/ha.

COR /CI /4 Quality Evaluation Trial

COR /CI/4.1 Quality evaluation in coriander

Jobner

At Jobner, 13 coriander accessions tested under CVT were analysed for volatile oil content. The oil content ranged from 0.3 to 0.4%. Highest oil content (0.4%) was in local check and LCC.32 and the minimum (0.3%) in DH.48, UD.685 and UD.686.

The mean performance of accessions evaluated over two years (1996-97 to 1997-98) revealed that highest mean volatile oil was in JCo.331 (0.38%), followed by DH.52, local and L C C.32 (0.35%) (Table 33).

The comparison of volatile oil of accessions grown at Jobner and

Table 32 Yield performance of Coriander genotypes at Hisar. (Series-III)

Sl. No.	Name of entry	Seed yield (q/ha)				% increase over check
		1995-96	1996-97	1997-98	Mean	
1.	C C-745	-	11.2	15.0	13.1	-10.3
2.	C C-748	-	12.5	16.3	14.4	-1.4
3.	C O_3	-	15.5	17.8	16.7	14.4
4.	LC C-15	14.0	14.1	15.2	14.4	-1.4
5.	LC C-32	12.8	12.3	13.7	12.9	-11.6
6.	DH-13	16.1	17.2	16.0	16.4	12.3
7.	DH-48	18.1	15.8	15.0	16.3	11.6
8.	DH-52	14.5	13.6	14.2	14.1	-3.4
9.	JC O-327	-	16.0	17.7	16.9	15.8
10.	JC O-331	-	13.9	16.5	15.2	4.1
11.	UD-684	19.6	17.5	17.3	18.1	24.0
12.	UD-685	19.8	18.1	17.7	18.5	26.7
13.	UD-686	17.6	14.4	15.7	15.9	8.9
14.	Hisar Anand	21.5	20.6	19.9	20.7	41.8
15.	Narnaul Sel.(check)	15.6	13.7	14.4	14.6	-
	C D at 5%	3.1	2.3	1.8		
	C V %	10.7	9.3	6.7		

Hisar did not show much variation in the oil content. In the Hisar accessions, the volatile oil content ranged from 0.3 to 0.4% . Among the 14 accessions, the oil content was high (0.4%) in CC.745, CC.748, *Narnaul* selection, JCo.327 and LCC.15, while oil content was low (0.3%) in UD.684, UD.685, UD.686 and DH.48.

Twelve accessions included in the IET were also analysed for oil. UD.118 (0.4%) has the highest oil content followed by UD.340, UD.88, UD.434-113 (0.3%).

COR/CM/1 Nutrient Management Trial

COR/CM/1.1 Response of fertility levels and plant spacing on the yield of coriander

Kumarganj

Studies were undertaken at Kumarganj to assess the response of various fertilizer levels and spacing on growth and yield of coriander. The experiment comprised of three levels of fertilizers (20:10:10, 40:20:20, 60:30:30 kg/NPK/ha) and four spacings (30x5, 30x10, 45x5, 45x10 cm), laid out in RBD with three repli-

cations during *Rabi* 1997-98. Based on the observations recorded, both spacing and fertilizer levels significantly influenced the yield. The fertilizer level of 60:30:30 kg/ NPK/ha recorded higher yield (1800 kg/ha). As regards spacing, 30x10 cm gave higher yield (1700 kg/ha) compared to other spacings. Though interaction effect was not significant for yield, the combination of 20:10:10 kg/ NPK/ha with 45x10cm recorded the highest grain yield of 2437 kg/ha followed by the combination 60:30:30kg NPK/ ha with 30x5 cm spacing (2066 kg/ ha).

COR/CM/1.2 Response of coriander to micronutrients

Jobner

To study the response of coriander to micronutrients, an experiment was laid out in RBD with three replications using the variety RCr.435 during *rabi* 1997-98 involving 13 treatment combinations. This includes $ZnSO_4$ (20 kg/ha soil application, 0.5 % foliar spray, 10 kg/ha soil application + 0.25% foliar spray), $FeSO_4$ (10 kg soil application, 0.25% foliar, 5.0 kg soil application + 0.125 % foliar), Mn SO_4 and $CuSO_4$ (each of 25 kg/ ha soil application, 0.5% foliar, 12.5 kg soil application + 0.25 % foliar). The first year data revealed that application of micronutrients significantly influenced the yield and yield attributing traits. Significantly higher grain yield (599 kg/ha) and straw yield (2874 kg/ha) were recorded in plants that received $FeSO_4$ 5.0 kg/ha + 0.125% as foliar spray over control (321 and 1936 kg/ha of grain and straw yield respectively).

Table 33 Mean performance of coriander accessions for volatile oil at Jobner

Accession	Grain Yield (kg/ha)	Volatile oil (%)			Mean oil yield (l/ha)
		1996-97	1997-98	Mean	
JC o – 331	608	0.40	0.35	0.38	2.3
DH – 52	583	0.40	0.30	0.35	2.0
Local	573	0.30	0.40	0.35	2.0
LC C – 32	394	0.30	0.40	0.35	1.4
JC o – 327	543	0.32	0.35	0.34	1.8
RC r – 41	664	0.35	0.30	0.33	2.2
LC C – 15	474	0.30	0.35	0.33	1.5
UD – 684	885	0.30	0.30	0.30	2.7
UD – 686	707	0.30	0.25	0.28	1.9
UD – 685	554	0.30	0.25	0.28	1.5
DH – 13	733	0.20	0.30	0.25	1.8
DH – 48	661	0.25	0.25	0.25	1.7

During the year the yield was low due to hail storm that damaged the crop.

COR /CP /1 Disease Management Trial

COR /CP /1.1 Survey to identify the disease incidence, collection and identification of causal organism

Dholi

The stem gall is a serious disease caused by the fungus *Proteromyces macrosporous*, that causes severe damage to coriander. In order to study the extent of severity of damage, surveys were taken up in coriander growing areas of Bihar during the past two years. The study showed that the disease is prevalent in all coriander growing areas of the state and the incidence of gall is severe.

COR /CP /1.2 Studies on wilt and powdery mildew management in coriander / Biocontrol of wilt in coriander

Coimbatore

At Coimbatore, 11 accessions were screened for wilt incidence. Two accessions *viz*., ATP-77 and JCo.64 registered the lowest wilt incidence (5.4% and 5.7% respectively). Studies were carried out at Coimbatore to evolve an effective biocontrol measure for wilt in coriander with 16 treatment combinations including control. The results from Table 34 revealed that treatments significantly reduced the wilt incidence. During the year the wilt incidence ranged from 3.5 to 23.8% among the treatments. The lowest incidence(3.5%) was noticed in two treatments *viz*., seed treatment with *Trichoderma viride* along with foliar spray of Hexaconazole and seed treatment with *T. viride* along with foliar spray of Thiophenate methyl on 25, 40, 55 DAS as against control (20.0%). The mean data over two years (1997 and 1998) also showed that the lowest incidence (3.5%) was recorded in the *Trichoderma* + Hexaconazole combination followed by *Trichoderma* + Thiophenate methyl combinations (3.7%). The *Trichoderma* + Thiophenate methyl combination was also best in obtaining higher yield (347.5 kg/ha) compared to control (234.0 kg/ha).

COR/CP/1.3 Studies on stem gall disease management of coriander by different fungicides

Dholi

The seed treatment with Bavistin 1g/kg of seed for 15 minutes recorded only minimum stemgall disease incidence in coriander at Dholi.

Treatment details

T_1 - Seed treatment with *Trichoderma viride* + Hexaconozole foliar spray on 25,40,55 days after sowing

T_2 - Seed treatment with *Trichoderma viride* + Thiophanate methyl foliar spray on 25,40,55 days after sowing

T_3 - Seed treatment with *Trichoderma viride* + Mancozeb foliar spray on 25,40,55 days after sowing

T_4 - Seed treatment with *Trichoderma viride* alone

T_5 - Seed treatment with Carbendazim + Hexaconazole foliar spray on 25,40,55 days after sowing

T_6 - Seed treatment with Carbendazim + Thiophanate methyl foliar spray on 25,40,55 days after sowing

T_7 - Seed treatment with Carbendazim + Mancozeb foliar spray on 25,40,55 days after sowing

T_8 - Seed treatment with Carbendazim alone

T_9 - Soil application of neem cake + Hexaconazole foliar spray 25,40,55 days after sowing

T_{10} - Seed Treatment of neem cake + Thiophanate methyl foliar spray on 25,40,55 days after sowing

T_{11} - Soil Application of neem cake + Mancozeb foliar spray on 25,40,55 days after sowing

T_{12} - Soil Application of neem cake alone

Table 34 Biocontrol of coriander wilt at Coimbatore

Treatment	Yield (kg/ha)			Wilt incidence (%)		
	1997-98	1998-99	Mean	1997-98	1998-99	Mean
T_1	315	335	335	3.5	3.5	3.5
T_2	345	350	348	3.8	3.5	3.7
T_3	310	340	325	4.6	4.0	4.3
T_4	305	345	325	5.0	4.5	4.8
T_5	295	315	305	5.6	5.0	5.3
T_6	270	320	295	5.8	5.5	5.7
T_7	255	305	280	6.8	6.0	6.4
T_8	250	300	275	7.5	7.0	7.3
T_9	255	295	275	6.6	6.5	6.6
T_{10}	248	300	274	6.9	6.5	6.7
T_{11}	243	310	277	7.3	7.0	7.2
T_{12}	238	295	267	10.6	9.5	10.1
T_{13}	235	249	242	11.0	10.0	10.5
T_{14}	233	248	241	12.5	9.5	11.0
T_{15}	235	250	243	12.5	10.5	11.5
T_{16}	228	240	234	27.5	20.0	23.8
C D at 5%	6.4	2.1	-	2.8	1.6	

T_{13} - Hexaconazole foliar spray on 25,40,55 days after sowing

T_{14} - Thiophanate methyl foliar spray on 25,40,55 days after sowing

T_{15} - Mancozeb foliar spray on 25,40,55 days after sowing

T_{16} - Control

CUMIN

CUM/CI/1 Genetic Resources

CUM/CI/1.1 Germplasm collection, characterization, evaluation, conservation and screening against diseases

Jobner and Jugudan

The Jobner centre maintains 323 accessions. During the current year, survey was carried out in Kishangarh, Kekari, Malpura, Niwai, Todaraisingh and Makrana areas and 14 new collections were added to the germplasm. In the screening of cumin accessions for disease resistance, the percent mortality due to disease incidence was low (8.3%) in EC.232684 with grain yield of 214 kg/ha against control (33.3% with 61/kg/ha).

At Jagudan, 58 new collections were made during the current year. At present 153 accessions are maintained. Two cultures viz., Sel. 75-1 and Sel.73-1 are resistant to *Fusarium* species out of 41 accessions tested under wilt sick plot condition. For root knot nematode (*Meloidogyne incognita*) the accessions JC-94-23 and JC-94-57 showed moderate resistance.

CUM/CI/2 Hybridization Trial

CUM/CI/2.1 Mutation studies and hybridization programmes in cumin

Jagudan

Hybridization programme was initiated at Jagudan to develop high yielding varieties with disease resistance.

The centre is maintaining five exotic wilt resistant lines, one line with bold seed and another line with spreading and dwarf nature. These genotypes are being used for crop improvement work.

From the F_1 seeds of the cross EC.232684 x GC 2 only one plant germinated and appeared as dwarf and also wilt resistant. From this F_2 seeds were harvested for further study.

In another cross involving GC.2 x EC 232684, none of the F_1 seeds germinated. During the year some more crosses were made successfully and F_1 seeds were harvested from the crosses GC2 x Hairy cumin; GC 3 x white flower cumin; white flower cumin x GC 2 and GC 3 x GC 2.

Standard breeding methods are not available in cumin. Hence, to determine the optimum day and time of pollination for high fruit set, pollination trials were attempted at different days and time intervals in the cross GC 2 x Hariyumin. The treatments are as follows:

For optimum day of pollination

T_1 - Pollination on second day of emasculation

T_2 - Pollination on third day of emasculation

T_3 - Pollination on fourth day of emasculation

T_4 - Pollination on second and third day of emasculation

T_5 - Pollination on third and fourth day of emasculation

T_6 - Pollination second third and fourth day of emasculation

T_7 - No Pollination (only emasculation).

For optimum time of pollination (GC 2 x Hairy cumin)

T_1 - Pollination immediately after emasculation (a time)

T_2 - Pollination same day at 11.00 am

T_3 - Pollination same day at 12 .00 pm

T_4 - Pollination same day at 1.00 pm

T_5 - Pollination same day at 2.00 pm

T_6 - Pollination same day at 3.00 pm

T_7 - Pollination next day at 10.00 am

T_8 - Pollination next day at 11.00 am

T_9 - Pollination next day at 12.00 pm

T_{10} - Pollination next day at 1.00 pm

T_{11} - Pollination next day at 2.00 pm

T_{12} - Pollination next day at 3.00 pm

Note : Emasculation was done before 10.00 am

From all the treatment combinations total of 216 F_1 seeds were collected for further studies.

CUM/CI/3 Coordinated Varietal Trial

CUM/CI/3.1 CVT 1994 – Series II

Jobner and Jagudan

At Jobner, the CVT was laid out in RBD with three replications during *rabi* 1997-98, involving eight accessions from Rajasthan (UC.217, UC.220, UC.223, RZ.19 and local check) and Gujarat (JC.147, EC.232684 and EC 279081). During the year, the accession EC.232684 recorded highest grain yield of 214 kg/ha as against RZ.19 (91 kg/ha) and local check (84 kg/ha). The crop was severely damaged due to heavy incidence of wilt (8.3 to 33.3%) and blight (11.7 to 50%), due to which very low yield was recorded during the year. The mean performance of accessions evaluated over three years (1995-96 to 1997-98) indicated the superior performance of UC.223 with a grain yield of 237 kg/ha as evidenced from Table 35. This was closely followed by EC.232684 (227 kg/ha). The lowest yield (167 kg/ha) was recorded in UC.220. The wilt incidence was lowest (11.3%) in UC.223.

The CVT at Jagudan consists of seven accessions (EC.232684,

EC.279081, JC.147, UC.217, UC.220, UC.223 and GC.2 (check) laid out in RBD with four replications during *rabi* 1998-99. During current year the yield differences were non significant among the accessions. However, an increase in yield over control (797 kg/ha) of 9.03% was observed in EC 279081 (869 kg/ha). The pooled data over three years (1995-96 to 1998-99) presented in Table 36 revealed that the yield differences were non-significant among the accessions. However, an yield increase of 12.9% over control (699 kg/ha) was recorded by the accessions EC.279081 (789 kg/ha).

CUM/CI/4 Quality Evaluation Trial

CUM/CI/4.1 Quality evaluation in cumin

Jobner

During the year the crop completely failed due to frost and hail storm. The blight incidence was also high. Hence, the crop yield was very low and the volatile oil content was very high. The trial will be taken up during next year in the normal condition. Out of the accessions (EC. 232684, JC.147, EC. 279081, RZ.19, UC.217, Local, UC. 223) analysed, volatile oil content, ranged from 4.3 to 6.3%. The highest volatile oil content (6.3%) was recorded in EC.232684 and lowest (4.3%) in UC. 223.

CUM/CI/4.2 Evaluation of essential oil of cumin

Jobner

The volatile oil content of seven accessions viz., RZ-19, JC.147, UC.220, UC.223, UC.217, EC.279081 and EC.232684 grown at agricultural farm, SKN College of Agriculture, Jobner were fractionated on GLC. The essential oil of cumin contains seven main peaks on the basis

Table 35 Yield performance of cumin accessions under CVT at Jobner

Accession	Grain yield (kg/ha)				Wilt incidence (%)			
	1995-96	1996-97	1997-98	Mean	1995-96	1996-97	1997-98	Mean
UC – 217	260	195	91	182	28.8	21.3	23.3	24.4
UC – 220	296	143	61	167	12.5	26.3	33.3	24.0
UC – 223	313	352	46	237	5.0	13.8	15.0	11.3
JC – 147	284	255	130	223	27.5	18.8	16.7	21.0
EC – 279081	281	202	156	213	20.0	31.3	21.7	24.3
EC – 232684	180	286	214	227	15.0	12.3	8.3	11.9
RZ – 19	243	286	91	207	25.5	12.3	13.3	17.0
L. Check	272	260	84	205	27.5	22.50	11.7	20.6
C D at 5%	070	088	51					

of their retention time. The per cent area determined was shown in Table 37.

The volatile oil of cumin consists of mixtures of terpenes of oxygenated compounds (cuminaldehyde, cuminyl alcohol) and hydrocarbon compounds (terpenes, P-cymenes, pinenes). The ratio of oxygenated compound and hydrocarbon compounds were determined and correlated with wilt incidence occurred during the year (Table 38).

The oxygenated compounds *viz*., cuminaldehyde and cuminyl alcohol are responsible for wilt resistance. The data from above table clearly indicated that the wilt resistant accession EC.232684 had the highest (0.84) ratio of oxygenated compound vs hydrocarbon which was responsible for wilt resistance. The other accessions having less oxygenated compound to hydrocarbon ratio, were susceptible to the disease.

CUM/CM/1 Irrigation Trial

CUM/CM/1.1 Irrigation schedule for cumin with reference to yield and blight diseases

Jagudan

At Jagudan, a trial with five treatments was laid out to work out the ideal irrigation schedule. The treatments showed significant difference for yield. The highest yield (555 kg ha) was recorded with five irrigations (at sowing 8, 30, 50 and 70 DAS) and was at par with four irrigations. The blight incidence was low (10.85%) with two irrigations whereas, the incidence was high (20.89%) in five irrigations.

CUM/CM/2 Nutrient Management Trial

CUM/CM/2.1 Integrated nutrient management in cumin

Jagudan

An experiment, comprising of eight

Table 36 Yield performance of cumin accessions under CVT at Jagudan

Accession	Grain yield (kg/ha)				% increase
	1995-96	1997-98	1998-99	Mean	over control
EC – 232684	714	613	722	683	12.9
EC – 279081	850	648	869	789	-
JC – 147	351	657	718	575	-
UC – 217	557	523	847	642	-
UC – 220	479	498	671	549	-
UC – 223	400	480	735	538	-
GC 2 (Check)	671	629	797	699	-
C D at 5%	2.2	0.4	NS	NS	

treatment combinations involving organic cakes and inorganic fertilisers was laid out in an RBD with four replications during *rabi* 1998-99 for the second time. The results are presented in Table 39. During the current year the treatment viz., half recommended dose in the form of mustard cake + half recommended dose in inorganic form recorded higher yield (1139 kg/ha) though the yield difference due to treatments was not significant. Similar trend was recorded last year also.

CUM/CP/1 Disease Management Trial

CUM/CP/1.1 Blight disease control by manipulation of agronomic practices

Jagudan

In the trial involving six treatment combinations viz., T_1 - control, T_2 - straw mulch, T_3 - inter culturing a day after irrigation, T_4 - removal of dew by cloth or rope, T_5 - providing strip of more cooling type crop (gram), T_6 - by putting hygroscopic chemical in plot ($CaCl_2$) to find out the factors influencing blight disease the treatments significantly influenced the yield. Significantly higher grain yield (747 kg/ha) was recorded under the treatment T_3 (inter culturing a day after irrigation) as against control (556 kg/ha). The mean performance of yield over two years presented in Table 40 also revealed that the same treatment was the best, registering higher yield (571 kg/ha) than control (449 kg/ha).

CUM/CP/1.2 Epidemiological study of *Alternaria* blight of cumin

Jobner and Jagudan

At Jobner, a trial was laid out during *rabi* 1997-98 in RBD with four

Table 37 GC pattern of volatile of oil of cumin accessions at Jobner (Peak area %)

Main Peaks	RZ-19	JC-147	UC-220	UC-223	UC-217	EC- 279081	EC- 262384
A	14.2	14.5	12.9	13.2	10.6	11.3	13.4
B	1.0	1.1	1.0	1.0	0.9	0.9	1.2
C	38.6	38.0	37.6	35.2	40.0	39.7	24.6
D	15.9	15.7	16.3	16.8	16.1	16.3	13.0
E	0.8	1.5	1.4	2.0	2.8	1.5	1.4 1.2
F	12.4	12.8	12.8	15.0	12.9	12.6	19.0
G	12.3	12.0	13.9	11.4	11.6	12.2	22.5
Ratio (Oxygenated to Hydrocarbon)	0.4	0.4	0.4	0.4	0.4	0.4	0.9

A,B,C,D Hydrocarbon components

E,F,G oxygenated components

Table 38 Volatile oil constituents and relative wilt resistance in cumin

Entry	Volatile oil constituents (%)		Ratio of a:b	Relative wilt resistance
	a	b		
EC-232684	44.0	52.1	0.84	R
UC-223	28.4	66.1	0.43	S or MR
JC-147	26.2	69.3	0.38	S or MR
UC-217	27.4	67.5	0.41	S or MR
UC-220	28.1	67.7	0.42	HS or S
RZ-19	25.5	69.7	0.38	HS or S
EC-279081	26.3	68.1	0.39	HS or S

R = Resistant MR = Moderately resistant S= Susceptible HS= Highly susceptible
a = Oxygenated compounds b = Hydrocarbons

replications involving five dates of sowing (10, 20, 30 Nov. and 10 and 20 Dec.) to study the effect of dates of sowing on wilt incidence and yield of cumin. Though blight disease did not appear during the year, the wilt incidence recorded ranged from 20% (10, Nov.) to 46.0% (20, Dec) among different sowing dates.

At Jagudan, in order to identify several epidemiological parameters related to disease development such as weather factors, crop factors and pathogen / disease development during an epidemic under natural conditions, a trial was laid out in RBD during *rabi* 1998-99 with three replications comprising five dates of sowing (5, 15, 25, Oct., 5 and 15, Nov.).

During the current year, powdery mildew incidence was not noticed, thus per cent disease index on blight alone was worked out. The dates of sowing significantly influenced the blight incidence and yield. The data presented in Table 41 showed that early sowing (5, Oct) had significantly less blight index (1.7) compared to other sowing dates. However, this was on par with 15 October and 15 Nov. sowing. The disease index was more (2.4) in 25, Oct. sown crop. Similar trend was recorded in last year crop also.

As regards yield, significantly higher grain yield (216.5 kg/ha) was recorded in 15 Oct sown crop followed by 25 Oct. sown crop (132.0 kg/ha). Thus 15 Oct. seems to be most appropriate date of sowing in terms of less disease incidence (1.82) with high yield (216.5 kg/ha).

Table 39 Integrated nutrient management in Cumin

Treatment	Grain yield (kg/ha)		
	1997-98	1998-99	Mean
T_1 – F.R.D in form of castor cake	448	997	723
T_2 – F.R.D in form of mustard cake	497	1037	767
T_3 – F.R.D in form of FYM	497	941	719
T_4 – ½ R.D in form of castor cake + ½ R.D in inorganic form	480	1026	753
T_5 – ½ R.D in form of mustard cake + ½ R.D in inorganic form	613	1139	876
T_6 – ½ R.D in form of FYM + ½ R.D in inorganic form	532	1053	793
T_7 – F.R.D in inorganic form (N & P)	587	1087	837
T_8 – F.R.D N in inorganic form	550	1058	804
S.Em. ±	41.18	70.86	38.49
C D at 5%	NS	NS	NS

Abbreviation
F.R.D – Full recommended dose ½ R.D – Half recommended dose

Correlation coefficients between blight and various parameters were worked out (Table 42). Significant positive correlation between blight incidence and crop age was observed in all dates of sowing indicating that blight incidence increase with increasing crop age. The maximum temperature was found to have significant negative correlation with blight intensity in 5 and 25 Oct. and 5 Nov. sown crops indicating that increase in temperature reduced the disease incidence. Both minimum temperature and mean temperature showed negative correlation (in 15 Nov, and 25 Oct, 5 Nov.sown respectively). The relative humidity did not show any correlation with blight disease.

Table 40. Blight disease management by agronomic practices

Treatment	Grain yield (kg/ha)		
	1997-98	1998-99	Mean
T_1	342	556	449
T_2	388	683	536
T_3	396	747	571
T_4	391	689	540
T_5	306	647	476
T_6	365	644	505
S.Em. ±	63.1	32.3	34.09
C D at 5%	NS	97.3	NS

T_1-T_6 : see text

CUM/CP/2 Pest Management Trial

CUM/CP/2.1 Integrated management of pests and disease of cumin

Jobner and Jagudan

The Jobner centre laid out a trial during rabi 1997-98 for the effective management of pests and diseases of

Table 41 Epidemeology of *Alternaria blight* of cumin at Jagudan

Treatment	1997-98		1998-99	
	Blight (PDI)	Yield (kg/ha)	Blight (PDI)	Yield (kg/ha)
5, October	0.3179 (6.4)	75.0	1.7	57.5
15, October	0.4283 (8.6)	235.9	1.8	216.5
25, October	3.1425 (62.9)	203.1	2.4	132.0
5, November	4.2067 (84.1)	154.1	2.3	70.8
15, November	3.1825 (63.7)	100.0	1.8	97.5
C D at 5%	0.14		0.6	107.5

cumin. The trial consisted of four main treatments (T_1 - seed treatment and soil application with *Trichoderm a harzianum*, T_2 - seed treatment with 0.1% Carbendazim + soil application of *T. harzianum*, T_3 - neem cake, T_4 - control) and 13 subtreatments and laid out in a split plot design with three replications.

The wilt incidence was recorded in each treatment as the percentage of plants wilted till maturity of the crop. Three sprays were given at an interval of 15 days. Observations were made for blight and powdery mildew incidence and for number of aphids and thrips before and after 72 hours of each spray and at the time of harvest.

It is revealed from Table 43 that the treatments *viz*., basal application of *T. harzianum* with and without Carbendazim and neem cake as soil application reduced the wilt incidence in comparison with control. The lowest incidence (23.7%) was recorded in plots that received *T. harzianum* as both seed treatment and soil application along with plot sprayed with Mancozeb (Indofil M 45) @ 0.3% + neem oil @ 1.0% and *Tepol* @ 1.0% as against control (34.3% incidence).

Table 42 Correlation between blight disease and meteorological factors

Treatment	Meteorological parameters				
	Crop age	Max. Temp	Mini. Temp	Mean	Mean RH
5 October	0.93*	-0.89	0.31	-0.74	-0.67
15 October	0.77*	-0.73	0.52	-0.27	-0.43
25 October	0.99*	-0.88*	-0.49	-0.76*	0.01
5 November	0.96*	-0.90*	-0.66	-0.85*	-0.03
15 November	0.96*	0.20	-0.77*	-0.10	-0.71

Table 43 Integrated management of pest and diseases of cumin at Jobner

Sub treatment	Main treatments			
	ST+SA of TH PWI	ST.C+SA TH PWI	A OC (Neem) PWI	Control PWI
Mb @ 0.3%	25.0	27.0	35.0	42.0
Mb @ 0.3%+No @ 1%+TP	23.7	27.7	32.0	40.0
Mb @ 0.3%+MOP @ 0.04%	29.0	27.3	29.3	33.3
Mb @ 0.3%+Acep	28.3	26.0	34.3	45.0
Hex (Contact) @ 0.05%	29.7	26.7	36.0	40.3
Hex@0.05%NO@1%+Tp@1%	32.7	24.7	38.0	45.0
Hex @0.05% MOP @ 0.04%	33.7	27.0	39.0	46.7
Hex @ 0.05% + Acep @ 0.075%	26.7	28.0	36.0	47.7
Pene.(Topas) @ 0.05%	30.0	27.3	33.3	43.7
Pene.(Topas) @ 0.05% + MOP @ 0.04%	32.3	25.7	37.0	43.3
Thp.Me (Top.M) @ 0.07%	29.7	25.3	37.7	44.3
Thp.Me (Top.M) @ 0.07% + MOP @ 0.04%	31.7	28.0	35.3	48.0
Control (No spray)	34.3	33.3	40.3	51.7

PWI	=	Percent wilt incidence	Acept	=	Acephate
ST	=	Seed treatments	Hex	=	Hexaconazole
SA	=	Soil application	Tp	=	Tepol
ST with SA	=	ST with carbendazim + SA	Pene	=	Penaconazole
OC	=	Oil cake	Thp Me	=	Thiophanate Methyl
TH	=	*Trichoderma harzianum*	Com CV	=	Combined CV
Mb	=	Mancozeb	MOP	=	Monocrotophos
NO	=	Neem Oil			

The yield data could not be recorded due to hail storm damage. The overall efficiency of foliar fungicides, insecticides, neem oil and *Tepol* either alone or in combination with basal applications could not be worked out due to poor incidence of foliar diseases (blight and powdery mildew) and insects (aphids and thrips) which were only observed in control (no foliar treatment).

The Jagudan centre laid out the trial with three main treatment (T_1 - seed treatment and soil application of *Trichoderma harzianum*, T_2 - seed treatment with 0.1% Carbendazim + soil application of *Trichoderm a* , T - control) and 11 sub treatments (similar to Jobner) in a split plot design with two replications using GC.2 during 1998-99, but the trial was vitiated due to natural calamities.

FENNEL

FNL/CI/1 Genetic Resources

FNL/CI/1.1 Germplasm collection, characterization, evaluation, conservation and screening against diseases

Jobner, Jagudan, Hisar and Dholi

The Jobner centre is maintaining 193 cumin accessions which includes 19 new collections from Kishangarh, Kekari, Malpura, Niwai, Todaraisingh and Makrana areas added during the current year.

At Jagudan 155 accessions are being maintained. During current year 27 new collections of fennel were made from various fennel growing areas of the state. In the screening programme, four accessions *viz.*, JF.376, JF.377, JF.379 and JF.421 were moderately resistant to root knot nematode (*Meloidogyne incognita*). At Dholi, 40 accessions are being maintained.

At Hisar 58 accessions of fennel were evaluated in two row plots of 2.5m length (2.5 sq.m.) each using PF.35, GF. 1 and Local as checks during 1996-97 and 1997-98. The mean seed yield of the germplasm ranged from 210g (HF.159) to 710g per plot (HF-118). Thirty lines gave higher seed yield than the highest yielding check PF.35. The most promising lines are HF.110, HF.113, HF.118, HF.122, HF.125, HF.127 and HF.129. These lines were maintained by sib mating under muslin cloth and self seed of all the lines have been harvested.

FNL/CI/2 Hybridization Trial

FNL/CI/2.1 Mutation studies and crossing programme in fennel

Jagudan

There is no standard breeding method exists in fennel. Hence, hybridization work was initiated at Jagudan, with the objective of developing varieties with high yield and resistance to biotic stress (*Ramularia* blight, powdery mildew and aphids) coupled with dwarfness and earlyness.

In the F_2 study of the cross GF_1 X EC.386375 (for dwarfness), out of 11 plants germinated one appeared GF_1 type but had very late maturity and bitter taste. In another cross GF_1 X Bloom less (for inheritance study) 22 plants germinated, but all were bloom less type.

FNL/CI/3 Coordinated Varietal Trial

FNL/CI/3.1 CVT 1994 – Series II

Jobner, Hisar and Jagudan

At Jobner the CVT was laid out with 11 accessions, five from Jobner (UF.143, UF.144, RF.101, RF.125 and local check), three each from Hisar (HF. 33, HF.35, and HF.39) and Jagudan (JF. 186, JF.192 and JF.200). The trial was laid out in RBD with four replications during *rabi* 1998-99.

During current year, the crop was severely damaged by hail storm and yield was low. The accession RF.125 recorded best grain yield (281 kg/ha) followed by UF.143 (269 kg/ha), as against the lowest yield (100 kg/ha) registered in local check. The volatile oil content was highest (2.0%) in RF.125 while it was lowest (1.60%) in three accessions *viz*., local check, UF.143 and HF.39.

The CVT at Jagudan consists of eight accessions (JF.186, JF.192, JF. 200, UF.143, UF.144, HF.33, HF.39 and GF.2; check) laid out in RBD with four replications during *rabi* 1998-99. The accessions differed significantly for yield, but not significantly superior over control. However, an yield increase of 7.4% was observed in JF.192 (2743 kg/ha) than control (2554 kg/ha). The pooled data from Table 44 indicated that the mean differences were significant for yield. The accession JF 200 registered an yield of 2720 kg/ha which was 6.8% higher than control (2547 kg/ha) and was on par with JF 186, JF.192 and GF.2.

At Hisar ten entries of fennel *viz*., HF.33 and HF.39 from Hisar; JF.186, JF.192 and JF.200 from Jagudan; UF.143 and UF.144 from Jobner and PF.35, GF.1 and local were tested as check during the year 1997-98 and 1998-99. Maximum seed yield was recorded in PF.35, closely followed by HF.33 and JF.186. Plant height ranged from 121.9 to 139.3 cm; number of branches from 6.3 to 7.5 and umbels per plant from 23.9 to 38.9. In 1998-99, the crop was damaged due to heavy infestation of caterpillar.

FNL/CI/4 Quality Evaluation Trial

FNL/CI/4.1 Quality evaluation in fennel

Jobner

The volatile oil content of 11 accessions (evaluated under CVT) analysed at Jobner ranged from 1.3 (UF.143, HF.39, JF.192 and local) to 2.0% (RF.125). The highest oil yield (5.62 l/ha) was recorded in RF.125 followed by JF.186 (3.66 l/ha) and lowest in local (1.30 l/ha).

Table 44 Yield performance of Fennel accessions under CVT at Jagudan

Accession	Grain yield (kg/ha)			
	1997-98	1998-99	Mean	% increase over control
JF – 186	2766	2606	2686	5.5
JF – 192	2618	2743	2681	5.3
JF – 200	2833	2606	2720	6.8
JF – 143	2360	2307	2334	–
JF – 144	2650	2402	2526	–
HF – 33	1737	2079	1908	–
HF – 39	2140	1947	2044	–
Check	2539	2554	2547	–
C D at 5%	5.8	3.2	3.1	

FNL/CM/1 Irrigation Trial

FNL/CM/1.1 Response of *rabi* fennel to irrigation, nitrogen and phosphorus

Jagudan

The highest grain yield of fennel was obtained at IW/CPE ration of 1:0 (10 irrigations) when fetilized with 90kgN & 30kg P_2O_5/ha.

FNL/CM/2 Spacing /Sowing Trial

FNL/CM/2.1 Effect of different inter and intra row spacings on yield of fennel

Jagudan

To study the effect of spacing on the yield of fennel, an experiment consisting six treatment combinations *viz.*, T_1 - 30 x 15cm , T_2 - 30 x 22.5cm, T_3 - 45 x 15cm, T_4 - 45 x 22.5cm, T_5 - 60 x 15cm, T_6 - 60 x 22.5cm was laid out in an RBD with four replications during *rabi* 1998-99. The results presented in Table 45 showed that the treatments significantly influenced the yield. During current year, higher grain yield (2236 kg/ha) was recorded under 30 x 15cm spacing and was on par with 30 x 22.5 cm spacing (2108 kg/ha). The same treatment (30x15cm) also recorded higher mean yield (2099 kg/ha).

Table 45 Effect of spacings on the yield (kg/ha) of Fennel

Treatments	Yield (kg/ha)		
	1997-98	1998-99	Pooled
T1	1962	2236	2099
T2	1807	2108	1958
T3	1910	1999	1954
T4	1589	1930	1759
T5	1867	1936	1902
T6	1749	1892	1821
C D at 5%	233.9	156.6	140.0

FNL/CM/3Nutrient Management Trial

FNL/CM/3.1 Studies on organic and inorganic source of fertiliser for sustainable productivity in fennel

Jagudan

An experiment involving both organic and inorganic form of fertilizer for attaining sustainable productivity in fennel was laid out in an RBD with four replications during *rabi* 1998-99 for the second time.

The treatment differed significantly for yield during both the years (Table 46).

During current year the highest gain yield of 2825 kg/ha was recorded in the treatment T_7 (Full recommended N & P in inorganic form) which was on par with T_2 (Full recommended dose as mustard cake) T_4 (½ recommended dose in form of castor cake + ½ recommended dose in inorganic form) and T_5 (½ recommended dose in form of mustard cake + ½ recommended dose in inorganic form). The same treatment (T_7) recorded higher mean yield (2500 kg/ha) but was not significant.

Table 46 Effect of organic and inorganic source of fertilizer on the yield of fennel at Jagudan

Treatments	Yield (kg/ha)		
1. F.R.D in form of castor cake	1677	2391	2034
2. F.R.D in form of mustard cake	1869	2687	2278
3. F.R.D in form of FYM	1776	2068	1921
4. ½ R.D in form of castor cake + ½ R.D in inorganic form	2083	2676	2380
5. ½ R.D in form of mustard cake + ½ R.D in inorganic form	1663	2619	2116
6. ½ R.D in form of FYM + ½ R.D in inorganic form	1912	2469	2198
7. F.R.D in inorganic form (N & P)	2176	2825	2500
8. F.R.D N in inorganic form	1984	2449	2217
CD at 5%	226.7	328.3	NS

FRD – Full recommended dose ½ RD – Half recommended dose

FENUGREEK

FGK/CI/1 Genetic Resources

FGK/CI/1.1 Germplasm collection, characterization, evaluation, conservation and screening against diseases

Jobner, Jagudan, Coimbatore, Guntur, Hisar, Dholi and Kumarganj

At Jobner, 337 accessions are maintained. This involves 319 indigenous, 12 exotic and six new collections. The new collections were made from Kekari, Baran, Kota, Jalwar and Bhawanimandi areas. Screening for locating resistance to root knot nematode indicated that accessions UM.32, UM.34 and UM.464 were resistant, while the UM.117, UM.127, UM.128, UM.129 and UM.305 are moderately resistant.

Jagudan centre holds 50 accessions in which 48 are indigenous and two are exotic. In the screening programme, the accession *Kasuri* showed resistance against powdery mildew disease; whereas, none of accessions was resistant to nematode. However, accessions HM.114 and UM.301 were moderately susceptible against *M.incognita* and M.*javanica* respectively.

Coimbatore centre maintains 262 accessions. During the current year, 62 new accessions were added from various fenugreek growing areas. The accessions evaluated varied

phenomenally for yield and growth traits. About 53 accessions are promising for yield.

At Dholi, 105 accessions are being maintained. Under screening programme the accessions HM.103, *Rajendra Kanti,* UM.306, UM.9, RM.5, UM 29, J.Fenu.58, UM 66, RM.1, HM 291, J.Fenu.115, CF 390, Sel.109 were graded as moderately resistant to *Cercospora* leaf spot.

At Kumarganj centre 65 accessions were maintained and evaluated for yield and agronomic traits. The accession HM.114 recorded the highest yield (2316 kg/ha) followed by JF.58, UM.301 and HM.305 with grain yield of above 2000 kg/ha.

The Guntur centre is holding 124 accessions and 54 accessions were evaluated during *rabi* 1998-99. The grain yield ranged from 600 (LFC.112) to 1400 kg/ha (LFC.114). The accessions *viz*., LFC.113, KFC.99, LFC.124 and LFC.87 were the high yielders with grain yield above 1200 kg/ha.

FGK/CI/2 Hybridization Trial

FGK/CI/2.1 Evolving varieties resistant to powdery mildew through mutation breeding and crossing programme

Jagudan

Similar to cumin and fennel, fenugreek lacks standard breeding technique and such technique has to be developed to evolve improved varieties coupled with resistance to powdery mildew.

At Jagudan, crosses were made between *Methi* local (F) x *Kasuri,* (M) with the objective of developing powdery mildew resistant line. During current year, the F_1 seeds of the cross were sown. All plants appeared similar to the female parent, *Methi* local. The F_2 seeds were collected for further study.

FGK/CI/3 Coordinated Varietal Trial

FGK/CI/3.1 CVT 1995 – Series III

Coimbatore, Jobner, Guntur, Hisar, Dholi and Kumarganj

The coordinated varietal trial 1995 series III was laid out at the above centres (Table 47).

At Jobner, the CVT consists of 16 accessions from Rajasthan (UM.301, UM.302, UM.303, UM.304, RMt.1 and local check), Hisar (HM.110, HM.114, HM.291 and HM.305), Jagudan (J.Fenu. 581. J.Fenu. 102), Coimbatore (CO. 1464) and Dholi (RM.1 and RM.5) including Local check was laid out in RBD with four replications during *rabi* 1997-98. Significant differences among the accessions were noted for yield and yield parameters. The accession UM 303 recorded the highest grain yield (2494 kg/ha) followed by RMt.1 (2305 kg/ha) and J.Fenu 102 (2297 kg/ha). The check recorded the lowest yield

Table 47 Comparative yield (kg/ha) performance of fenugreek accession under CVT at AICRPS centres (1998-99)

Accession	Dholi	Kumarganj	Coimbatore
UM – 301	1713	1875	490
UM – 302	1481	2150	556
UM – 303	1805	2500	556
UM – 304	1528	2566	467
RMt.1	-	2258	-
Check	-	K.selection	
2583	-		
HM – 110	1875	2291	534
HM – 114	1713	2505	530
HM – 291	1389	2187	490
HM – 305	1343	2258	-
J.Fenu 58	1273	2325	-
J.Fenu 102	1478	2466	-
C O.1	-	-	463
ACC.464	-	-	-
RM 1	1667	2258	-
RM 5	1632	2429	-
HM 346	-	2291	-
HM 350	-	1875	-
Rajendra Kanti	1296	2291	-
HM 295	-	-	467
C D at 5%	1.3	3.1	5.6

(1498 kg/ha) as evidenced from Table 48. The powdery mildew incidence was lowest (1.0%) in the accession UM 302 as against the highest (8.0%) recorded in HM.305 and HM.110.

The mean performance of accessions evaluated for three years (1995-96 to 1997-98) indicated the superiority of UM.303 with highest yield (2321 kg/ha) followed by HM.114 (2116 kg/ha) and J.Fenu.102 (2080 kg/ha) as against the lowest yield (1595 kg/ha) registered under local check. The lowest incidence (1.60 score) of powdery mildew was noted in UM.304, whereas, the incidence was highest (7.0 score) in HM.110.

At Coimbatore, the CVT was laid out in RBD with three replications during *kharif* 1998. There were nine accessions (HM.114, HM.295, HM.110, HM.291, UM.301, UM.302, UM.303 and UM.304) including check (CO.1). The accessions evaluated

Table 48 Mean performance of Fenugreek accession under CVT at Jobner

Accession	Grain yield (kg/ha)				Powdery mildew incidence (%)			
	1995-96	1996-97	1997-98	Mean	1995-96	1996-97	1997-98	Mean
UM – 301	1979	1979	2071	2025	7.0	4.0	5.0	5.3
UM – 302	2534	1458	1654	1506	3.0	2.0	1.0	2.0
UM – 303	2500	2148	2494	2321	5.0	4.0	4.5	4.3
UM – 304	2153	2213	1869	2041	1.0	0.8	4.0	1.6
HM – 110	2344	1953	2109	2031	7.0	6.5	8.0	7.0
HM – 114	2083	1953	2279	2116	7.0	5.3	7.5	6.5
HM – 291	2188	1967	2038	2003	3.0	1.5	3.5	2.7
HM – 305	2118	1941	2161	2051	7.0	2.3	8.0	5.8
ACC- 464	1476	1589	2025	1807	3.0	2.0	6.0	3.7
C O – 1	-	1550	2025	1788	-	2.0	6.0	4.0
JF – 58	-	1758	2077	1918	-	2.5	7.0	4.8
JF – 102	-	1863	2297	2080	-	6.3	6.0	6.1
RMt 1	1841	1810	2305	1985	7.0	4.8	6.0	5.9
Check	-	1693	1498	1696	-	2.5	5.0	3.8
C D at 5%	4.3	5.0	4.2	-	-	-	-	-

showed significant difference for yield and various agronomic traits. The grain yield ranged from 463 kg/ha (CO.1) to 556 kg/ha (UM.302) among the accessions.

At Jagudan, the CVT was laid out with 12 accessions *viz*., J.Fenu.195, J.Fenu.204, J.Fenu.210, J.Fenu.321, UM.322, UM.305, UM..324, HM.346, HM.350, AM.1, AM.5 and Guj.methi.1 (check) during *rabi* 1998-99 with three replications in RBD.

Yield among the accessions varied significantly during current year. The accession J.Fenu.195 recorded the highest grain yield (1694 kg/ha) which was 8.2% higher than control (1565 kg/ha). This was followed by J.Fenu.204 (1685 kg/ha) and HM.530 (1630 kg/ha).

The pooled results of three years (1995-96 to 1997-98) is presented in Table 49. The accession J.Fenu.102 recorded 7.0% higher yield (1864 kg/ha) than control (1741 kg/ha), though the mean yield difference was insignificant among the accession.

At Guntur, 12 accessions viz., RM.1, HM.305, HM.346, HM.350, JF. 195, JF.204, JF.210, UM.321, UM.322,

UM.323, UM.324 and Lam Selection 1 were evaluated in RBD with three replications during *rabi* 1998-99. The accessions differed significantly for yield and ranged from 650 (UM.323) to 1417 kg/ha (JF.210). The accession *viz*., JF.204, Lam.selection 1 and JF.195 are in the next best (1300, 1017 and 1000 kg/ha respectively) for high yield.

The Dholi centre laid out the trial with 13 accessions in RBD with three replications. The accessions differed significantly for yield traits and yield. The highest yield (1875 kg/ha) was recorded in HM.110 against check (1296 kg/ha). The accessions UM.303, UM. 301 and HM.114 are the next best yielders (1805 and 1713 kg/ha).

At Kumarganj, among the 16 accessions evaluated the highest yield (2583 kg/ha) was recorded in the entry Kumarganj selection. However, it was on par with the accessions UM.304, HM.114, UM.303 J.Fenu.102 and RM.5.

At Hisar 14 entries were tested including two from Coimbatore *viz*., CF.464 and C O.1, four from Hisar *i.e.*, HM.110, HM.114, HM.291 and HM.305; two from Jagudan ie., JF.58 and JF.102, four from Jobner ie., UM.301, UM.302, UM.303 and UM.304 along with Hisar *Sonali* and Local

Table 49 Mean performance of fenugreek accession under CVT at Jagudan

Accession	Grain yield (kg/ha)				% increase over control
	1995-96	1996-97	1997-98	Mean	
JF – 41	1951	1656	1333	1647	-
JF – 58	1759	1612	1662	1678	-
JF – 102	1889	1776	1927	1864	7.1
UM – 301	2154	1670	1510	1778	2.1
UM – 302	2154	1759	1528	1814	4.2
UM – 303	1883	1527	1422	1610	-
UM – 304	1790	1460	1681	1644	-
HM – 110	2019	1704	1702	1808	3.9
HM – 114	1944	1695	1556	1732	-
HM – 291	1531	1764	1445	1580	-
HM – 305	1821	1418	1329	1523	-
Methi Local	1864	1746	1611	1741	-
C D at 5%	3.0	1.9	NS	NS	-

(check) during 1997-98. The trial was laid out in randomized block design with three replications. The plot size was 4.0x2.4m accommodating 8 rows of 4 meter length spaced at 30cm apart with plant to plant spacing of 10cm maintained by thinning. Significant differences were obtained for all growth and yield parameters except for length of pods. Maximum seed yield was recorded in Hisar *Sonali* (22.3q/ha) which was at par with JF.102, HM.114, JF.58, UM.302 and UM.303. These entries gave significantly higher yield than local check. Plant height ranged from 75.0 to 104.0 cm; number of branches from 4.5 to 6.0; number of pods per plant 68.0 to 92.7 and number of seeds per pod from 15.6 to 17.3.

On the basis of average yield for three years (1995-96 to 1997-98) at Hisar the maximum seed yield was recorded as 22.6 q/ha in Hisar *Sonali* which was 37.8% higher over local check followed by UM.302 (25.0%) and JF.102 (20.7%) (Table 50).

Table 50 Yield performance of fenugreek genotypes at Hisar over three years (Series-III)

Sl.No.	Name of entry	Seed yield (q/ha)			%increase over Local check Mean
		1995-96	1996-97	1997-98	
1	C F-464	-	14.9	19.2	17.1	4.3
2	C O-1	-	16.0	19.0	17.5	6.7
3	HM-110	16.9	17.2	19.8	18.0	9.8
4	HM-114	19.4	18.2	21.3	19.6	19.5
5	HM-291	17.8	18.3	20.5	18.9	15.2
6	HM-305	16.7	17.7	19.5	18.0	9.8
7	JF-58	15.9	18.3	20.8	18.3	11.6
8	JF-102	18.8	19.4	21.3	19.8	20.7
9	UM-301	21.8	17.1	19.8	19.6	19.5
10	UM-302	21.4	19.2	20.8	20.5	25.0
11	UM-303	18.6	17.5	20.8	19.0	15.9
12	UM-304	17.3	15.3	18.5	17.0	3.7
13	Hisar Sonali	23.8	21.6	22.3	22.6	37.8
14	Local check	16.6	15.9	16.8	16.4	-
	C D at 5%	3.6	3.2	1.6	-	-
	C.V. %	11.3	10.8	4.3		

FGK/CI/4 Varietal/Evaluation Trial

FGK/CI/4.1 Comparative yield trial

Coimbatore, Hisar

At Coimbatore, the CVT was laid out with eight accessions (UM 143, UM.144, HM.103, HM.141, JF.145, JF. 148, CF.169, CF.390, and CO.1 (check)) during *kharif* 97 and *rabi* 98-99. The accessions showed significant differences, in respect of yield and growth parameters. During 1998-99 the accession CF.390 registered the highest yield (562.5 kg/ha) followed by CF.169 (534 kg/ha) as against the check (448.5 kg/ha) (Table 51).

The pooled data over two seasons indicated that the accession CF.390 was the best yielder with 562.5 kg/ha followed by CF.169 (534 kg/ha) and HM.103 (527 kg/ha) as against control (448.5 kg/ha).

At Hisar two initial evaluation trial (IET) in fenugreek were conducted, one for powdery mildew resistance and the other on green seed coat mutant lines, during the year 1995-96 to 1997-98 in a plot measuring 3.0 x 1.2m. The results indicated that HM.350 having resistance to powdery mildew gave 20.9 q/ha seed yield with an increase of 20.8% over Pusa Early Bunching. Among green seed coat mutant lines HM.346 gave the highest seed yield of 23.1 q/ha with an increase of 43.5% over Pusa Early Bunching.

FGK/CM/1 Spacing /Sowing Trial

FGK/CM/1.1 Effect of time of sowing and spacing in fenugreek

Coimbatore

The Coimbatore centre laid out an experiment to find out the optimum

Table 51 Yield performance of fenugreek accession under CYT at Coimbatore

Accession	No. seeds /pod			Grain yield (kg/plot)			Yield (kg/ha)
	1996-97	1997-98	Mean	1996-97	1997-98	Mean	
UM.143	16.1	16.8	16.5	0.531	0.490	0.5105	510.5
UM.144	14.7	13.6	14.1	0.425	0.423	0.4240	424.0
MH.141	14.9	15.9	15.4	0.480	0.467	0.4735	473.5
HM.103	14.3	16.6	15.5	0.530	0.512	0.5270	527.0
JF.148	15.0	15.8	15.4	0.490	0.467	0.4785	478.5
C F.169	14.7	16.2	15.5	0.465	0.490	0.4775	477.5
C F.169	14.8	15.4	15.1	0.578	0.490	0.534	534.0
C F.390	14.2	17.0	15.6	0.591	0.534	0.5625	562.5
C O.1	14.5	17.0	15.8	0.439	0.458	0.4485	448.5
C D at 5%	NS	1.2	-	0.014	0.192	-	-

spacing and time of sowing for fenugreek under Coimbatore condition, with three spacings (15 x 10, 22.5 x 10, 30 x 10 cm) and six dates of sowing (5 and 20 Sep., 5 and 20 Oct., and 5 and 20 Nov.,) in RBD with three replications. The results indicated that closer spacing (15x10 cm) under October sown crops (5 and 20 Oct.) recorded the highest yields (1304 and 1271 kg/ha respectively) compared to other spacing and sowing dates.

FGK/CM/2 Nutrient Management Trial

FGK/CM/2.1 Response of fenugreek varieties to row spacing and date of sowing

Jobner

In order to study the response of fenugreek varieties to spacing and date of sowing an experiment comprising 18 treatment combinations, involving two varieties (RMt.1 and UM.305), three row spacing (20, 25 and 30 cm) and three dates of sowing (31 Oct., 15 Nov., and 30 Nov.) was laid out during *rabi* 1997-98 in RBD with three replications.

Based on the first year result, the variety RMt.1 significantly differed from UM.305 for yield and yield traits and gave 2515 kg/ha as against UM.305 (2182 kg/ha). With respect to spacing, 30 cm row spacing registered significantly higher yield (2504 kg/ha) than other spacings. As regards sowing dates, 15 Nov. sown crops gave higher yield of 2443 kg/ha compared to 31, Oct. and 30, Nov. sown crops.

FGK/CM/2.2 Response of fertility levels and spacings on growth and yield of fenugreek

Kumarganj

The trial was laid out in a factorial RBD using three fertility levels (F_1-20:30:10 kg NPK/ha, F_2-40:40:10 kg/ha, F_3-60:50:10 kg/ha) and three spacings (S_1 - 30x5 cm, S_2 - 30x10 cm, S_3 - 30x15 cm). Fertility levels caused significant improvement in yield; 2285 kg/ha was obtained at F_3. Spacing of 30x10 cm produced significantly higher seed yield (2265 kg/ha) than other spacings. But the results were non significant.

FGK/CM/2.3 Response of fertilizer on the yield of fenugreek

Jagudan

An experiment with graded levels of fertilizer was laid out in an RBD with three replications during *rabi* 1998-99. The results presented in Table 52 revealed that the treatments differed significantly for yield under different levels of NPK. Among the nutrient levels (kg/ha) 40 kg N, 20 kg P, 205 kg K and S level, 20 kg/ha recorded higher yields (1385, 1435, 1437 kg/ha respectively). The same treatments recorded higher mean

yield also (1642, 1687, 1654 kg/ha respectively).

Table 52 Effect of fertilizer on the yield of fenugreek at Jagudan

Treatments	Yield (kg/ha)		
	1997-98	1998-99	Pooled
N levels			
N_1 – 10	1710	1303	1507
N_2 – 20	1882	1334	1608
N_3 – 40	1899	1385	1642
C D at 5%	94.8	NS	NS
P levels			
P_0 – 00	1720	1272	1496
P_1 – 10	1832	1315	1573
P_2 – 20	1939	1435	1687
C D at 5%	94.8	68.3	57.7
S levels			
S_0 – 00	1718	1236	1477
S_1 – 10	1901	1348	1624
S_2 – 20	1872	1437	1654
C D at 5%	94.8	68.3	57.7

FGK/CP/1 Disease Management Trial

FGK/CP/1.1 Bio control of root rot in fenugreek

Coimbatore

To evolve an effective biocontrol measure to fenugreek root rot, an experiment comprising eight treatment combinations was laid out at Coimbatore for two seasons viz., *kharif* 1997 and 1998. The treatments showed differential efficiency in the management of root rot during the two seasons studied and the results are presented in Table 53. During current year the root rot incidence was low (2.5%) in plants that received the combined treatment combination *viz.*, Seed treatment with *T.viride* along with soil application of neem cake, whereas, it was very high in

Table 53 Biocontrol of root rot of fenugreek at Coimbatore

Treatments	Root rot incidence (%)			Yield (kg/ha)		
	1997-98	1998-99	Mean	1997-98	1998-99	Mean
S.T with Carbendazim (2g/kg) + Soil drenching (0.1%)	7.0	3.5	5.3	325.0	345.0	335.0
S.T with T. *viride* (4g/kg)	5.5	2.7	4.1	365.0	385.0	375.0
S.A of T. *viride* 20 DBS	7.8	2.9	5.4	315.0	335.0	325.0
S.A of Neem cake (150 kg/ha)	10.0	5.0	7.5	285.0	315.0	300.0
S.T with T.*viride* + S.A of neem cake	5.0	2.5	3.6	375.0	390.0	382.5
S.A of T.*viride* + S.A of Neem cake	6.0	3.0	4.5	360.0	388.0	374.0
S.T with Carbendazim, soil drenching + S.A of neem cake	10.0	5.5	7.8	290.0	318.0	304.0
Control	43.0	25.0	34.0	220.0	295.0	257.5
C D at 5%	3.1	1.5	-	6.2	4.4	-

S.T : Seed treatment S.A : Soil application

control plots (25.0%). The next best treatment was seed treatment with *T. viride* alone (2.7%) followed by soil application of *T. viride* + neem cake which recorded the disease incidence of 3.0%. With respect to yield, seed treatment, with *T. viride* + soil application of neem cake recorded the highest yield (390 kg/ha) followed by the treatment soil application of *T. viride* + soil application of neem cake (388 kg/ha) as against control (295 kg/ha).

The mean performance of accessions evaluated for two years (1997-98 to 1998-99), the treatment *viz*., seed treatment with *T. viride* + soil application of neem cake registered significantly higher yield (382.5 kg/ha) compared to control (257.5 kg/ha).

GENETIC RESOURCES OF SPICES AT AICRPS CENTRES

(As on 31.3.1999)

Crop/Centre	Indigenous		Exotic	Total
	Cultivated	Wild and related sp		
Black pepper				
Panniyur	105		105	
Sirsi	75	21		96
Chintapalli	16	25	41	
Yercaud	106			106
Pundibari	2			2
Dapoli	9			9
Dholi	7	1		8
Cardamom				
Pampadumpara	77	14		91
Mudigere	238	7		245
Ginger				
Pottangi	160	2	3	165
Solan	176			176
Dholi	27			27
Raigarh	18			18
Kumarganj	10			10
Pundibari	15			15
Turmeric				
Pottangi	185	22		207
Jagtial	188			188
Dholi	57			57
Bhavanisagar	124			124
Raigarh	43			43
Kumarganj	28			28
Pundibari	60			60
Solan	172			172
Chintapalli	23			23
Coimbatore	232		2	234
Clove				
Yercaud	13			13
Thadiyankudisai	1			1
Pechiparai	21			21

Crop/Centre	Indigenous		Exotic	Total
	Cultivated	Wild and related sp		
Nutmeg				
Yercaud	15			15
Thadiyankudisai	1			1
Pechiparai	12			12
Dapoli	14			14
Cinnamon				
Yercaud	11			11
Thadiyankudisai	6			6
Pechiparai	12			12
Dapoli	12			12
Coriander				
Jobner	649		112	761
Jagudan	52		18	70
Coimbatore	205		205	
Guntur	230			230
Hissar				
Dholi	110			110
Raigarh	24			24
Kumarganj	67			67
Cumin				
Jobner	313		10	323
Jagudan	145		8	153
Kumarganj	19			19
Fennel				
Jobner	185		8	193
Jagudan	135		20	155
Hissar				
Dholi	40			40
Kumarganj	34		34	
Fenugreek				
Jobner	325		12	325
Jagudan	48		2	50
Coimbatore	262			262
Guntur	124			124
Hissar				
Dholi	105			105
Raigarh	13			13
Kumarganj	65			65

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ACTION TAKEN REPORT ON THE RECOMMENDATIONS OF THE XIV WORKSHOP ON SPICES HELD AT BANGALORE DURING JULY 1997

Decisions	Actions Taken/Remarks
1. In genetic resources, the NBPGR may be advised to identify the locations and prioritise the crops to be covered in accordance with the catchment area of the crop. The Scientists of the Coordinating Centres must be involved in the multiinstitutional team to conduct the survey for genetic resources.	The details on germplasm resources available at the Coordinating Centres were collected under crop wise and under different category wise in order to prioritise the area of collection of these spices germplasm and were communicated to Director, NBPGR. NBPGR has been approached for introduction of seed spices germplasm. NBPGR is also finalising the germplasm activities under NATP programme under which crops and the areas are being prioritised for collection. The multi-Institutional Team is being constituted under the NATP programmes. Joint programmes are planned between IISR and coordinating centres for completing collection of major spices germplasm in a time targetted manner.
2. All the centres are advised to adopt new technologies and utilise the available protocols for multiplication of the planting material. It is essential to ensure the analysis of plant and soil samples before and after laying out experiments - especially relating to those on irrigation, fertilizer, etc. While calculating the cost benefit ratio, the fixation of price for the produce must be done in consultation	New technologies and protocols available are being adopted for the production of planting materials in pepper and cardamom. However, tissue culture is not being pursued for planting material production because of various technical reasons. Directives have been given to all centres that analysis of plant and soil samples before and after laying out the agronomic trials should be carried out in

with the market arrival rates / prices as documented by the National Horticultural Board (NHB) wherever possible.	the case of all nutritional and agronomic trials. While calculating B:C ratio, market arrival rates/prices are taken into consideration.
3. Training programmes to be arranged for the Scientists under AICRP system, could be done at IISR, only after ascertaining that at least 75% response to the proposal /decision.	Will be followed.
4. In the case of plant quarantine acitivity, it may not be possible for each centre to have necessary staff in all relevant disciplines to take care of this issue; however, this responsibility can be vested with the IISR.	IISR can take up the responsibility of providing expertise and advice in case of plant quarantine activity. However for all practical purposes, NBPGR is vested with this responsibility.
5. The experiments on nursery management and developing a suitable package must be conducted in all the centres so that the nursery code / certificate becomes a reality in the near future.	Many coordinating centres laid out new experiments on nursery management and suitable package is being developed for future use. Other centres will be instructed to follow this immediately. However, standards for certification have not been implemented so far.
6. Ajowan may be included in the Coordinated trial and is necessary to describe the germplasm lines available at Guntur, Dholi, Jagudan and Hisar.	The Coordinating centres viz., Guntur, Dholi, Jagudan and Hisar are having collections of Ajowan germplasm and are being evaluated and maintained. The crop is yet to be included in the coordinated programme as a mandate crop.
7. Passport data must be prepared for the germplasm collected and duplicate set of collection along with a copy of the passport data must be sent to IISR.	The IPGRI proforma for recording of passport data has been supplied to all centres. The cardamom centre has been requested to describe the accessions based on the IPGRI format. The descriptor for ginger and turmeric are under preparation.

8. Crop cafetaria of all released varieties to be established in all centres.	Work has been initiated in this direction by various centres and are in progress. In some centres (such as Panniyur and Mudigere) the field has already established and are in good condition.
9. All centres should follow the uniform technical programme as decided in the Workshop, if necessary 1 or 2 treatments as per local requirements may be included without altering the original treatment schedule.	Deviation has been noticed in the treatments in certain centres. Efforts will be made to keep uniformity of trials in all respects. Local checks are always form part of the trial.
10. The new four AICRPS centres namely, Dapoli, Raigarh, Kumarganj and Pundibari must collect local germplasm of mandate spice crops.	The new centres viz., Dapoli, Raigarh, Kumarganj and Pundibari started strengthening the germplasm of their mandate crops by local survey apart from exchange with other centres and Institutes. Efforts will be made to strengthen this activity. One major constraint highlighted by all centres is the lack of a vehicle for survey and collection.
11. The local germplasm collected (one set) must be passed on to the NBPGR along with the passport data for assigning IC number	Directions have been given to all centres. While it is possible to implement this in the case of seed spices, it becomes very difficult in the case of vegetatively propagated spices, both for transportation and maintenance at NBPGR.
12. Integrated strategy should be evolved using different bio-control agents to achieve desired level of pathogen suppression, priority should be given for collecting local promising isolates. Inoculum potential may be quantified for different media.	Integrated pest management is being given importance in the technical programme. Major emphasis has been given to IPM and biocontrol agents in the technical programmes that is being finalised. Various firms/agencies working on biocontrol agents have been approached for getting

	their products to be included in the AICRPS multilocational trials being planned. Priority is given for collecting local promising isolates of various biocontrol organisms.
13. Variability in pathogen and biocontrol agents, fixation of dosage using uniform carrier media, applicable to different agroecological zones should be given due priority in formulating new programmes.	The suggestion will be taken care of.
14. Efforts may be made to collect the germplasm in collaboration with NBPGR using the infrastructure facilities available with the NBPGR. The exploration must be followed in high priority crops in a phased manner.	Efforts have already been initiated to strengthen the germplasm through NBPGR from various countries by way of introduction in the priority spices. However, it becomes increasingly difficult to get materials from other countries. Collection of indigenous germplasm will be intensified during the implementation of the NATP programme which is being implemented by NBPGR in collaboration with other agencies (including IISR).
15. Three major diseases viz., foot rot of pepper, rhizome rot of ginger and wilt of cumin should be considered as disease of national importance. A standing committee should be formed to review the work, formulation of technical programme and to fix locations where work has to be carried out. Committee also should review the implementation of recommendations at farmers level.	Research work on these diseases will be intensified through *adhoc* projects being implemented at various Institutes and through new projects that will be formulated. The suggestion to form a Standing Committee was brought to the notice of DDG. The Phytonet scheme is now taking care of the foot rot of pepper.
16. All the centres should compile results of various disease and pest management trials of the last 5-6 years and	All Centres have been instructed to send the data on crop protection experiment to the PC for finalisation of

submit the same to PC (Spices) for finalising the treatment schedule.	future technical programmes during the workshop.
17. Biocontrol agents from different coordinating centres may be isolated and maintained at IISR, Calicut for future use and reference.	Centres are suitably instructed to send the local isolates to IISR for future use and reference.

BLACK PEPPER

1. New disease management strategy may be formulated using the leads from concluded experiments and tested at Panniyur, Sirsi and Chintapalli	The centres at Panniyur and Sirsi have laid out new trials for the management of diseases and they are in progress.
2. Treatment schedule for the new programmes of the management of nursery disease of pepper will be provided by IISR, Calicut	Already been provided.
3. Survey work on pests of pepper at RRS, Mudigere should be continued and monitoring to be extended up to March	The Mudigere centre continued the survey up to March 1998 and found heavy infestation of mealy bug at higher altitudes whereas, incidence of scales was very less.
4. At Pampadumpara, management trial on pests of pepper should be undertaken in pest-prone areas	The trial could not be initiated at Pampadumpara due to lack of an Entomologist at the centre during the season.
5. Experiments on irrigation concluded at Panniyur, findings are ready for transfer.	The findings of irrigation experiment on pepper has been transferred and included in the package of practices of K A U.
6. The experiment at Sirsi may be continued. The stand of Karimalligesara is poor and therefore gap filling is necesesary whenever revival of the previously planted vine is not possible.	The experiment is continued with gap filling and is in progress.

7. The minimum stress period required for induction of flowering may be ensured in all the irrigation experiments on pepper.	This will be taken care of while laying out the irrigation trials on pepper.

CARDAMOM

1. The MLT Series III (1993) with Mysore and Malabar Types to be relaid out in all cardamom centres.	The trial has been relaid out at the centres and is in progress.
2. Ongoing chemical control trials on thrips and capsule borers at Mudigere may be concluded and new programmes may be started in consultation with PC and IISR, Calicut.	New programmes will be finalised in the coming Workshop.
3. All the experiments on Agronomy and Soil Science will continue as per the technical programme.	Being continued as per the technical programme.

GINGER

1. In all the future fertilizer and irrigation trials in ginger, percentage of dryage and fibre content should also be estimated.	Centres are suitably instructed to follow the recommendation.
2. In the proposed Plant Pathology experiments in ginger at Solan centre, the treatment schedule should be finalised in consultation with PC, IISR, Calicut	The treatment schedule received from the centre for the project "Biocontrol of rhizome rot of ginger" has been modified, finalised and communicated by PC. But the centre did not take up the revised and finalised technical programme as the Pathologist in position has gone abroad for higher training. This will be taken up in the next season.

3. At Pundibari, the associated pathogens of soft rot of ginger should be isolated and their pathogenicity confirmed. Required training and expertise will be provided at IISR.	Isolation of associated pathogen of soft rot of ginger was attempted but pathogenicity could not be confirmed. Required training has been provided from IISR in this regard.

TURMERIC

1. In quality analysis, guidelines formulated by IISR are to be followed. IISR, Solan, Pottangi, Kumarganj, Coimbatore and Dholi centres will take up a new CYT to test the effect of altitude on quality with six promising varieties and send the material to IISR, Spices Board and Soaln for quality analysis.	Guidelines formulated by IISR are being followed for quality analysis. The centres viz., Coimbatore and Solan have laid out a new CYT to test the effect of altitude on quality.
2. Soft rot management trial at Jagtial may be modified in consultation with IISR Calicut.	The Jagtial centre did not take initiative in this matter.

TREE SPICES

1. The drip irrigation project at Yercaud will continue	It is continued.

SEED SPICES

1. The entries for CVT will be accepted from the centres based on two years consistent performance under IET in respect of yield besides quality. Each centre will have to include their latest recommended/released variety as check under IET.	Centres are advised to follow the recommendation.

2. The present CVT on coriander, fenugreek and cumin will continue for two more years with the same entries.	Continued as per recommendation.
3. A new CVT in fennel will be laid out at Hisar, Jagudan and Jobner centres (CVT 1998) with eight accessions.	The new CVT has been laid out at Jobner and Jagudan with eight accessions.
4. Effect of stage of maturity on oil content of coriander varieties may be studied.	At Jobner, this aspect was studied under an *adhoc* project sanctioned by Spices Board.
5. Integrated nutrient management with components like biofertilizer, organic manures etc. on seed spices need to be experimented	On completion of ongoing experiments on micronutrients, experiments on biofertilizer and organic manures will be formulated in seed spices in the next season.
6. The NBPGR will be pursued to strengthen the programme for systematic induction of germplasm from other countries particularly from centres of origin/diversity.	NBPGR has been approached.
7. The passport data and characterisation of all available germplasm entries in all the centres have to be completed and updated.	The work has been initiated and is in progress.

ACTION/COMMENTS ON THE RECOMMENDATIONS OF QRT ON AICRPS

The Indian Council of Agricultural Research, New Delhi constituted the Quinquennial Review Team (QRT) for the review of work of AICRPS under the Chairmanship of Dr K V Ahammed Bavappa with Dr R P Sharma, Dr S Chaudhuri, Dr R K Sharma and Dr Rajendra Gupta as members and Dr A K Sadanandan as Member Secretary. The recommendations of the QRT are given below:

Recommendations	Comments
Genetic resources	
1 The varieties released by the AICRPS centres, may be characterised through DNA finger printing along with their parents in the case of hybrids, and deposited at the respective SAUs as well as NBPGR, New Delhi. A national number may be obtained for each variety registered with NBPGR.	The Solan (for turmeric and ginger) and Jobner (Seed Spices) centres can be identified for taking up characterisation programme based on molecular markers. None of the AICRPS centres are now equipped to carry out the work of DNA finger printing. So these two centres will need considerable strengthening both in terms of facilities and expertise. Facilities exist at the RAU, Bikaner campus in the Dept. of Plant Biotechnology. The work may have to be entrusted with them by way of an *adhoc* project. Meanwhile IISR will be able to support this work especially in major spices - where efforts have already being made for molecular characterisation.
2 Though some progress has been made in germplasm collection of major spices, there is an urgent need to complete the work on time targeted basis. The Project Coordinator may prepare two projects, one for plantation spices and other	PC has carried out discussions on this issue of preparing the research projects and draft projects are getting ready and the same will be discussed in the forthcoming Workshop.

for seed spices in consultation with SAUs and submit to the ICAR for funding. The duration of the project may be five years.

For strengthening of germplasm, action has already been initiated to introduce germplasm from other countries.

3 The following centres may be mandated to evaluate, characterise and catalogue the germplasm of crops noted against each Centre.

The centres identified for each crop are suitably instructed to follow the recommendation.

Black pepper	:	Panniyur and IISR
Cardamom	:	Mudigere and ICRI
Cardamom (L)	:	ICRI Regional Centre, Gangtok
Ginger and Turmeric	}	Pottangi and IISR
Coriander	:	Jobner (RAJAU) North Indian collection, Coimbatore (TNAU)- South Indian collection
Cumin	:	Jobner
Fennel	:	Jagudan
Fenugreek	:	Jobner

4 Each centre collecting the germplasm will divide the material into three sub samples- one sample of each go to NBPGR for cryopreservation, other to the centres identified for cataloguing and third retained at the collecting centre. Nomenclature assigned by the collecting agency should not be changed at any stage/ centre.

As the cryopreservation protocols are not available for most of the spices it is difficult to preserve the germplasm under cryopreservation. However, the AICRPS centres can send a set of material to the centre identified for cataloguing and the other set can be maintained at the collecting centre. One set can be supplied to IISR Calicut for depositing in the in vitro gene bank. Suitable instructions have been given to various centres on this aspect.

5 NBPGR should enhance their efforts to collect the exotic germplasm from countries growing them/centres of diversity. Samples of germplasm so obtained should be made available to the centres identified for cataloguing, which will multiply and make the material available to other centres. Since lack of genetic variability for economically important characters has been felt as the biggest constraint in crop improvement programme of seed spices, it is strongly suggested that an exploration team be constituted and assigned the job of collecting the germplasm.	Efforts have already been initiated for germplasm introduction of seed spices from various countries through NBPGR. A set of samples collected will be sent to the centres identified for conservation and cataloguing.
6 Germplasm accessions collected should be described using the descriptor and also screened for biochemical characteristics. This information along with material may be passed on to IISR which will arrange for the DNA finger printing through the NRC DNA printing network facilities being established in NBPGR and registration of the materials. The concerned centres should maintain each of the registered varieties / accessions along with their numbers.	Efforts are being made for the preparation of detailed descriptors jointly by the IISR and AICRPS and their publication through IPGRI. Draft descriptors for ginger and turmeric are getting ready and these will be discussed among the workers.
7 For every registered spice variety released as well as those in the germplasm, quality attribute profiles of the essential oils should be studied and incorporated in the descriptors.	This is being done regularly in the case of all the varieties proposed for release.

Varietal improvement

8	In order to exploit the locked up variability in black pepper, a large scale hybridization programme involving lines with diverse desired characters may be undertaken. A project involving SAUs of Kerala, Karnataka and Tamil Nadu and IISR may be prepared as envisaged in the IISR QRT report.	Hybrid production is one of the primary mandates of IISR, and a large number of hybrids are available, which are under evaluation at IISR and Pepper Research Station, Panniyur. This work will be further intensifed in view of the QRT recommendation.
9	Twelve improved varieties of different spices were released during the period under report, while several lines are in the pipe line for release. Different agencies (Agriculture / Horticulture Depts., NGOs and farmers) who have the ability to produce quality planting materials may be identified by the centre which has evolved the variety and breeders stock of the varieties released made available to these agencies on a certification programme. They may be given training in the technique of planting material production and should be subjected to periodic inspection to ensure quality.	The AICRPS centres are taking up the production and distribution of quality planting materials and nucleus seed/planting material is being produced by the AICRPS centres and are distributed to various agencies and progressive farmers. And efforts will be made to strengthen this activity. However, lack of sufficient manpower and contingency fund are major hitches.
10	Hybridization (recombination breeding) or heterosis exploitation must be enlarged to develop better varieties. In crops like cumin and coriander where hybridization is extremely difficult, sound population improvement programmes must be immediately started to make best use of exist-	Heterosis breeding will be exploited in spices where the productivity is low. In seed spices, population improvement programmes are being carried out and more emphasis will be given while formulating the technical programme. However the full use of heterosis potential is not possible due to the non-availability of homozysom

ing variability. The breeding strategy should be for high yield, better quality and disease resistance (wilt, powdery mildew etc in seed spices). The existing facility for oil profile analysis at Jobner centre may be strengthened.

lines of distinct genetic stocks.

The facility at Jobner will be strengthend in the next five year plan period

Crop production

11 Black pepper is cultivated extensively in homesteads and under diverse farming systems. However, on-farm trials to evolve agrotechniques for mixed cropping of black pepper under such systems has not been undertaken so far. Trials need to be laid out to generate information in this area. Since large scale planting of black pepper is being undertaken in coffee, this system may be studied on a priority basis.

Spices based cropping system and their agro- technological requirements are being investigated. If such studies are now lacking in any centre, they will be taken up.

12. For crops like ginger, turmeric and seed spices location specific package of practices for targetted yields may be developed for the major agroclimatic regions.

The seed spices centres viz., Raigarh, Dholi, Pundibari and Kumarganj are requested to prepare location specific projects for finalisation of technical programme. In the forthcoming Workshop programmes for targetted yield production will be discussed and finalised.

13 For sustainable production, it is essential that a balance between off-farm and on-farm inputs are maintained. Research on on-farm biomass generation for recycling as source of nutrients as part of IPNM should receive attention at all centres of the Coordinated Projects.

This will be followed while formulation of technical programme in the coming Workshop.

14 In tree spices, nutrient and water requirements including fertigation needs special emphasis and trials should be laid in these directions.

At present one trial is progressing at Yercaud but due to acute shortage of water the Yercaud centre finds it difficult to continue this. While at Dapoli such problem may not arise. Trials will be laid out at Dapoli or at TNAU Research centre at Pechiparai where plenty of water is available and are ideal for tree spices. However commercially tree spices are low priority crops.

Crop protection

15 Among the different diseases that affect the spices, *Phytophthora* foot rot of black pepper, *katte* of cardamom, *Chirkey* and *Foorkey* of large cardamom and rhizome rot of ginger and turmeric still continue to be the most devastating in most of the areas. However, the team during its field trips observed that certain tracts (eg. Shevroy hills with little incidence of quick wilt) are almost free from some of these maladies. It is suggested that the AICRPS centres may study the problem from the angle of location specificity so that these tracts are maintained free of the pathogen in future as well.

Efforts are being made to identify suitable areas free from *Phytophthora* for pepper, *katte* for cardamom, and rhizome rot for ginger and turmeric through the combined effort of AICRPS and IISR. Joint surveys are planned to locate such localities.

Some such areas have been located.

16 As at present, IPM approach in pest and disease management has not received serious attention in the Coordinated programmes. It is strongly recommended that this technology is developed to the maximum extent possible for major pests and diseases.

These recommendations will be followed by reorienting the technical programme giving major emphasis on IPM as well as biological control. New projects will be formulated using biocontrol for the management of soil borne diseases. Various firms/agencies working on this aspect are being

Post harvest processing and quality upgradation

17 A study of the existing practices adopted in the post harvest processing of each spice may be under taken by every AICRPS centre to identify factors that affect the quality of finished products and undertake field studies to prevent un-hygienic practices. While preparing package of practices for each crops, a section on post harvest processing should invariably be included to bring awareness among farmers about the importance of quality.

approached for getting their produce to be included in the AICRPS trial.

The AICRPS centres are requested to study the local practices and to enlighten the growers as to the need for proper drying and other post harvest operations. The centres are further requested to include a section on post harvest processing while preparing the package of practices.

General

18 Though Tamil Nadu has over 60,000 ha under turmeric, this crop has not been included under the AICRPS for research. The crop has both production and post harvest processing problems which need urgent attention. It is recommended that turmeric may be included as a mandate crop for research at Coimbatore centre with no additional staff (the existing Horticulturist and Pathologist would be attending this work).

Turmeric is included as a mandate crop of Coimbatore.

19 The Spices Board research establishment at Gangtok be recognized as the nodal R and D centre for large cardamom with mandates for germplasm collection, evaluation and improvement, production of elite planting materials of im-

Council's action is very much important in this matter. Approval may be given to include Spices Board Regional Station as a Voluntary centre for large cardamom.

(Approval received from Council).

proved varieties (Breeders foundation seeds) and formulation of package of practices. The scientific position of the ICAR NEH Research Complex may be shifted to ICRI (Spices Board), Tadung, Gangtok together with budget allotment as a regular AICRPS centre to work on large cardamom.

20 The IARI sub-station at Kalimpong in linkage with the Division of Mycology and Pathology of IARI be entrusted to work on characterisation and early detection of viruses in large cardamom. The sub-station may be included as a co-operating centre.

The matter has already been brought to the notice of the Director, IARI and his reaction is expected.

21 BCKV, Pundibari mandated to work on ginger, turmeric and black pepper should give greater emphasis for ginger for its germplasm collection, conservation and cataloguing since the NE has considerable genetic diversity for this crop. In terms of soft rot management of ginger, this centre should undertake front line demonstration and training jointly with KVK at Kalimpong.

The AICRPS centre at Pundibari is suitably instructed to serve as a lead centre for germplasm collection for the NE Region. To function effectively this centre needs further strengthening - both personnel and funds. Further, the centre is requested to initiate demonstration programmes for the management of ginger diseases in collaboration with KVK located at Kalimpong. Financial assistance is requested from the Council for smooth running of this programme.

22 AICRPS should strengthen the R&D work on black pepepr in the NEH through CPCRI sub station at Mohitnagar and Kahikuchi, Guwahati in link with IISR.

Council may address letters to Director, CPCRI and Mohitnagar and Kahikuchi centres regarding this. PC has requested DDG to give suitable instruction to CPCRI and IISR. IISR will be able to provide planting material and technical inputs.

(Action initiated - A meeting to discuss this item was convened by Director, CPCRI. It was decided to lay out a trial to identify varieties suitable for the area, and appropriate production technology).

23 The Centres of the AICRP on Spices are located in remote locations with little access to literature. The library of IISR is doing an excellent job in bringing out bibliographies on spices periodically as well as other publications to bring out awareness about R & D in spices. Copies of such publication should regularly be supplied to each of the centres. This would substantially improve the awareness of the scientists working in the projects.

The publication from IISR, Calicut is being sent regularly to all the AICRPS centre.

Scientific manpower development

24 The cultivation of black pepper in the higher elevations of Shevroy and Kodaikanal hills of Tamil Nadu is considerable. The area is also relatively free of *Phytophthora* foot rot disease. Varietal evaluation is an urgent need of this tract. The existing staff at Yercaud centre consist of only one Agronomist and one Horticulturist. It is recommended that one post of Breeder be created at Yercaud to take up the varietal improvement work.

This recommendation is brought to the notice of Council. However creation of a post will be possible only during the next Plan period.

Project formulation

25 During the workshop new research programmes are being formulated in a hurry and much attention is not given. It is therefore suggested that a day prior to workshop may be allotted for group discussion and formulation of research programmes. The services of the Heads of Departments of the IISR may be made use of for the formulation of the programmes along with scientists of the concerned disciplines from the coordinating centres.

This has been done.

Monitoring and evaluation

26 Since the coordinated projects on spices are being implemented through 15 SAUs, it is necessary that the scheme should be closely monitored by both the Director of Research of the respective Universities and Project Coordinator who are responsible for close monitoring and evaluation. It is suggested that the Director of Research may make at least one inspection in a year and the detailed report sent to the Vice Chancellor with a copy to Project Coordinator. Similarly, the Project Coordinator may visit the centres at least twice in a year and copies of his inspection report sent to the Director of Research/Vice Chancellor concerned.

The PC is visiting the centres regularly and the reports of the visit are sent to Director of Research and Vice Chancellor. The Directors of Research are also requested to make yearly visits to monitor the functioning of the Projects.

Manpower and infrastructural facilities

27 The Committee strongly felt the need for one Clerk-cum-Typist to PC's Cell. The existing Jr. Steno-grapher is unable to meet the mounting work load consequent to the entrusting of PC to directly attending to the monitoring and budgetary preparation and release of funds to the centres. It is understood that as per the recommendations of the previous QRT, provision has been made in the VIII Plan of IISR but this has not materialised.

Included in the IX Plan proposals of IISR.

R & D on spices in the North Eastern Hill Region

28 Among the spices, ginger, large cardamom, black pepper and turmeric are the more important crops of significance for the area. While ginger and large cardamom are more suitable and extensively cultivated in relatively high altitudes (100-1500 m) black pepper is grown primarily in foot hills (up to 1000 m). Turmeric grows well in the plains or foot hills. Continuous R and D and policy support for promotion of production, value addition, marketing of the identified spice crops is very important for economic development of at least some of the states of the region.

Black pepper R&D work will be intensified at the CPCRI Research Centre at Mohitnagar and Kahikuchi (Assam) with the support of CPCRI.

As for large cardamom, the recommendation to transfer research programmes to ICRI Centre at Gangtok has been implemented Some agencies have been contacted for initiating R&D programmes in NE Region in the case of ginger & turmeric.

29 Immediate attention may be paid to production of disease free planting materials in large cardamom. The programme has to be supported with quick diagnosis of viruses in symptomless materials, the method for which is being standardized by the IARI centre at Kalimpong. The Government has already taken steps for distribution of tissue cultured disease free plants and the same technique may be promoted. The ICRI Regional Station, Gangtok may be entrusted with this work.

This matter has already been taken up with ICRI regional station, Gangtok. However, this centre has no facilities for virus disease diagnosis. Popularisation of TC plants may be necessary here.

ICAR *AD-HOC* RESEARCH SCHEMES ON SPICES

Title of the schemes	Principal Investigator & Location	Total outlay (Rupees)	Date of start
Improvement of Kokum (*Garcinia indica* Choisy) in Konkan region	R N Nawale College of Agriculture Dapoli - 415 712 Ratnagiri, (Maharashtra)	533500	1-12-95
Production of somaclones and somatic hybrids of cardamom (*Elettaria cardamom* Maton) for high yield and resistance to disease	K V Peter IISR, Calicut (Kerala)	2289759	30.3.96
Scheme for intensification of research on vanilla (*Vanilla planifolia* Andrews)	P N Kumar HC&RI TNAU, Coimbatore (Tamil Nadu)	378400	01.04.96
Etiology of rhizome rot of turmeric	M.N. Reddy P. Mahila Vishwa-vidhyalayam, Tiruputi (Andhra Pradesh)	541000	01.11.96
Effect of organic fertilizer on soil quality, productivity and quality of black pepper and cardamom.	V Srinivasan IISR, Calicut (Kerala)	1041100	01.08.97
Production of haploids and dihaploids of cardamom (*Elettaria cardamomum* Maton) through anther culture/ pollen culture	P N Ravindran IISR Calicut (Kerala)	575210	01.10.97
Collection, maintenance, evaluation and standardisation of agro-techniques of seed spices germplasm.	Luchan Saikia Dept. Horticulture AAU, Jorhat (Assam)	516170	01.12.97
Exploring the possibility of spices under humid sub temperate conditions of Himachal Pradesh	Yudhvir Singh HPKVV, Palampur (Himachal Pradesh)	550460	01.01.98
Biological control of plant parasitic nematodes of major spice crops	K V Ramana IISR Calicut	891860	01.04.98
Establishing *in vitro* conservatory of spices germplasm.	K V Peter IISR, Calicut (Kerala)	1050720	01.10.97

Title of the schemes	Principal Investigator & Location	Total outlay	Date of start
Hybridization in ginger (*Zingiber officinale* Rosc.) through *in vitro* pollination	P A Valsala College of Horticulture KAU, Thrissur (Kerala)	622400	
Development of resistant variety/lines of cumin to wilt diseases caused by *Fusarium oxysporum* using *in vitro* techniques.	R K Sharma Rajasthan Agrl.Univ. Bikaner(Rajasthan).	926440	26.12.98
Characterisation of nutmeg germplasm for quality	B. Krishnamurthy IISR, Calicut (Kerala)	862480	
Elucidation of biosynthetic pathways of curcumin in turmeric (*Curcuma longa* L.)	B Chempakam IISR, Calicut (Kerala)	1112480	
Studies on the compatability of *Azospirillum* and biocontrol agents in turmeric	R. Sridhar TNAU, Coimbatore (Tamil Nadu)	612480	28.05.99

PROJECTS CLOSED IN 1998-99

Species relationship in the genus *Piper* and scope of related taxa in the improvement of *Piper nigrum* L.	VS Sujatha College of Horticulture Vellanikkara	609000	22.9.94
Characterization, early detection and management of *Kokke kandu* disease of cardamom.	M N Venugopal IISR, CRC Appangala (Karnataka)	551760	24.07.95
Investigations on crop response in large cardamom (*Amomum sublatum* Roxb.) to major nutrients.	Director (Research) ICRI Kailasanadu Myladumpara (Kerala)	1203400	01.12.95
Clonal propagation of tamarind (*Tamarindus indica* L.) through *in vitro* culture.	G Balakrishnamurthy TNAU, Coimbatore (Tamil Nadu)	577800	01.10.95
Management of seed borne pathogens and wilt disease of coriander by using biotechnological approaches	R. Rabindran TNAU, Coimbatore (Tamil Nadu)	437300	01.07.96
Phenol metabolism during host pathogen interaction in *Fusarium* wilt of cumin	M K Mandavia Dept. of Biochemistry College of Agriculture Junagarh - 362 001 (Gujarat)	601500	01.11.96

Title of the schemes	Principal Investigator & Location	Total outlay	Date of start
Investigations of cardamom based cropping system	V S Korikanthimath CRC Appangala IISR, Calicut (Kerala)	1480647	22.07.96
Integrated management of rhizome rot of ginger	Y R Sarma IISR, Calicut (Kerala)	2251200	09.05.96
Biological control of scale insects infesting black pepper	S Devasahayam IISR, Calicut (Kerala)		29-7-94
Developmental morphology of rhizomes of ginger & turmeric	P N Ravindran IISR Calicut (Kerala)	1010800	07.07.95
Creation of variation for improvement of yield of coriander through mutation brfeeding	K Ramakrishna SKN College of Agriculture Jobner (Rajasthan)		
Biochemical characterization of ginger and turmeric	T John Zachariah IISR, Calicut (Kerala)	739880	19.07.95
Integrated management of rhizome rot of ginger.	N P Dohroo Dr. YSPUH&F, Solan (Himachal Pradesh)	668500	01.03.96
Developing hardening protocols for tissue culture plants of spices	J.Rema Scientist IISR Calicut (Kerala)	4434412	30.03.96
Research on herbal spices in Shevroy hills of Tamil Nadu	G Balakrishnamurthy Yercaud, TNAU (Tamil Nadu)		

Note: The progress reports of some of the projects have not been received from the PIs inspite of repeated requests.

AhP 1. Improvement of Kokum (*Garcinia indica* Choisy) in Konkan Region

(R N Nawale)

Department of Horticulture, Konkan Krishi Vidyapeeth, Dapoli

Objectives

- To collect variations and establish a scion bank after identifying elite types of kokum (*Garcinia indica* Choisy) from Ratnagiri and Sindhudurg districts of Konkan region and from the State of Goa.
- To standardise vegetative propagation technique (softwood grafting)
- To evaluate 'Anthocyanin' pigment (red colour pigment) from the fruits

Progress of Research

Collection of elite types (early, high yielding and bold types) of kokum (*Garcinia indica* Choisy) and establishment of scion bank are in progress. The softwood grafting technique has been found suitable for clonal multiplication of kokum on larger scale. The other aspects on softwood grafting technique are being studied.

Length of scion stick is playing an important role in success of grafting. Standardisation of length of scion stick for soft wood grafting is progressing. The mature scion sticks of 5-6 months old were used in grafting. The results showed that per cent success of grafting varied from 74.0 to 95.0 in the different treatments. The maximum success (95.0 per cent) was observed with scion sticks of 10.0 cm length followed by the scion sticks of 7.5 cm length (94.0 per cent) which were on par. The graft success showed decreasing trend with the budsticks of 12.5 cm and 15.0 cm length.

Studies on the effect of retention of leaves on rootstock indicated that the success of softwood grafting ranged from 60.0 to 94.0 per cent in the different treatments; the best (94.0 per cent) was when four pairs of leaves were retained on the rootstock; the next best was with three pairs of leaves (85.0 per cent) and were on par). The other treatments gave below 62.0 per cent success. The results indicated that retention of more leaves on the root stock is necessary for obtaining higher success in softwood grafting of kokum.

The results of the studies on the effect of using different types of branching shoots on success of softwood grafting showed that maximum percentage of success (67.5 per cent) was with the downward growing scion shoots, and followed by the middle laterally growing shoots (52.4 per cent) and the errect growing scion shoots (48.0 per cent).

AhP 2. Production of Somaclones and Somatic Hybrids in Cardamom (*Elettaria cardamomum* Maton.) for High Yield and Resistance to Diseases.

(K V Peter, K Nirmal Babu)

Indian Institute of Spices Research, Marikunnu PO, Calicut - 673 012

Objectives

- Production of somaclonal variants through callus regeneration
- Production of somatic hybrids through fusion of protoplasts of cardamom with that of other related taxa like *Alpinia* sp. and *Hedychium* sp.
- Screening of somaclones and somatic hybrids against diseases *viz. Katte, 'Kokkai kandu* and evaluation of high yield and desirable quality characters.

Progress of Research

Production of somaclones

Callus was initiated from different explants of cardamom in MS medium supplemented with 2 mgl^{-1} 2,4-D. The calli produced were of two different types, one is hard embryonic callus and other is creamy white friable callus. The hard embryogenic callus on transfer to MS medium containing 1 mgl^{-1} BA and 0.5 mgl^{-1} NAA turned organogenic and produced plantlets. Large number of plantlets (somaclones) were produced from callus cultures. These callus regenerated plants showed variation in the culture itself. The plantlets exhibited three morphotypes in culture, they are: i) plants with short needle like leaves, ii) short and stout plants with normal but small leaves and iii) plants with long internode and normal leaves.

Callus regenerated plants (somaclones) rooted in MS basal medium and hardened by a two step process in the hardening facility. Hardened plants were transferred to polybags and maintained in the green house.

Plants, 50-60 cm height (four months old), were transferred to field at Cardamom Research Centre, Appangala and evaluated for high yield and other quality characters. Data collected from these plants after two years showed considerable variation in terms of morphological characters. Data on yield parameters are to be taken from next season onwards. The prominent variations observed include some robust plants with darker green leaves, some very tall plants and one plant that showed the production of inflorescence from the terminal part of the leafystem.

Production of somatic hybrids

For this purpose protoplasts have to be isolated from cardamom and the related genera which show resistance to Katte *viz. Hedychium* and *Alpinia* and fused to obtain somatic hybrids. Protoplasts were isolated from *in vitro* as well as *ex vitro* leaves, callus cultures and suspension cultures of cardamom. For the isolation of protoplasts the tissues were digested with an enzyme mixture containing macerozyme and cellulase, 7-10% mannitol was added to the isolation medium as osmoticum. Of the different combinations of the enzymes used, enzyme solution 14 (1.0% Macerozyme + 1.0 cellulase +9% mannitol) and enzyme solution 15 (1.0% Macerozyme + 2.0 cellulase +9% mannitol) gave the best results after 18h of incubation, in terms of protoplast yield and viability. The yield of protoplasts were ascertained using hemocytometer and the viability using fluoresine diacetate staining. Protoplasts were also isolated from callus cultures and cell suspension cultures.

Isolated protoplasts were purified using a combination of centrifugation, filteration and washing. The purified protoplasts were cultured in protoplast culture medium in petri dishes. Division of protoplasts were initiated after seven days of culture and new culture medium was added in every seven days interval. Within 30 days of culture the dividing cells produced microcalli.

In vitro shoot and callus cultures of *Hedychium /Alpinia* were established and these cultures are being used for the isolation of protoplasts.

Closed project

AhP 3. Developing Hardening Protocols for Tissue Cultured Spices

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

Indian Institute of Spices Research, Marikunnu PO, Calicut - 673 012

Objectives

- Establishment of hardening facility suitable for tissue cultured plantlets of tropical spices.
- Development of suitable protocols for hardening tissue cultured plantlets of spices.

A hardening facility consisting of three separate chambers with separate controls for temperature, light and humidity was established. Two of the chambers are maintained at 24 °c (cooling pad), and the third is main-

tained at 15 °c with the help of four air conditioners. This facility is being made use of for hardening *in vitro* raised tissue cultured plants.

Piper spp. namely *P. nigrum*, *P. longum*, *P. betel*, *P. colubrinum*, *P. barberi*; Zingiberaceous taxa like ginger, turmeric, cardamom; herbal spices such as mentha, ocimum, thyme and marjoram and orchid spice, vanilla were multiplied in large numbers using standardised protocols and were used for hardening experiments.

Hardening was carried out using different planting mixtures *viz.*, soil, sand, cowdung, coirdust singly and in different combinations. Among the different mixtures sand was found to be the best.

Piper spp. was hardened within 15 days at 24 °c at 80-70% humidity with 80% survival when compared to 30 days in conventional method. In zingiberaceous crops, cardamom plants of height 4.5 cm with 3-4 well developed leaves and 5-6 roots were ideal for hardening at 24 °c. Ginger, large cardamom and turmeric with 4 to 5 cm height with 3-5 leaves kept at 80-70% humidity and 28-30 °c resulted in 80 % survival rate. In tree spices, *in vitro* raised curry leaf, cinnamon and camphor were hardened at 28 °c and 70% humidity with 90% survival rate. Herbal spices namely ocimum, thyme and mentha were hardened at 24 °c with 60-70 % humidity in sand with 90 % survival rate.

Experiments of *ex vitro* rooting of *in vitro* plants was carried out at different concentrations of IBA in black pepper and curryleaf.

Anatomical studies were carried in black pepper, ginger and cardamom at different stages of growth to understand the changes occurring during hardening process.

High elevation spp. of pepper like *P. silentvalleyensis* (male and female), *P. schmidtii* (male and female), *P. galeatum* (male and female), *P. wightii* (male and female), *P. mullesua* (male and female) and *P. peepuloides* (male and female) being maintained in the hardening facility and temperate herbal spice like parsley, sage, chives, which normally do not establish in the plains were established in the hardening facility. These species would be further utilized for *in vitro* conservation.

The project concluded in September 1999.

AhP 4. Scheme for Intensification of Research on Vanilla (*Vanilla planifolia* Andrews)

(N Kumar)

College of Horticulture, Tamil Nadu Agricultural University, Coimbatore - 641 003

Objectives

- Establishing a germplasm collection of *Vanilla*
- Developing production technology for the cultivation of *Vanilla* for the hill region of Tamil Nadu

Progress of Research

Collection, conservation and evaluation of Vanilla genotypes

The mean data recorded on length of vine, internodal length, number of leaves and number of laterals showed that among the various genotypes tried, VP.11, collected from M/s. Linenaph Chemicals (P) Ltd, Rajapalayam registered the maximum length of vine, internodal length, number of leaves and number of laterals. The vines have not yet come to flowering.

Studies on Integrated nutrient management (INM) in Vanilla

The biometric characters on length of vine, number of laterals, internodal length and number of leaves were recorded for each treatment. It was observed that the length of vine, internodal length and number of leaves were maximum in the treatment 100g of NPK/vine/year along with 25g each of VAM, *Azospirillum* and phosphobacterium / vine/year. The treatment 75g NPK/vine/year records maximum number of laterals.

Standardization of quicker mass multiplication techniques

This trial was repeated again during December 98 to March 99 season.

The mean data recorded on per cent success (rooting), mean plant growth (new flush formation) and the root length (cm) showed that among the various types of cuttings tried, one metre long cuttings registered the highest per cent of rooting (100%) followed by four, three, two and single nodal cuttings in that order. The one metre length cutting also produced more plant growths and root length than the rest of the cuttings. There is no perceptible difference among the types of media in influencing the rooting success. Among the various concentrations of IBA tried, 2000 ppm appeared to induce better rooting concomitant with better plant growth and root length.

AhP 5. Etiology of Rhizome Rot of Turmeric

(M N Reddy)

Dept. of Applied Microbiology, S P Mahila Viswavidhyalayam, Thirupathi

Objectives:

- To survey turmeric areas, study of occurrence of rhizome rot disease, collection of isolates and their study.
- Studies on disease incidence, spread influence of local agricultural practices on disease incidence, disease management and other related aspects.

Progress of Research

Samples of infected roots & rhizomes were collected, during field surveys in Cuddapah and Guntur districts, and subjected to isolation by routine isolation procedures. These isolations yielded mostly *Fusarium* sp. but a few samples from Cuddapah district, collected during November & December months only, yielded *Pythium* sp.

Pathogenicity studies were carried out by all the routine methods. Infected portions of roots and rhizome of these plants were subjected to isolation of the pathogen and obtained the same pathogen as that used for inoculation, thus confirming the pathogenicity.

The identity of the pthogens was established as *Pythium aphanidermatum* and *Fusarium solani,* by cultural characteristics and on comparison with the reference cultures obtained from the Indian Institute of Spices Research, Calicut. As the culture of *Pythium* sp. was mostly contaminated/associated with species of *Cunninghamella* and also because of sparse association with the disease, no work has been carried out with this isolate. The main concentration was only on the *Fusarium solani* because of its constant association with the disease. The identity of the pathogens has also been confirmed by Prof. K. Natarajan, CAS in Botany University of Madras, Chennai.

Disease development

Pathogenicity tests as well as field surveys from the early stages of growth of plants have revealed the initiation of the disease as root rot, which gradually extends and finally reaches the rhizome. In due course, the entire root is damaged. The general observation is that the pathogen is taking some time to infect the rhizome. The symptoms on the root appeared as water soaked lesions at the initial stages and later turned necrotic, dark brown/black. Once the patho-

gen reaches the rhizomes, they get rotted, with water-soaked lesions which later turn necrotic, dark brown and sunken. Diseased portions of rhizomes and roots of infected plants, when subjected to isolation, yielded the same pathogen.

Studies on seed – borne nature of infection

The varieties used were the local *Mydukar* and *Sugandham* varieties. The rhizomes when sown separately in both sterile and unsterile soils, the symptoms could be observed by way of rotting of roots, stunted growth, marginal drying and yellowing of leaves. Rotting of rhizomes was also observed in such plants at a later date. Isolation of infected portions yielded mostly *F.solani*, thus confirming the seed borne nature of the pathogen. The seed borne infection was observed in both sterile and unsterile soil, but the intensity was comparatively more in the former samples. Different growth parameters like height of the plant, root length, colour of the leaves and the length of the leaves were also studied on comparative basis.

Rhizosphere studies

Rhizosphere and non rhizosphere soils of different varieties of turmeric were screened or subjected to isolation and came across with some antagonistic fungi like *Trichoderm a* and *Gliocladium* sp., some bacteria and actinomycetes. They have been tested for their antagonistic activity and observed a positive reaction, under pot culture studies. Further trials are in progress. The roots of different varieties have been screened for VAM association and observed wide variation as to the nature and formation of vesicles, arbuscules and spores.

Studies on the root exudates

The root exudates from one month old seedlings, grown under controlled and sterile conditions, were collected aseptically and tested for their effect on the growth rate of the pathogen by incorporating into the medium. There was significant stimulation of growth of the pathogen. The exudates were also analysed for amino acids, sugars and organic acids and observed significant increase in their quantities in the exudates of inoculated plants.

Behaviour of the pathogen on the surface of the host

The behaviour of the pathogen was observed by takng thin peels of the rhizome surface, on which the pathogen was allowed to grow, by placing small bits of culture grown on agar medium, staining with trypan blue and observing under the microscope for any infectious structures.

Studies on the pathogen factors

Studies on varied physiological and biochemical characteristics of the

pathogen and also infected host were carried out, to implicate the role of the pathogen during pathogenesis and also in the deranged host metabolism. Culture filtrate of the pathogen was tested by bio assay technique for any toxic effect on the host and observed positive response, indicating a possible involvement of toxic factors and hence role in pathogenicity.

Field Trials

Experiments were conducted in the sick soil at Agricultural Research Station, Anantharajupet of Cuddapah district, where a total of 10 treatments, with various combinations and permutations of the fungicides, Mancozeb 0.3%, Bavistin 0.2%, Ridomil MZ 500ppm, and the antagonistic microorganisms *Trichoderma harzianum* & *Gliocladium* sps, were applied. The results were very positive and encouraging.

Experimental trials were also set up in a field in Guntur district by field application (soil drenching), of *Gliocladium* & *Trichoderma* cultures grown on broken maize seed-meal, in isolation and also in combination. Trials were also set up by field application (soil drenching method) of a formulation by name Bio start 2000 and Biostart 2000G consisting of a mixture of bacterial species. Positive results were obtained in all these trials with disease intensity and better yield. These trials are to be repeated for confirmation.

AhP 6. Effect of Organic Fertilizers on Soil Quality, Productivity and Quality of Black Pepper and Cardamom.

(V Srinivasan)

Indian Institute of Spices Research, Marikunnu PO, Calicut - 673 012

Objectives

- Investigations for understanding the organic status of traditional pepper and cardamom growing soils of Kerala and Karnataka states
- Investigations into changes induced in soil quality by introduction of various kinds of organic fertilizers on physical, physico-chemical and microbiological properties of soils.
- Investigations on effect of organic fertilizers in making available native and added nutrients.
- Investigations into effect of organic matter decomposition, entry of organic ions into root system and plant body, which help better translocation of nutrient ions.

- Investigations on effect of organic fertilizer on nutrient use efficiency
- Investigations on effect of organic fertilizers on production and quality of organic spices.
- To workout the production cost.

Progress of Research

Field experiments were laid out in Coorg district of Karnataka, both for pepper and cardamom in split plot design, in June '98. Main plots were-with and without pesticides application. The sub-plot treatments were-check, FYM, neem cake, leaf compost, vermi compost and NPK @ 100:40:140 kg/ha. The greenhouse experiment with the same treatments are being carried out at IISR experimental farm, Peruvannamuzhi, Calicut, using cvs. Panniyur 1 and Karimunda (bush pepper) plants.

Green house experiment

The soil nutrient status showed that the availability of organic carbon, phosphorus, calcium, magnesium and micronutrients increased with the application of organic fertilizers. The berry nutrient status showed that both FYM and leaf compost treatments were on par with regard to N & P uptake and K uptake was highest in leaf compost treatment.

The yield was highest in FYM treatment, which was on par with leaf compost treatment for both the varieties. Highest piperine content was observed in vermi- compost treatment, which was on par with leaf compost treatment for Karimunda. Highest percentage of oleoresin was in leaf compost treatment for both the varieties.

Bacterial population was highest in the FYM treatment, followed by vermi compost. Population of free-living, N_2 fixing bacteria was highest in neem cake treatment for var. Panniyur1. In Karimunda, highest bacterial and actinomycetes populations were observed in vermi compost treatment, while neem cake application increased the population of free-living bacteria and fungi.

Field experiment

Black pepper

Application of organic fertilizers decreased the bulk density and increased the Water Holding Capacity (WHC) and Hydraulic Conductivity (HC).

The availability of macro and micro nutrients increased with the application of organic fertilizers for pepper in the field. There was build up of organic C, P, Ca, Mg and Zn in the soil. The uptake of N, P & K were highest in the FYM, followed by vermi compost treatment. Highest yield was recorded for FYM treatment followed

by vermi compost. Berry analysis showed high piperine content in FYM treatment.

Microbial population in the soil increased with the imposition of organic treatments. The bacterial population was highest in FYM treatment, whereas the population of phosphobacteria was highest in vermi compost treatment and that of fungi in neem cake. The microbial population in the plot without pesticide application was greater than that in the plot with pesticides.

Cardamom

Organic carbon content increased with the application of organic manures. Nutrients like P, K, Fe, Mn and Zn were also found to increase with imposition of organic treatments when compared to the control. The yield was maximum in FYM treatment.

The microbial population increased with the application of organic fertilizers. The bacterial population was highest in FYM treatment, whereas the population of free-living N_2 fixing bacteria, fungi and actinomycetes were highest in neem cake.

Analysis of soil samples collected during surveys from Idukki, Wayanad and Kasargod districts of Kerala and Coorg district of Karnataka are in progress. The organic status of traditional pepper and cardamom growing areas of Kerala and Karnataka will be determined.

AhP 7. Production of Haploids of Cardamom (*Elettaria cardamomum* Maton.) through Anther Culture / Pollen Culture.

(P N Ravindran, K Nirmal Babu)

Indian Institute of Spices Research, Marikunnu PO, Calicut- 673 012

Objectives

- The anther / microspore culture technology and subsequent production of dihaploids is an important means by which homozygous lines could be achieved for the subsequent production of high yielding hybrids exhibiting maximum heterosis.
- Production of haploids through the ' microspore callus ' is a sure way of introducing variation in the crop. The variations obtained may be useful in breeding, especially for developing disease tolerant lines.

- In cardamom, resistance to the katte virus seems to be a recessive character or a character controlled by cytoplasmic factors. Through anther / microspore culture, it is possible to fix the recessive genes in homozygous condition.
- Cardamom is a naturally cross-pollinated crop and the dihaploids from such hybrid plants are recombinant homozygous products useful in the fixation of gene loci. Additive effects are fixed in dihaploids.
- The ultimate aim of the project is to evolve high yielding disease resistant cardamom lines through crossing of dihaploids, derived from distinct parentages.

Progress of Research

One of the important parameters in anther culture is selection of anthers at an appropriate stage of pollen development. In most of the plant species, uninucleate stage of microspore has been reported to give optimum response. So standardization of flower bud size and stage of microspore for culture was carried out. It was found that 1.1 cm long flower buds, just emerging from the leafy bracts, containing anther with microspores at early uninucleate stage, is suitable for culturing.

Flower buds from different varieties like Malabar, Mysore, Vazhuka and important lines from Cardamom Research Center, Appangala like CCS-1, NKE-34, RR-1, MB-3 and Green gold were used in the present study.

Standardisation of disinfection procedures of flower buds and excision of anthers were carried out. Disected anthers were inoculated in different basal media like Kellers, MS, N&N, SH, with or without growth regulators like NAA, 2,4 –D, IAA, IBA, BAP, KN, at different concentration and combinations.

Anthers incubated in MS and SH media with BAP (0.5 mg/l) and NAA (0.5- 2.0 mg/l) under dark at 24^0c swelled within 4-6 days of inoculation. Some of the swelled anther were transferred to MS medium with BAP (0.5 mg/l), NAA (1.0 mg/l) and KN (0.5 mg/l) and they produced embryo like structures. Experiments are progressing.

AhP 8. Collection, Maintenance, Evaluation and Standardization of Agro-technique of a Few Seed Spices of N.E. India

(Luchon Saikia, A Sadeque)

Assam Agricultural University, Jorhat – 785 001, Assam

Objectives

➢ To collect, maintain, evaluate and standardise agrotechniques of seed spices such as Black cumin, Cumin, Fenugreek, Fennel and Coriander.

Progress of Research

Cumin

Germplasm collection, maintenance and evaluation : In the first year five cultivars from Rajasthan Agricultural University. (RZ-209, RZ-19, UC-198, UC-223) and one locally cultivated in the Dhubri district of Assam were tested.

The performance of cumin in general was poor and the following observation were noted:

☛ Seed germination was more than 75% at laboratory conditions; while in field the germination was restricted to 15-20%.

☛ The crop miserably failed to produce any seed despite vegetatively the plants showed fair performances till flowering

☛ At the flower initiation stages *Alternaria blight* was detected in the inflorescence and all part became highly infested by the causal organism leading to drying of the floral parts. Pathologists from the University were consulted for identification of the problem and control measure. However, the crop could not be saved.

☛ A severe physiological problem was noticed in the plants that were free from *Alternaria blight* disease. Such plants borne symptomatic congestion of inflorescence part showing a broom like appearance.

☛ The fate of the crop was totally controlled by the cumin wilt and the crop loss was total.

Black cumin

Germplasm collection, maintenance and evaluation : Six local cultivars were collected from lower Brahmaputra valley including one from Central Brahmaputra valley and evaluated. The yield potential of these cultivars ranged from 780 to 1090 kg/ha, with a crop maturity period of 185 to 190 days. Local 2 entry from Baliabil, Dhubri showed significantly better yield of 1091 kg seed/ha.

Standardization of agro-technique

Among the five different sowing dates tested at fortnightly interval starting from 15th October, showed that mid-November sowing was the best. Spacing of 30cm x10 cm was significantly superior, giving an yield of 1353 kg seed/ha at a maturity standard of 183 days. A Fertilizer dose of N:P:K @ 30:30:40 produced significantly more yield of 1547 kg seed/ha.

Fenugreek

Germplasm collection, maintenance and evaluation : Eleven cultivars were collected, and evaluated. UD-446 was the best yielder. There was wide variation of phenotypic-yield attributing characters of the cultivars. In varietal evaluation trial Rmt-1, Local 2 and UM-117 performed significantly better than the others.

Standardization of agro-technique

Sowing on 15th November was the best, and the spacing of 30cm x 10cm was superior producing an yield of 1008 kg seed/ha. Fertilizer dose of 40:40:60 of N:P:K was found to be better.

Coriander

Germplasm collection, maintenance and evaluation : Nine cultivars were collected from Rajasthan Agricultural University and two local collections were made from Assam. The cv. UD-446 performed significantly better, giving an yield of 1232 kg.

Standardization of agro-technique

Sowing on 15th November was best in Assam situation, giving an average yield of 811.5 kg seed/ha. A spacing of 30cm x 20cm was found to be statistically best, the yield being 1348 kg/ha. Fertilizer of 60:60:60 NPK was significantly better, giving an yield of 815 kg/ha.

Fennel

The Fennel crop failed consecutively in the last two years, indicating that fennel is not a suitable crop for Assam region.

Ahp 9. Exploring the Possibility of Spices Under Humid Sub Temperate Conditions of Himachal Pradesh

(Yudhvir Singh)

Department of Vegetable Science and Floriculture, H P Krishi Vishvavidyalaya, Palampur, Dist. Kangra, H.P. 176 062.

Objectives

- To screen varieties of spices like ginger, turmeric, large cardamom and fennal suitable for the subtemperate areas of Himachal Pradesh
- To develop basic agrotechnology for their production.

Progress of Research

Among fortyeight germplasm collections of ginger, twenty were collected from HARS, Pottangi, Gujarat and remaining from different parts of Himachal Pradesh. On the first year of field evaluation of these diverse genotypes, K-local from Himachal Pradesh yielded highest fresh rhizomes per plant. It also showed resistant reaction to rhizome rot, a devasting disease of the crop in the state, under field conditions and was also marked the best genotype on the basis of its morphological characters scored in the field. Genotypes from Dadasiba collection, Suneht (upper), Jwalapur and Mehruwala also showed promising behaviour with respect to yield and rhizome rot resistance reaction. For further evaluation and screening, these genotypes have been planted in the field during May, this year. Promising genotypes have been planted in larger area for multiplication and further screening. During first year of research, crude fibre and essential oil estimation was also done and genotypes Jwalapur, Naraga, V1E8-2, Suravi and Suprabha were found superior for crude fibre and genotype Nehrian Pukhar and Samoh-I were promising in respect of essential oil content.

An experiment on storage longevity of ginger genotypes was also conducted under different sets of conditions to find out the genotypes with longer shelf life so as to provide healthy, disease free seed material for next crop. Pit storage method with sand is found superior than storage in-situ and local storage (heap storage) method because of lesser sprouting and rotting of rhizomes.

Experiment on effect of rhizome size and spacing on yield and yield attributes was also conducted during first year of research. The highest yield (fresh) per plot (kg) was obtained from the combination medium *size (50g) at closer spacing (30x20cm).*

Five new collections of large cardamom were collected from ICRI, Tadong, Gangtok, Sikkim for planting but could not flourish well under Palampur conditions. Some local collections from Himachal Pradesh are showing promise and these plants have come into flowering this year. The seed of large cardamom varieties recommended for low altitudes will be procured from ICRI, Gangtok, Sikkim for which officials of Spices Board, Gangtok have been contacted and seed availability assured by them.

Thirtyfive genotypes of fennel were collected from Gujarat Agricultural University, Main Spices Research Station, Jagudan, Dist. Mehsana and other parts of the country and outside the country. Among these collections EC 386375 was introduced from Germany which is dwarf and

long duration type. Another introduction from outside the country is PLPF-1. Being a dual purpose genotype (vegetable type + seed type) it is performing extremely well under Palampur conditions and found highly promising in respect of seed yield and fresh yield as vegetable.

Seventytwo diverse genotypes of turmeric were collected from different parts of the country and within the Himachal Pradesh state. These genotypes were planted for studying variability and yield potential. *Kangra* Local-3 (collection from H.P. state) followed by *Mananthody*, PTS-10-A, Kangra Local-2, Sel.No.2, *Sudarshana*-A and *Alleppey* were found superior with regard to yield and other yield attributing traits. An experiment on intercropping of turmeric with maize, okra and colocasia was also practised and it was observed that turmeric plants intercropped with maize, french bean (dwarf and pole), okra and colocasia gave luxuriant growth. This may be due to the shading effect of intercrops on turmeric. Intercropping in turmeric may benefits the farmers with additional income.

At present replanting of the experiments for next year has been done. In turmeric one set of genotypes was left in the field to verify and compare their performance for yield and curcumin contents after one year and second year of digging. Classification of turmeric genotypes are also being made on the basis of curcumin content.

AhP 10. Biological control of Plant Parasitic Nematodes of Major Spice Crops

(K V Ramana)

Indian Institute of Spices Research, Marikunnu PO, Calicut – 673 012

Objectives

- Isolation and identification of native isolates of biocontrol agents from the rhizosphere and rhizoplane of ginger and turmeric
- Culturing and maintenance of the isolates, testing their efficacy in suppressing the target nematode species - *in vitro* and *in vivo* studies.
- Understanding the ecology and mode of action of these isolates on plant parasitic nematodes.
- Standardizing mass multiplication of promising agents and developing suitable delivery systems.

Progress of Research

Isolation of naturally occurring biocontrol agents (BCAs)

A random survey was undertaken in four districts of Kerala viz., Wynad, Kannur, Kasaragod and Calicut for isolation of naturally occurring BCAs (fungi and bacteria) in the ginger rhizosphere. Thirty root samples of ginger along with rhizosphere soil were collected and processed. From these samples 29 each of bacterial and fungal isolates were obtained.

Standardisation of culturing and maintenance of pure culture of microorganisms

Ginger roots were washed and stained in Phloxine B solution for staining the root knot nematode egg masses. The stained egg masses were surface sterilized and were plated in Potato Dextrose Agar (PDA) medium and incubated for a week at 25°C. The fungal colonies growing from the egg masses were subcultured, purified and stored in PDA slants for further studies. For long term storage of fungal cultures, Potato Carrot Agar medium or liquid paraffin was used.

For isolation of bacteria, the rhizosphere soil was serial diluted and plated in nutrient agar and the bacterial colonies emerged were subcultured in Yeast extract-glucose-calcium carbonate agar slants. *Trichoderma* spp., *Paecilomyces lilacianus*, *Verticillium chlamydosporium* and *Pseudomonas fluorescence* were isolated using specific, selective or semi-selective media.

Standardisation of protocols to test the bioefficacy of test organisms on nematode suppression

1) Fungi : The fungal isolates were grown in PDA and a 5mm agar disc was transferred to 1.5 per cent water agar and the plates were incubated for five days. Egg masses of root knot nematodes were collected, sufrace sterilized in 0.01 per cent mercuric chloride, washed in sterile water and subsequently treated with streptomycin sulphate. These egg masses were then aseptically transferred to the culture plates where the fungi were growing and incubated for a week. One batch of egg masses was then subjected to hatch test and the other batch was stained for observing egg parasitization by the test fungi.

Hatch test : After the incubation period, the egg masses treated with fungi were transferred to sterile distilled water and nematode hatching was enumerated with the aid of stereo microscope. The number of juveniles released from eggs were recorded and compared with that of uninoculated control and the percent decrease of hatching was calculated.

Egg parasitization : Egg masses treated with the fungi were also simultaneously tested for parasitization by the fungi. The treated egg masses were stained with two different stains namely, cotton blue-lactoglycerol and modified lacto-glycerol (lactic acide-85%, glycerol-99.5% and distilled water, 2:2:1 vol/vol). These egg masses were kept on a glass slide and pressed under a cover glass to release the eggs. The difference in permeability of the egg shell of asymptomatic and symptomatic eggs quickly became clear in a minute, whereas asymptomatic eggs remained unchanged for more than five minutes. Attachment of spores and fungal mycelia to the nematode eggs was also recorded.

Wherever egg parasitization was observed, the test was repeated using a different technique. Young root knot nematode females were excised out of the roots and were placed in sterile salt solution on a glass slide to get individual eggs of known age. These eggs were treated with the spore suspension of the candidate fungus and were observed for the growth of the fungus, which is a clear indication of the egg parasitization.

2) Bacteria : The bacterial isolates were inoculated in 5ml sterile potassium phosphate buffer (pH 6.8) in test tubes and were incubated at 4°C for 10 days. A known number of root knot nematode juveniles were surface sterilized and exposed to this bacterial suspension as well as sterile water (control) and the mortality of the nematodes in these suspensions were compared at periodic intervals.

3) In vitro bioassay : All the fungal and bacterial isolates were tested for their suppressive effects on nematode hatching in the laboratory bioassays. There was a significant supression (> 80%) in the hatching of nematodes treated with the fungal isolates (No. 4, 5, 7, 8, 11, 14, 16, 23, 25 and 29). Further, nine isolates also showed parasitization of nematode eggs. Among 29 bacterial isolates, isolate No.1, 3, 4, 5, 8 and 10 caused 80 per cent or more mortality to second stage juveniles of root knot nematodes.

AhP 11. Establishing In vitro Conservatory of Spices Germplasm

(K V Peter, P N Ravindran and K Nirmal Babu)

Indian Institute of Spices Research, Marikunnu PO, Calicut - 673 012

Objectives

- Standardisation of ideal protocols for *in vitro* conservation of spices germplasm.

- Developing protocol for ultra low temperature (Cryopreservation) for long term storage of spices germplasm.

- Conserving the currently available germplasm accessions of black pepper, cardamom, ginger, turmeric, vanilla and herbal spices in the *in vitro* conservatory, and its maintenance.

Progress of Research

Developing Slow Growth Protocol for Ginger, Turmeric and Vanilla

Utilising the existing protocol developed at Indian Institute of Spices Research, vanilla cultures were multiplied to generate adequate materials for experimentation. In ginger and turmeric approximately two cm sized plantlets were harvested from *in vitro* multiplied cultures and inoculated in MS medium supplemented with different combinations of sucrose and mannitol. It was found that the cultures can be stored, without subculturing up to one year, in half strength MS medium supplemented with $10gml^{-1}$ each of sucrose and mannitol. Experiments were also initiated for refining the existing protocol, so as to increase the subculture interval, beyond one year.

Developing Cryopreservation Protocols for Long Term Storage of Spices Germplasm

Meristems, being ideal materials for cryopreservation, were isolated from *in vitro* plantlets of cardamom, ginger, turmeric and vanilla, and attempts were made to store them as synthetic seeds by encapsulating in 3-5% sodium alginate. This meristem synseeds germinated within two weeks when cultured in liquid MS basal medium, without any growth regulators.

Cryopreservation experiments were initiated using these synseeds and also with *Capsicum* seeds. *Capsicum* seeds were desiccated at different time intervals to moisture levels varying from 20.3% to 7.6%. From these initial experiments it was found that the seeds desiccated to 11.3% and 10.9% moisture content had a survival rate of 50% and 60% respectively, after cryo-preservation, and their desiccation control also had a survival rate of 60%.

Conservation of Spices Germplasm

Establishment of accessions *in vitro* was attempted and priority was given to those with important characters like high quality, high yield, resistance to disease and endagered species. Some important accessions established *in vitro* are:

Piper

Piper silentvalleyensis	:	Endangered Spp.
P. nigrum – Kalluvally	:	Drought tolerant
P. nigrum – Pournami	:	Nematode tolerant

Cardamom

NKE Lines	:	Natural katte escapes
APG 150	:	dwarf, multibranched

Ginger

Varada	:	released variety
Acc 9, 69	:	extra bold rhizome
Acc 108	:	high volatile content (> 2%)

Turmeric

IISR Pratibha	:	Released variety having high yield and high curcumin
Suguna, Suvarna, Sudarsana	:	" "

AhP 12. Hybridisation in Ginger, *Zingiber officinale* (Rosc) Through *In Vitro* Pollination

(P A Valsala)

College of Horticulture, Vellanikkara - 680 654, Trissur

Objectives

- Embryo rescue and germination studies of *in vitro* produced seeds of ginger
- Production of hybrid population of ginger through appropriate crosses by *in vitro*
- Establishment of hybrid population by *in vitro* cloning
- Field establishment and evaluation of hybrid population

Progress of Research

The cultivars *Maran* and *Rio-de-Janeiro* were raised in field for continuous supply of flowers. *In vitro* seeds were raised by crossing *Maran* and *Rio-de-Janeiro* and vice versa. The *in vitro* placental pollination technique for ginger as standardised by

Valsala (1994) was used for raising seeds. Embryo culture and seed germination studies were conducted for the growth of the embryo.

Germination studies of in vitro seeds of ginger

The studies on germination of ginger seeds showed that primary treatments like water soaking and incubating on moist filter paper, moist sand or basal medium (both solid and liquid state) did not favour germination of ginger seeds. Incubating the seeds in 1/2 MS + 6% sucrose along with 2,4-D 0.1 to 1.0 mg/l or NAA 0.5 to 2.0 mg/l and BAP 5 to 20mg/l had no influence on germination of ginger seeds. The combination of NAA 0.5 mg/l or IAA 0.05 to 0.2 mg/l with 2ip 2.5 to 5 mg/l had no influence on seed germination. GA3, 5 to 10 mg/l and ethepon 5 to 10 mg/l also did not favour seed germination.

Seed treatments like chemical and mechanical scarification, stratification, washing the seeds in running water and subjecting the embryos to stress condition by dehydrating hydrated seeds for 12 h or soaking the seeds in 12% each of mannitol and PEG-4000 solution did not influence germination.

Investigations on embryo rescue studies in ginger

Embryo rescue techniques tried had no favourable response on the germination of embryo. Embryos along with endosperm were isolated from the seeds of 20, 40, 60 and 80 days after pollination and were cultured in the basal medium of 1/2 MS containing various concentrations of auxin and cytokinin combinations

AhP 13. Development of Resistant Variety / Lines of Cumin to Wilt Caused by *Fusarium oxysporum* using *In Vitro* Techniques

(R K Sharma)

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Objectives :

- Establishment of callus culture from explant of cumin
- To survey, isolate, identify and characterise different pathogenic strains involved in disease development in plants
- To formulate and standardise the protocol for regeneration from callus cultures
- To isolate and purify the toxin from virulent *Fusarium* strains
- Bioassay, demonstration of manifestation of wilt disease symptoms in the presence of toxin

- In vitro selection of cell line tolerant / resistant to wilt toxin
- Regeneration of plants from tolerant / resistant cell line

Progress of Research

Collection of *Fusarium* isolate and isolation and bioassay of toxins

During March 1999 a survey was undertaken in major cumin growing areas of Rajasthan viz., Jalore, Barmer and Jodhpur districts. By and large the wilt incidence ranged from 10-30 per cent, however, in certain places, fields were completely wiped out due to wilt disease. Wilt infected cumin plants were collected from 25 locations and 46 isolates of *Fusarium* spp. were obtained. These isolates are being examined for further identification up to species / F. species level. Prior to this survey 10 isolates of *F. oxysporum* f. sp. *cumini* were collected from SKNCOA, Jobner (Lead centre on seed spices research) and adjoining areas during the year 1998. Pathogenicity of all the 10 isolates to cumin was proved using sick plot technique.

An experiment was conducted to determine optimum pH and temperature levels for best mycelial growth of *F. oxysporum* f.sp. *cumini*. The results revealed that optimum pH and temperature for linear mycelial growth were 7.0 and 27°C respectively.

Filter sterilised crude culture filterate (C C F) of *F. oxysporum* f. sp. *cumini* was found to be potent in inducing wilt in seedling explants of cumin genotypes. Considering this, the C C F was further processed for purification of toxin (Fusaric acid).

Closed project

AhP 16. Species relationship in the genus *Piper* and scope of related taxa in the improvement of *Piper* nigrum L.

(V S Sujatha)

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Objectives

- Survey and collection of species of the genus *Piper* and genotypes of *Piper nigrum*
- Study the genus *Piper*
  - i) Morphologically
  - ii) Cytologically
  - iii) Isoenzyme variation
- Find out species relationship in the genus *Piper*

Achievements

Survey and collection

Extensive surveys were conducted in the forest areas of Western Ghats for collecting wild species of *Piper* and wild types of *Piper nigrum*. Survey and collection was also conducted in the homesteads of Kerala to collect genetic diversity of *Piper nigrum*. Collections were also made from Pepper Research Station, Panniyur, NBPGR Regional Station, Vellanikkara, RARS, Ambalavayal and IISR, Calicut. Fourteen species of *Piper* and 130 genotypes of *Piper nigrum* were collected.

Morphological studies

The following *Piper* spp. were studied morphologically and cytologically:

P. argyrophyllum (male), *P. argyrophyllum* (female), *P. attenuatum* (male), *P. bababudani*, *P. chaba* (female), *P. colubrinum*, *P. longum* (male), *P. longum* (female), *P. longum* (female), *P. nigrum* (Panniyur 1), *P. nigrum* (wild male).

Detailed morphological descriptions were made and based on this a key for identification of the species has been suggested.

Cytological studies

To find out the somatic chromosome number of different species of *Piper*, mitotic studies were carried out using root tip squash method. Somatic chromosome number of *Piper* species studied are given below.

P. argyrophyllum 36, *P. attenuatum* 52, *P. bababudani* 32, *P. betle* 32, *P. chaba* 24, *P. colubrinum* 26, *P. longum* 32, *P. nigrum* (Panniyur1) 52, *P. nigrum* (wild) 52.

The chromosome numbers did not follow a clear arithmetic progression and it was difficult to draw any definite conclusions regarding the basic chromosome numbers. However, it was observed that, apart from the South American species all other species possessed chromosome numbers that are multiples of four.

Isoenzyme variation

Twentysix varieties of *P. nigrum* and eleven species of the genus *Piper* were studied for variation in three enzyme systems viz., peroxidase, esterase and Got.

Peroxidase

Ten isoenzyme bands were found common in all the varieties. Four variant isoenzymes were found in the varieties studied.

Esterase

Five isoenzyme were observed in the 26 collections studied. EST-15 was common in all the twenty six types. Varieties were grouped into two based on the presence of either EST-2 or EST-4 in them.

GOT

A total of 15 isoenzymes were observed in the 26 varieties of *P. nigrum* analysed. A grouping of varieties was done based on variations in GOT zymogram.

Similarity among P.nigrum varieties

Similarity index among the varieties for isoenzymes was calculated according to Sokel and Sneath (1968). Similarity index for three enzymes put together ranged from 0.4 to 1. The wide variation among cultivated *P. nigrum* was in confirmation with Kanakamani's (1985) observation on morphology.

***Isoenzymes variation and species relationship in the genus** Piper*

Peroxidase

A total number of 31 isoenzymes were found in the species studied. *P. bababudani, P.pseudonigrum* and *P. nigrum* possessed identical peroxidase pattern with a similarity index of one among them. Peroxidase profile of *P. argyrophyllum* and *P. attenuatum* were similar which support a high level of morphological similarity between the species. Within species variation was observed in *P.betle, P.chaba* and *P. hapnium* were closely related with S.I. 0.75.

Esterase

Different species differed widely in esterase pattern. However, *P. argyrophyllum,* and *P. attenuatum* showed a similarity index of one. Within species variation was less in *P. betle* types but much in *P. attenuatum, P. longum* and *P. argyrophyllum, P. colubrinum, P. chaba* and *P. hapnium* and differed from the rest of the species in esterase pattern.

GOT

A total of 24 isoenzymes were observed in GOT for *Piper* spp. The similarity index ranged form zero to one. The maximum being among *P. argyrophyllum* and *P. attenuatum* types and *P.pseudonigrum* and *P. bababudani. P. hapnium* possessed a different zymogram from rest of the species. The similarity of *P. hapnium* with other species for GOT zymogram was mostly zero and less than 0.2 with *P. nigrum, P.pseudonigrum* and *P. longum. P. chaba* showed its distinctness from rest of the species with a similarity index of zero with most of the species and a low similarity of 0.2 with *P. colubrinum.* GOT pattern of *P.galeatum* was different from P.nigrum, *P.pseudonigrum* and *P. bababudani* unlike the case of peroxidase and esterase.

Similarity index among** Piper **spp. for the three enzymes

Average similarly indices for the three enzymes were computed

among the eleven species of *Piper*. The groups of species closely related are

Group I *P. nigrum, P. pseudonigrum, P. bababudani, P. galeatum* (SI 0.38 to 0.78)

Group II *P. argyrophyllum* and *P. attenuatum* (SI upto 0.72)

Group III *P. chaba, P. hapnium* and *P. colubrinum* (SI 0.30 to 0.51)

P. bababudani and *P. pseudonigrum* are recently reported species. These species are very similar to *P. nigrum* morphologically. In isoenzyme studies, highest similarity index of 0.78 was observed between *P. pseudonigrum* and *P. bababudani* which showed their closeness, confirming the morphological similarity. *P. nigrum* showed a similarity index of 0.75 with *P. bababudani* and 0.67 with *P. pseudonigrum* is closer to *P. pseudonigrum* (SI 0.45) and *P. bababudani* (SI 0.41) than *P. nigrum* which showed a similarity index of only 0.38

P. attenuatum and *P. argyrophyllum* are two other species which were observed to be very closely related in the present study (SI upto 0.72). This confirms the report earlier workers based on morphology and D2 analysis.

P. colubrinum, P. hapnium and *P. chaba* formed the third group with maximum similarity between *P. colubrinum* and *P. chaba* (SI 0.51). The similarity of *P. hapnium* with *P. chaba* was 0.42 and that with *P. colubrinum* was 0.30

The study revealed the distinctness of *P. longum* and *P. betle* from the rest of the species, having very low similarity index with others. The low similarity observed between *P. longum* and *P. hapnium* was contradictory to the high morphological similarity observed between the species.

Closed project

AhP (7). Integrated Management of Rhizome Rot of Ginger

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Objectives

- To demonstrate the leads obtained at IISR, Calicut, Rajasthan Agricultural University, Udaipur and Dr Y. S. Parmar University of Horticulture and Forestry, Solan on disease management. Soil solarisation and biocontrol of rhizome rot caused by *Pythium aphanidermatum* in the different agroclimatic zones especially in major ginger growing areas.

- Standardisation of large scale multiplication of *Trichoderma* (T. *harzianum* and *T. hamatum*) spp. and *Gliocladium virens*.
- Development of effective and cheap delivery systems, both for soil application and seed treatment.
- Setting up of demonstration plots in the respective regions which represent the different agroclimatic zones

Achievements

A field survey was conducted during Oct. 1996 to estimate the severity of Rhizome rot disease of ginger in some of the major ginger growing districts of Kerala viz. Calicut, Ernakulam, Wayanad, Kottayam and Idukki. About 150 fields were surveyed.Of these 61 fields showed a disease incidence of less than 10%, 18 fields recorded a disease incidence of 11-25%, 11 fields had a disease incidence of 26-50%, 7 fields recorded a disease severity of more than 50% while 53 fields had no disease at all. From each of the fields healthy as well as diseased samples were collected. The pathogen *Pythium aphanidermatum* was consistantly isolated from diseased samples and its pathogenicity established. From the healthy ones 68 bacterial isolates, 109 isolates of *Trichoderma* and 132 other fungal agents were isolated. These were screened subsequently for their biocontrol potential both in vitro and in vivo. Ten bacterial isolates, three isolates of *Trichoderma* and five other fungal isolates showed disease suppression upto 70% as compared to 50% in control. In addition, about 116 species of *Trichoderma* from the IISR Repository of biocontrol agents were screened to test their efficacy. Of these, 17 isolates were found effective. These efficient isolates included four isolates of *T. hamatum*(with 0-10% D.I, when screened invivo), two isolates of *T. aureoviride*, (0-6% DI) two isolates of *T. virens* (0-7% DI), five isolates of *T. harzianum* (5-8% DI), two isolates of *T. pseudokoningii* (0% DI) and one isolate each of *T. longibrachiatum* (0% DI) and *T. polysporum* (6.3% DI). The present collection of biocontrol agents is being maintained.

Studies on storage of ginger seed material

Different agrochemicals viz. insecticides like Quinalphos, Malathion and fungicides like Ridomil MZ and Mancozeb alone and in combination with *Trichoderma harzianum* as seed treatment were tested for their efficacy in reducing storage rot.

Trichoderma harzianum did not show any additive effect during storage. However, treatment with Dithane M-45(0.4%) and Quinalphos(0.1%) was most effective during storage.

Percentage of recovery was 8.5 kg when compared to 7.4 kg in control.

Field trials

Experiments on integrated disease management of rhizome rot of ginger were set up at the IISR experimental farm, Peruvannamuzhy, to evaluate the bioefficacy of the biocontrol agents alone and with different amendments like farm yard manure, starch(2%-used as seed treatment) and fungicides like Ridomil MZ and Mancozeb.

Seed treatment with starch and biocontrol agents reduced preemergence rot(4-12%), disease incidence (13-21%), and increased yield (1.5-3.2 kg/3m^2 bed) when compared to 11%, 33% and 0.8kg/bed respectively in control. Although application of different dozes of BCAs had no effect in controlling the disease, application of the biocontrol agents twice was more effective in controlling the disease(12-17% D.I in treated beds as compared to 30.5% in control).

Soil solarization experiments were also conducted in the experimental plot. Disease incidence in solarized plot ranged from 11 to 25.6% compared to 40% in control. Similarly the yield were 2.6 to 6.6 kg/3m^2 bed compared to 0.8 kg/3m^2 bed in control.

Pot culture studies

The efficient bacterial isolates obtained from the 1996 survey were screened for the growth promotive and disease suppressive effects. An increased vigour in terms of increased germination percentage(83-100%), height(29-53cms) and no. of sprouts(12-16/pot) was obtained when the seed rhizomes were treated with bacterial isolates. A disease incidence upto 25% was obtained in the treated pots as compared to 60% in control.

Field demonstration

IDM demonstration trials were set up in farmers' fields for two consecutive years in Kannur, Wayanad, Idukki and Calicut during 1997-98, and in Kannur, Kasaragod and Wayanad during 1998-99. The treatments imposed included seed treatment with fungicides alone and in combination with soil application of the biocontrol agent, *Trichoderma harzianum*.

During 1998-99, complete absence of disease incidence in biocontrol treated beds compared to 10 to 30% disease incidence in untreated beds was noticed. In 1998-99, a reduced disease incidence of 0-5% was obtained in the treated beds as compared to 5-20% in control. An increased yield of 8-14 kg/bed was also observed in these when compared to 4-9 kg/bed in control.

Biocontrol agents were mass multiplied and supplied to farmers during 1996-99 and about 64.6 acres of the ginger fields were treated with the biocontrol agents. The feedback obtained revealed that about 80% of the

farmers are convinced of the use of biocontrol agents in the suppression of the disease.

During the current year, demonstration plots have been set up in five major districts ie., Kannur, Kasaragod, Wayanad, Calicut and Idukki. Field experiments with bacterial isolates at Peruvannamuzhy are also in progress.

Results of Scientific value

- The field trials conducted at the Institute and demonstration plots in different districts of Kerala have clearly brought out the efficiency of Integrated Disease Management Technology with greater emphasis on use of biocontrol for disease suppression.
- Potential bacterial isolates which have an increased vigour as well as disease suppressive effects have been isolated.

Recommendation

Seed treatment with Ridomil MZ (200 ppm) and application of biocontrol inoculum @ 50 g/bed along with neemcake @ 1kg /3m^2 bed (2 tonnes of neemcake/ha) is recommended.

Closed project

AhP (9). Biological Control of Scale Insects Infesting Black pepper

(S Devasahayam)

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Objectives

- Identification of natural enemy complex of scale insects infesting black pepper
- Biology of major natural enemies
- Standardization of techniques for mass rearing of natural enemies
- Field release and evaluation of efficacy of natural enemies
- Integration of biological control with other methods of control

Achievements

Documentation of natural enemies of scale insects

Extensive surveys were conducted in 32 locations of major black pepper growing areas in Wynad and Idukki districts of Kerala, Kodagu District of Karnataka and Dindigul Anna District of Tamil Nadu to document the incidence of scale insects and their natural enemies on black pepper. Among

the various species of scale insects recorded on the crop during the surveys, *Aspidiotus destructor* Sign. and *Lepidosaphes piperis* Green were more serious. Twenty one genera/species of predators and parasitoids were recorded on these two species of scale insects. Among them, *Mallada boninensis* (Okamoto) (Chrysopidae), *Chilocorus nigrita* (Fab.), *Pseudoscymnus* sp. (Coccinellidae), *Lesitodiplosis* sp. (Cecidomyiidae), *Adelencyrtus* sp. (Encyrtidae), *Aphytis* sp. and *Encarsia citrina* (Craw.) (Aphelinidae) were new records. Among the natural enemies, *Aphytis* sp. was the most widely distributed (occurring in 22 locations), followed by *Pseudoscymnus* sp. (18 locations) and *C. circumdatus* (13 locations).

Biology of Chilocorus spp.

The life history of the coccinellid predators, *C. nigrita* and *C. circumdatus,* that were identified to be the most potential bicontrol agents for the control of scale insects was studied. The total life cycle in *C. nigrita* and *C. circumdatus* was completed in 29.9 ± 2.5 and 22.6 ± 1.9 days, respectively. The fecundity of females was 101.2 ± 42.7 and 270.0 ± 100.0 eggs, and adult longevity 55.7 ± 13.3 and 32.0 ± 14.4 days, respectively, in *C. nigrita* and *C. circumdatus.*

The predatory potential of adults and IV instar larvae of *C. nigrita* and *C. circumdatus* on *L. piperis* and *A. destructor*, respectively was studied. Among the predators, *C. nigrita* fed more voraciously on *L. piperis,* the adults and larvae feeding on 27.6 ± 11.5 and 30.6 ± 17.9 scale insects, respectively, per day. *C. circumdatus* fed more voraciously on *A. destructor,* the adults and larvae feeding on 114.0 ± 37.8 and 77.8 ± 5.2 scale insects, respectively, per day.

Mass rearing of scale insects and natural enemies

Techniques were standardised for the mass rearing of *C. nigra* and *C. circumdatus* in the laboratory. Initially, various fruits/vegetables were evaluated for their suitability as host material for rearing *Aonidiella orientalis* (host scale). Among the various materials evaluated, the settlement of crawlers of the host scale, their subsequent growth and reproduction was satisfactory on fully matured pumpkins (*Cucurbita pepo*) alone. Hence, pumpkins were identified to be the most suitable host material for host scale multiplication and their subsequent use for rearing of the predators .

The critical periods for crawler production and inoculation periods for raising *A. orientalis* cultures on pumpkins were determined. Crawler production in *A. orientalis* was initiated 25-27 days after their establishment and was high up to the first six days.

At a time, three pumpkins could be inoculated with a single mother pumpkin, and an inoculation period of two days was ideal for optimum settlement of crawlers. The inoculation could be repeated thrice with the same pumpkin; thus, nine pumpkins could be inoculated with *A. orientalis* from a single mother pumpkin within six days. The pumpkins with the established scale insects could be used as food material 12 days after settlement of crawlers.

The optimum population levels of predators that could be maintained on a single pumpkin infested with *A. orientalis* were determined. Inoculation of 75 eggs of *C. nigrita* on a single pumpkin was optimum since the number of scales present was sufficient for the predators to complete its development without changing them to new pumpkins and very few scales were left behind. In the case of *C. circumdatus,* inoculation of 35 first instar larvae on pumpkins was optimum for culture of the predator .

Evaluation of efficacy of natural enemies

The coccinellid predators *C. nigrita* and *C. circumdatus* reared in the laboratory were evaluated in the field at Wyanad (Kerala) for their efficacy in the control of *L. piperis* and *A. destructor*, respectively.

Eggs of *C. nigrita* that were oviposited on cotton pieces in the predator rearing cages were tied on vines infested with *L. piperis;* a total of 125 eggs were tied per infested vine (five releases at 7-10 days intervals). The trials indicated that there was 45% decrease in the population of scale insects on the predator released vines whereas, there was a 14% increase in population of scale insects on the non released vines .

First instar larvae of *C. circumdatus* were evaluated against *A. destructor;* a total of 85 larvae were released per vine (five releases at 7-10 days intervals). The trials indicated that there was 69 - 92% decrease in population of *A. destructor* on the released vines compared to 4 - 56% increase in population of *A. destructor* in non-released vines.

Integration of biological control with other methods of control

Evaluation of plant and oganic products for the control of scale insects

The toxicity of plant and organic products (neem oil 0.3% and 0.6%, Neemgold 0.6% and fish oil rosin 3%) and insecticides (monocrotophos 0.01% and dimethoate 0.1%), to *L. piperis* and *A. destructor* was evaluated to develop management schedules for scale insects compatible with biocontrol agents.

All the products and insecticides evaluated were effective over control in reducing the population of *L. piperis* on the 15th day after treatment and

were on par with each other. However, on 30th day, all the treatments including control were on par with each other.

In the case of *A. destructor,* dimethoate 0.1%, monocrotophos 0.1% and fish oil rosin 3% were on par and significantly superior over other treatments. At 30th day after treatment, dimethoate 0.1%, monocrotophos 0.1% and fish oil rosin 3% were significantly superior over other treatments and were on par with each other .

Toxicity of insecticides to Chilocorus spp.

The toxicity of insecticides (monocrotophos 0.1% and dimethoate 0.1%), plant and organic products (neem oil 0.3% and 0.6%, Neemgold 0.6% and fish oil rosin 3%) to *C. nigrita* and *C. circumdatus* was evaluated under laboratory conditions to determine safe periods for release of the predators in the field.

The trials indicated that monocrotophos 0.1% and dimethoate 0.1% were toxic to *C. circumdatus* up to 15 and 7 days after spray, respectively. Neem oil 0.3% and 0.6%, Neemgold 0.6% and fish oil rosin 3% did not cause any mortality to predator even at 0 day of spray. In the case of *C. nigrita*, monocrotophos 0.1% and dimethoate 0.1% were toxic up to 7 and 1 days after spray, respectively, whereas neem oil 0.3 and 0.6%, Neemgold 0.6% and fish oil rosin 3% did not cause any mortality to *C. nigrita* even at 0 day of spray.

The trials indicated the feasibility of utilization of plant and organic products along with release of *Chilocorus* spp. for the integrated management of scale insects on black pepper.

Closed project

AhP (10). Developmental Morphology of Rhizomes of Ginger and Turmeric

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Objectives

This project was initiated to study in detail the developmental anatomy of the rhizomes of ginger and turmeric. The knowledge on rhizome development is a basic prerequisite to the manipulation of crop productivity and is also important in understanding the soil pathogen entry. This project had the following specific objectives

- To study the internal structure of rhizomes of ginger and turmeric
- To analyse the process of development and differentiation, anatomically and histochemically
- Varietal and species variations if any existing in the above pattern
- Influence of growth regulators in rhizome development and differentiation.

Achievements

Studies were carried on cytohistological zonation of apical meristem, development of procambial cells from meristematic region, initiation of new rhizome fingers, ontogeny of axillary bud initiation, root initiation, development of oil cells, curcumin cells etc. The study has shown, among other findings, the presence of vascular cambium in ginger and turmeric rhizomes, and this is a rare feature in monocots. Phloem without callus plugs in mature rhizomes shows evidence of living conducting tissues throughout the life cycle of the plant. The recycling of rhizome for seed propagation is made possible by this property. The process of development of oil cells and the oil secretion has been studied in detail. Comparative anatomy of related *Zingiber* and *Curcuma* spp. have indicated similar type of anatomical features in all species. However differences exist in histochemical pattern, leaf anatomy, stomatal characters, oil cell index, fiber dementions etc.

Influence of growth regulators on ginger and turmeric rhizome development was also studied. Treatments with paclobutrazole has increased the essential oil content in ginger and curcumin content of turmeric. The growth regulator application increased vasculirization of rhizomes and increased the size and number of vascular bundles, thereby influencing the transport capacity of the phloem. Increase in rhizome thickness (and epidermal thickness of rhizomes) also resulted. The increase in epidermal thickness may be useful in reducing *Pythium* infection.

The specific conclusions of the study are given below:

Ginger

- Rhizome is the underground storage stem of ginger plant. The branching of rhizome is by the enhanced growth of dormant axillary bud which is originating from the adaxial side of the leaf or scale leaf of each node.
- Girth increment of rhizome and new branches originate by three types of meristematic activity (1) Primary thickening meristem or procambium (ii) Secondary thickening meristem (iii) Actively dividing ground parenchyma.

- The presence of secondary thickening and cambium in ginger is a new report among monocot plants
- Phloem without callose plug in mature rhizome shows evidence of living conducting tissues throughout the life cycle of the plant
- Phloem with more companion cells functions as storage part of reserve food
- Oil cells are present more in shoot apices and nodal regions than in *internodal regions*
- Oil cells are found below the epidermis and they do not occur in the epidermal layers. Ontogeny of oil cells take place by schizogenously as well as lysogenously
- Oil diffusion from oil cells are through intercellular space and cell to cell transport through plasmodesmata
- Comparative anatomy of four species of *Zingiber* showed differences at species level. Such anatomical variations are useful in species delimitation
- *Zingiber officinale* has higher oil cell index compared to other three species
- Fibre sizes are high in *Z. zerumbet* than the other three species
- Stomatal index is higher in *Z. zerumbet*
- GA3 (1000ppm) treatment reduced fibre content in ginger rhizomes
- Application of 10g Triacontanol increased the dry weight of rhizomes
- The quantitative analysis of GA3, Paclobutrazole and Triacontanol treated ginger did not show any variations in the amount of gingerol or oleoresin compared to control
- Paclobutrazole treatment increased the wall thickness of epidermis and cortical cells compared to other treatments and control
- The size of the vascular bundles are comparatively larger in treated plants than in control.
- Starch accumulation was found to be higher in paclobutrazole and triacontanol treatments

Oil cells and oil canals

The differentiation of oil cells and formation of oil cavities occur at the apical part of shoot and root, before the initiation of vascular elements. Oil canal is formed by two methods – In the first type the primary duct is formed by separation of meristematic layer and the second type is by the lysis of the entire cell. The development of duct has four stages ie., initiation, differentiation, secretion and quiescence.

The primary duct is initiated by the separation of a group of densely stained meristematic cells which are previously arranged closely. The separation is due mainly to the dissolution of middle lamella, followed by the separation of duct initials leading to the formation of an intercellular space bordered by epithetial cells possessing dense cytoplasm. The intercellular space thus formed becomes a lumen.

The second type of duct formation – by lysis of the entire cell – is more frequent. This type is observed in both young and mature stages of rhizome development. The disintegration and lysis is a gradual process. Differentiation of oil cavity begins from the outer region of the cortex. Certain cells, in between the meristematic cells, become large with dense cytoplasm and a large nucleus. In the next stage, vacuolisation of such cells sets in, and also the dissociation of nuclear membrane. Gradually the nucleus disintegrates, simultaneously the surrounding cells also enlarge and become thin celled (called epithelial cells). The central enucleated cell gets gradually distingrated producing a central duct lumen lined by the enlarging neighboring cells (epithelial cells).

The epithelial cells are the secretory cells and the secretion from these cells accumulate in the duct lumen. The epithetial cells gradually get lysed, and subsequently new epithetial cells get differentiated and the process of secretion continues. The secretory activity stops later (quiescence) when the cells gradually become filled with starch grains and ceases to become meristematic.

Turmeric

In turmeric, the rhizome development takes place by means of primary thickening meristem (PTM) situated below the young leaf primordia. This PTM is responsible for primary rhizome thickening, adventitious root production and formation of linkage between root, rhizome and leaf vasculature. This PTM ceases activity at a short distance behind the apex, and subsequent rhizome thickness takes place by secondary thickening meristem (STM). Theese STM produce secondary vascular bundles and parenchyma cells towards its inner side. Though, turmeric is a monocot, the meristematic region contains true cambium cells – ray initials and fusiform initials – a dicotyledonous character, is a significant finding.

In turmeric, the girth increase in rhizome is by means of the initial meristematic acitivity of the procambial cells or primary thickening meristem (PTM), meristematic activity of intermediate cambium like zone (fugacious cambium) and division and enlargement of ground parenchyma.

The secondary thickening meristem is responsible for the initiation of adventitious roots and that this meristem (STM) continuously produce vascular bundles and parenchyma cells in addition to the production of adventitious root. Thus the root apex, shoot apex and primary growth of turmeric by different meristems such as short living cambium, secondary thickening meristem and contribution of ground meristem have been studied and explained (inter connecting each other) for the first time in this crop.

Comparative anatomy of four species of turmeric, namely *C. longa*, *C. aromatica*, *C. amada* and *C. zedoaria* have 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 occur scattered in both outer and inner zones in *C. longa* and *C. amada*, the number is less in *C. zedoaria* and very few in *C. aromatica*. The endodermoid layer forms a 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 wavy in nature. Due to the broken nature of endodermoid layer, the secondary vascular bundles are arranged in patches in these two species and not as 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.

Apart from this, the number of companion cells associated with sieve tube in vertical row is relatively high and highest number was recorded in *C. zedoaria*. Increasing the number of companion cells is directly proportional to metabolic translocation, especially reserve substances (starch). This was considered an identifying character among the species. The number and size of curcumin cells are higher in *C. longa* compared to other species.

The application of three growth regulators – Triacontanol, Paclobutrazol and GA3 – enhanced the vascularisation of the rhizome and increase the size and number of vascular bundles and finally influence the transport capacity of the phloem cells. The starch deposition was very high in paclobutrazol treated plants which shows enhanced photosynthate transport. Triacontanol application does not influence height of the plants

significantly. The maximum height was observed in GA treated plants. The girth (thickness) of rhizome was significantly more in paclobutrazol treated plants compared to other treatments and control.

The morphological alterations brought about by paclobutrazol include reduction in plant height, enhanced sucker production, wider canopy and bold rhizome. The reduction in plant height was directly proportional to higher concentration of paclobutrazol. The plants treated with 4ml paclobutrazol was quite short and more bushy. The short rhizome internodes with wider diameter is the result of the formation of more secondary tissues with wider vascular bundles and paranchyma cells. Because of the antigibberellin activity of paclobutrazol, the roots of treated plants exhibited increased length and diameter. These modification help the root to provide better anchorage and more efficient transportation of water and nutrients from the soil, and may also increase drought tolerance.

The size of vascular bundle is comparatively bigger in treated plants than in control. The number of xylem and phloem cells are also increased. The changes in phloem cross sectional area in the rhizome indicates its physiological effect on paclobutrazol treatment. It can also influence carbohydrate metabolism, increasing carbohydrate (starch grains) levels in rhizome.

Conclusions

The study led to the following information of practical and scientific value.

1) A thorough knowledge on the process of rhizome development
2) The process of development of oil secreting cells and oil canals have been outlined. The development is both schizogenous and lysigenous. The differentiation of oil cells starts early in the developmental stages, any attempt to increase the essential oil cells should begin during the early stages of development itself.
3) Anatomical features are found to be useful in species delimitation in both ginger and turmeric. These characters can supplement the morphological characters.
4) Investigations on the influence of growth regulators on anatomical features gave the following indications:

(a) GA_3 reduced fiber content in ginger

(b) Triacontanol increased dry weight

(c) Paclobutrazole led to increase in wall and epidermal thickness

(d) The size of vascular bundles increased, indicating the possibility of greater growth activity

(e) GA_3 and Paclobutrazole increased the frequency of oil cells indicating the possibility of higher oil content in treated ginger plant

(f) Paclobutrazol increased the curcumin cells in turmeric indicating the possibility of higher curcumin content in treated plants

(g) Paclobutrazole treatment increased root length, and root thickness, indicating that this chemical can increase both absorption process and tolerance to moisture stress.

The present study contributed substantially to the basic understanding on rhizome anatomy and development.

Closed project

AhP (11). Creation of Variation for Improvement of Yield of Coriander Through Mutation Breeding

(K Ramakrishna)

SKN College of Agriculture (Rajasthan Agrl. University), Jobner

Objectives

- To induce variability in the population
- To evolve coriander varieties with high yield and essential oil content
- To identify dual purpose types with high green and grain yield
- To isolate photoinsensitive types for growing both during kharif and rabi season
- To evolve early maturing types which can escape adverse conditions like drought.

Progress of Research

During 1994-95 experiments were conducted to standardise the optimal conditions to carry out experimental mutagenesis with two varieties of coriander namely RCr 20 and RCr 41. Results of pot and lab experiment revealed that L D50 in respect of gamma rays, sodium azide and EMS was 20 KR, 0.5% and 0.35%, respectively. During rabi of 1995-96, four released varieties of coriander viz., RCr-41, RCr-20, RCr-436 and C S-6 were given 15, 20 and 25 KR doses treatment of gamma rays (IARI, New Delhi) and with 1mm Sodium Azide or 1% Hydroxylamine treatments. EMS treatment could not be included as the

chemical could not be procured in time. The treated materials were sown in the field. Under field conditions 15 KR dose of gamma rays was found to correspond LD50. The surviving M1's were selfed and harvested separately in each variety. The M2 seeds of each M1 plant were sown in a row during Nov. 1996-97 to constitute an M2 family. Three hundred seventy eight families of RCr-41, 360 of RCr-20 and 264 each of RCr-426 and CS-6 were grown and observations (excluding C S 6) were taken on chlorophyll mutations, days to flowering, plant height, number of primary branches, umbels/plant, umbellets/umbel, seed setting/umbel, grains/umbel, 100 grain weight and yield per plant. Data were recorded on five randomly selected plants. For duration of flowering and maturity only single observations were taken. Observations on the rows having less than five plants were not included for statistical evaluation.

During rabi of 1997-98, a number of superior M3 progenies of RCr-41 (98), RCr-20 (49), RCr-436 (80) were raised. However due to severe hailstorm of 22nd March 1998, entire crop was damaged. But, plants covered under selfing bags were less damaged and thus M4 seeds of these progenies are available. The Senior Breeder, AICSIP, Jobner would be requested to take these progenies to raise M4 progenies for their evaluation.

As regards essential oil content, it may be pointed out that the existing method (distillation method) requires 100g of dry seedpowder to yield single observation. On account of limitation of seed material in M2 or M3 the essential oil in respect of a family was not determined. However, recently a rapid method of estimation of essential oil in sandlewood was devised using its extraction in hexane. This requires only 100mg of seed material per sample. We have adopted this procedure on coriander using 60 M2 families of RCr-20. The results obtained are encouraging and requires more experimentation for standardisation.

The data were subjected to statistical analysis. For all three varieties of coriander, the between progeny variance was significant while within progeny variance was non-significant. Further a number of progenies of the three varieties of coriander were identified which had higher mean than the respective control and were associated with higher or lower C.V. than the parent.

Closed project

AhP(12). Biochemical Characterization of Ginger and Turmeric

(T John Zachariah)

Indian Institute of Spices Research, Marikunnu PO, Calicut - 673 012

Objectives

- To establish genetic variability based on isozyme patterns
- To analyse quality parameters such as crude fibre, oleoresin, volatile oil, curcumin content
- To study relationship between isozyme profiles and quality traits

Achievements of the Project

Sixtythree accessions of ginger and 143 turmeric accessions from the Indian Institute of Spices Research (IISR) germplasm collection, were characterized using their isozyme profiles for four enzyme systems - acid phosphatase, superoxide dismutase (SOD), polyphenol oxidase (PPO) and peroxidase (PRX). Data on the categorization of the above accessions based on contents of major metabolities - total proteins, total free amino acids and total phenols has also been carried out. Characterizations based on above parameters were compared.

Accessions were collected from Kerala, (different locations) Andhra Pardesh (Visakapattanam) and other ginger and turmeric growing areas), Karnataka, Orissa, Meghalaya, Tripura, Arunachal Pradesh, Tamil Nadu (Koli Hills), Himachal Pradesh, Sikkim, UP, Assam, Manipur and seedling progenies.

Of the four isozyme systems studied in both ginger and turmeric, acid phosphatase gave maximum number of bands followed by SOD, PPO and PRX; were the most consistent and reproducible of the enzyme systems tested.

The isozyme profiles obtained were compared and paired affinity indices (PAI) were worked out between pairs of accessions. The percent of the PAI gave the % similarity between pairs of accessions. It was found that variability among the turmeric accessions studied was greater (36.4-100% average similarity) than those among the ginger accessions (85-100% average similarity). Dendrograms were constructed using the above data and the accessions were grouped based on their similarity in isozyme profiles. Categorization based on major metabolite contents did not always correlate with that based on isozyme profile.

Ginger

Dendrograms constructed using % similarity values of the four isozyme profiles, divided the 63 accessions screened into distinct groups. Acc.64, 372, 374, 204 and 291 formed distinct groups among the accessions.

Turmeric

One hundred and forty three turmeric accessions were categorised into groups of varying degrees of similarity from the dendrograms constructed on the basis of % similarity using the four isozyme profiles. Acc.1&4, 23&26, 35&39, 47&49, 47&52, 72&74, 75&76 and 92&95 showed the maximum similarity (100%) of the accessions and Acc.1862, 704 and 136 showed the least similarity. Acc. 62, 136, 352 and 135 formed distinct groups.

In general the accessions which showed 100% similarity were collected from the same geographical area which establishes the feasibility of using the study to identify distinct groups from the germplasm.

Electrophoresis assay

Young leaves including the first unfurled leaf and two to three leaves just below (mature leaves near the base were not used) were found most suitable for isozyme studies based on a preliminary standardisation using rhizomes, pseudo stems and leaves of different maturity. Enzyme extracts were prepared by thoroughly homogenizing 3.0-3.5g of the tissue in 5ml of prechilled extraction buffer (0.05m Tris-HCl, pH 7.4, containing 0.1% cysteine HCl, 0.1% ascorbic acid and 17% sucrose). The homogenate, after filtering through a muslin cloth was centrifuged at 15930g for 20min. at 100C. The supernatant was kept frozen until use.

STAFF

PROJECT COORDINATOR'S CELL

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Project Coordinator	:	Dr A K Sadanandan (Up to Nov. 1998) Dr P N Ravindran (From Jan. 1999)
Scientist	:	Ms C Vasugi
Technical Information Officer	:	Dr Johny A Kallupurackal
Jr. Stenographer	:	Ms C K Beena
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Asst. Professor (Ento.)	:	Dr (Ms) Mini Raj
Asst. Professor (Agron.)	:	Vacant
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Lab Assistant Gr.I	:	Mr P V Joseph
Peon	:	Mr K Aleykutty

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Tech. Assistant	:	Mr B Majumdar
Tech. Assiatant	:	Vacant

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Manuring of black pepper - U P K Nair

Control of Phytophthora foot rot disease of pepper - A Rajagopalan

Planting of pepper in homesteads & technique of bush pepper cultivation - K Arya

Harvesting & processing of pepper - K Arya

Management of pepper garden - U P K Nair.

METEOROLOGICAL DATA 1998

Pampadumpara

Latitude : 9° 45 N
Longitude : 77° 10 E
Altitude : 1100m MSL
Soil type : Clay loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)	
			Max	Min
January	8.4	2.0	23.9	16.4
February	1.0	1.0	26.7	17.5
March	0.0	0.0	29.3	18.4
April	52.0	5.0	29.8	20.3
May	83.0	6.0	27.4	20.0
June	345.3	28.0	23.4	18.7
July	376.8	30.0	21.9	17.0
August	291.0	27.0	22.9	18.1
September	219.0	27.0	22.7	18.2
October	319.0	24.0	22.6	17.7
November	237.2	15.0	24.1	17.0
December	191.2	12.0	21.8	16.0
Total/mean	**2123.9**	**204**	**24.71**	**18.07**

Chintapalli

Latitude : 17° 52 N
Longitude : 82°14 E
Altitude : 818m MSL
Soil type : Clay loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)		RH (%)
			Max	Min	
January	-	-	21.3	5.6	89.5
February	-	-	23.2	9.3	90.8
March	18.0	3	26.2	10.7	87.0
April	69.8	4	27.1	10.8	81.9
May	17.1	2	30.9	13.2	76.8
June	110.1	6	25.4	16.2	87.3
July	207.8	13	19.4	15.9	84.9
August	180.3	16	19.4	15.3	88.1
September	232.3	17	17.5	15.2	81.9
October	247.5	13	26.1	13.9	89.8
November	91.7	8	19.9	10.4	87.8
Devember	-	-	19.8	3.5	84.6
Total/mean	**1174.7**	**82**	**20.94**	**11.7**	

Guntur

Latitude : 16.18 N Longitude : 80.29 E

Altitude : 32m MSL Soil type : Black clay

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)		RH (%)
			Max	Min	
January	3.4	1	31.8	18.7	80.6
February	0.0	0	33.8	20.7	90.0
March	0.0	0	35.4	23.8	82.6
April	52.0	1	38.3	25.3	81.5
May	10.4	1	42.3	27.8	72.9
June	103.7	6	40.6	28.2	77.5
July	194.1	12	35.4	25.3	88.2
August	160.1	10	33.4	25.2	88.6
September	260.5	11	33.4	25.3	90.0
October	361.9	13	32.4	24.1	87.7
November	74.7	5	31.7	21.8	88.8
Devember	0.0	0	30.2	16.1	90.1
Total/mean	**1220.8**	**60**	**34.9**	**23.5**	

Kumarganj

Month	Rainfall (mm)	Temperature (°C)		RH (%)
		Max	Min	
January	-	21.1	5.8	71.1
February	25.2	24.0	10.7	68.0
March	5.2	30.0	16.3	60.0
April	3.0	37.0	25.2	51.6
May	25.4	38.4	27.9	57.1
June	54.6	30.8	26.1	85.7
July	115.6	32.2	27.5	82.9
August	50.0	31.3	25.4	81.5
September	146.0	30.8	24.6	83.6
October	47.4	30.1	15.5	74.6
November	-	27.1	14.9	68.0
Devember	-	22.9	18.9	63.7
Total/Mean	**472.4**	**29.6**	**19.9**	

Latitude : 11.4' N Longitude : 78.5' E

Altitude : 1450m MSL Soil type : Clay loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)		RH (%)
			Max	Min	
January	—	—	22.7	14.3	64.1
February	—	—	26.3	14.3	58.7
March	—	—	30.4	16.9	58.3
April	190.0	3	31.2	17.2	62.9
May	92.6	4	31.3	17.6	66.0
June	164.0	7	29.2	16.9	65.8
July	154.8	6	26.5	17.0	67.8
August	320.7	12	25.7	16.9	69.2
September	136.4	5	26.6	16.4	68.0
October	127.5	11	25.1	16.3	68.1
November	162.7	7	24.9	16.7	66.0
Devember	195.4	4	23.8	12.5	64.6
Total/mean	**1544.1**	**59**	**27.0**	**16.1**	

Solan

Latitude : 30.5° N Longitude : 77.8°E

Altitude : 1000m MSL Soil type : Loam

Month	Rainfall (mm)	Temperature (°C)		RH(%)
		Max	Min	
January	84.8	17.6	1.8	52.0
February	70.1	19.1	7.6	62.0
March	62.8	23.4	10.1	59.0
April	46.6	28.2	11.2	50.9
May	63.0	32.2	15.4	46.3
June	185.1	34.5	17.9	57.5
July	206.4	27.3	20.3	80.6
August	100.8	28.2	20.2	79.0
September	193.7	27.4	17.8	87.0
October	264.0	26.3	12.3	69.0
November	-	24.3	6.3	56.2
December	-	22.1	2.4	44.5
Total/mean	**1277.3**	**25.9**	**11.9**	

Jobner

Latitude : 23.52^0 N Longitude : 72.43^0 E
Altitude : 90.6 m MSL Soil type : Sandy loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (^{0}C)		RH (%)
			Max	Min	
January	-	-	23.6	3.5	61.0
February	-	-	25.5	5.8	77.0
March	40.5	3	30.2	11.8	59.0
April	5.0	1	40.1	20.9	36.0
May	2.4	1	43.6	22.8	30.0
June	18.4	4	39.2	24.3	52.0
July	247.8	5	34.4	25.6	62.0
August	30.1	6	34.3	25.8	67.0
September	84.9	6	33.8	24.7	67.0
October	18.0.1	2	31.7	18.0	65.0
November	32.5	1	28.2	10.6	55.0
December	-	-	26.0	4.9	60.0
Total/mean	**479.6**	**29**	**32.6**	**18.3**	

Panniyur

Latitude : 12.5^0 N Longitude : 74.55^{0}E
Altitude : 95m MSL Soil type : Laterite

Month	Rainfall (mm)	Rainy days (No)	Temperature (^{0}C)		RH (%)
			Max	Min	
January	-	-	34.3	21.5	87.5
February	-	-	36.2	21.9	81.9
March	-	-	37.9	22.6	83.0
April	10.0	1	38.7	25.7	80.4
May	124.8	9	36.5	25.0	82.6
June	990.6	26	29.9	24.9	88.5
July	1106.5	28	30.0	23.2	92.8
August	298.0	21	29.6	23.7	92.4
September	535.2	18	30.7	23.3	92.0
October	349.5	12	33.3	22.6	83.9
November	88.1	8	32.5	21.8	84.0
December	91.0	3	33.3	20.0	86.3
Total/mean	**3593.7**	**126**	**33.6**	**23.0**	

Sirsi

Latitude : 14°36 N
Longitude : 74°50 E
Altitude : 619m MSL
Soil type : Laterite

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C) (1997)	
			Max	Min
January	-	-	29.5	16.8
February	-	-	31.5	17.0
March	-	-	33.0	18.0
April	-	-	35.2	20.8
May	27.5	1	32.2	20.6
June	581.0	16	27.1	22.3
July	716.0	19	23.1	20.1
August	518.3	16	26.8	18.5
September	299.2	8	24.6	18.0
October	156.4	7	25.8	19.5
November	18.7	4	26.4	16.3
December	-	-	26.1	15.8
Total/mean	**2317.1**	**71**	**28.45**	**18.64**

Jagudan

Latitude : 23.52° N
Longitude : 74.43° E
Altitude : 90.6m MSL
Soil type : Sandy loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)	
			Max	Min
January	-	-	26.6	12.3
February	-	-	30.4	13.7
March	-	-	36.9	17.3
April	-	-	39.9	22.2
May	-	-	43.3	27.2
June	56	4	41.5	27.0
July	270	10	35.0	25.4
August	106	6	34.9	25.1
September	280	7	34.2	24.1
October	95	4	35.5	24.7
November	-	-	32.7	16.7
December	-	-	30.2	14.7
Total/mean	**807**	**31**	**35.1**	**20.9**

Dapoli

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)		RH (%)
			Max	Min	
January	-	-	30.0	11.7	98.7
February	-	-	30.7	12.2	92.9
March	-	-	31.1	14.1	91.4
April	-	-	32.0	19.2	89.0
May	10.6	1	33.4	22.6	87.7
June	714.6	17	30.6	22.6	92.5
July	288.1	26	28.1	20.7	95.1
August	1039.6	25	28.2	23.5	88.3
September	401.5	19	26.9	23.0	92.3
October	284.6	15	30.1	21.6	97.3
November	32.8	2	32.3	17.7	93.5
December	0.4	-	3.5	12.5	87.6
Total/mean	**2772.2**	**105**	**35.4**	**18.5**	

Dholi

Latitude : 25.41^0 N Longitude : 34.6^0 E

Altitude : 52.8m MSL Soil type : Sandy loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (^{0}C)		RH (%)
			Max	Min	
January	15.4	2	18.6	8.4	98
February	16.2	2	25.4	11.7	87
March	8.2	5	28.3	14.6	78
April	33.4	4	34.6	21.0	76
May	38.8	4	35.9	25.0	77
June	146.2	5	37.3	27.9	80
July	401.0	17	32.7	26.9	86
August	497.6	19	31.8	27.8	88
September	221.3	15	31.6	26.2	85
October	38.6	3	32.4	24.3	84
November	23.4	4	29.0	18.4	81
December	-	-	24.7	10.9	94
Total/mean	**1440.1**	**80**	**30.2**	**20.3**	

Pottangi

Latitude : 18°34 N
Longitude : 82.52 E
Altitude : 917m MSL
Soil type : Sandy loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)		RH (%)
			Max	Min	
January	1.0	2	25.0	18.0	82
February	2.5	3	24.0	17.0	82
March	2.9	3	25.0	18.0	81
April	1.5	7	27.0	24.0	82
May	43.1	7	28.0	23.0	84
June	33.2	10	29.0	22.0	86
July	83.8	27	26.0	21.0	86
August	91.8	29	24.0	21.0	91
September	136.2	3	25.0	21.0	87
October	191.8	2	25.0	19.0	91
November	12.5	3	26.0	19.0	91
December	-	1	24.0	16.0	83
Total/Mean	**600.3**	**97**	**25.7**	**20.0**	

Coimbatore

Latitude : 11° N
Longitude : 77° E
Altitude : 426.72m MSL
Soil type : Clay loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)		RH (%)
			Max	Min	
January	-	-	30.1	20.2	87
February	-	-	32.8	20.5	85
March	-	-	35.5	22.0	82
April	96.0	4	36.6	24.8	80
May	52.5	3	35.5	24.8	81
June	57.8	6	32.7	24.2	71
July	51.5	6	30.8	23.3	80
August	25.4	5	31.4	22.9	85
September	170.5	4	30.8	22.6	83
October	30.0	3	31.2	22.3	84
November	303.7	6	29.9	20.9	89
December	161.6	6	27.9	20.60	90
Total/mean	**949.0**	**43**	**32.1**	**22.3**	

Mudigere

Latitude : 13°50 N Longitude . 75°39 E
Altitude : 1175m MSL Soil type · Black clay loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (°C)		RH (%)
			Max	Min	
January	-	-	29 0	14 5	90
February	-	-	29 2	14 5	87
March	2 0	-	31.7	16.6	87
April	78 2	4	32 4	19 5	91
May	59 2	6	30.2	19 5	92
June	418 0	20	25.3	18 7	93
July	784 4	26	23.7	18 0	94
August	333 4	20	24 7	18 3	94
September	351.0	21	24.4	17.7	95
October	205.4	12	25 1	17.1	93
November	95 4	5	26 4	15 8	87
December	16.0	2	27 2	14 3	83
Total/mean	**2343.0**	**116**	**24.7**	**17.0**	

Raigarh

Latitude : 21°15 to 23°15 N Longitude : 82°95 to 84°20 E
Altitude · 237m MSL

Month	Rainfall (mm)	Temperature (°C)		RH (%)
		Max	Min	
January	0 45	26.4	14 1	84 6
February	22 9	29 6	17 1	84 8
March	17 8	34 0	19.1	81.0
April	3 0	40 0	22.1	75.9
May	7 6	41 9	27.7	70.7
June	126 3	40 0	28 3	73 2
July	266 6	31 4	25 5	89 6
August	264 2	31.4	27 3	91.0
September	312 7	31 9	25 7	88 3
October	166 1	32 3	25.3	86 4
November	-	30.3	19.1	83.9
December	-	27 9	10 7	83 9
Total/mean	**1232.2**	**33.1**	**21.8**	

Pundibari

Longitude: 89° 23.5" Altitude: 43m MSL

Latitude: 26° 19.86" Soil Type :Sandyloam to loam

Month	Rainfall (mm)	Rainy days (No)	Temperature (° C)		RH (%)
			Max	Min	
January	-	0	20.9	9.2	95.8
February	4.0	1	25.9	11.7	95.1
March	116.1	4	27.2	14.8	88.3
April	210.1	8	29.5	17.1	92.2
May	300.	11	33.4	23.2	90.4
June	690.2	18	31.4	24.5	95.2
July	1002.2	24	30.4	24.6	98.0
August	944.9	24	30.9	24.6	98.1
September	919.4	14	30.7	24.1	95.1
October	243.1	5	31.4	23.7	94.8
November	-	0	29.9	17.0	91.5
December	-	0	27.3	11.8	94.3
Total/Mean	**4430.7**		**29.1**	**18.9**	