



ANNUAL REPORT 2004 - 2005



All India Coordinated Research Project on Spices

AICRIPS



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INDIAN INSTITUTE OF SPICES RESEARCH

(Indian Council of Agricultural Research)

Calicut - 673012, Kerala

**ALL INDIA COORDINATED RESEARCH PROJECT
ON SPICES**

ANNUAL REPORT 2004-2005



INDIAN INSTITUTE OF SPICES RESEARCH
(Indian Council of Agricultural Research)
CALICUT – 673 012, KERALA, INDIA

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परियोजना समन्वयक की रिपोर्ट

अखिल भारतीय समन्वित मसाला अनुसंधान परियोजना (ए आई सी आर पी एस) देश के मसाला अनुसंधान का सबसे बड़ा नेटवर्क होता है, जिसका 19 केन्द्र देश के 14 राज्यों के 15 कृषि विश्व विद्यालयों में व्याप्त है। वर्ष 2004-2005 के लिए इस परियोजना का बजट 163.67 लाख रुपए है जिस में भारतीय कृषि अनुसंधान परिषद का अंश 123 लाख रुपए भी शामिल होता है।

इस परियोजना का अधिदेश विभिन्न कृषि पारिस्थितिक दशाओं के लिए उचित गुणवत्तायुक्त उच्च उपजवाले, कीट / रोग के सद्यः प्रतिरोधी किस्मों को अर्जित करना; विभिन्न कृषि पारिस्थितिक दशाओं के अन्तर्गत मसाला फसलों के लिए कृषि प्रविधियों को मानकीकृत करना; राज्य कृषि विश्व विद्यालय, आई आई एस आर एवं आई सी ए आर के बीच अन्तराफलक के रूप में काम करने के लिए मूल्य प्रभावित एवं कीट और रोगों के प्रबन्धन के लिए कुशल तरीकों को अर्जित करना आदि है। ए आई सी आर पी एस के अन्तर्गत आनेवाले विभिन्न केन्द्रों में 12 मसाला फसलों के 120 अनुसंधान परियोजनाएं चालू हो रही है। वर्ष 2004-2005 की प्रमुख उपलब्धियां नीचे दी जाती है।

फसल सुधार

ए आई सी आर पी एस केन्द्रों ने मसाला फसलों के जननिक संसाधनों को प्रबल बना दिया और ए आई सी आर पी एस के केन्द्रों में जर्मप्लासम में काली मिर्च के 612, इलायची के 273, अदरक के 603 हल्दी के 1332, वृक्ष मसालों के 202 और बीज मसालों के 3961 अक्सरनें उपलब्ध है। आशाजनक जर्मप्लासम को नये समन्वित प्रजाति परीक्षण (CVTs) और प्रारंभिक प्रजाति परीक्षण (IETs) द्वारा मूल्यांकित की। सी वी टी/ सी वाई टी/ आई ई टी/ जर्मप्लासम मूल्यांकन द्वारा उपजता के लिए 86 लाइनें तथा गुणवत्ता के लिए 36 लाइनों की पहचान की गयी।

फसल उत्पादन

मसाला उत्पादन में अजैव उर्वरक के साथ जैव उर्वरक लगाने की संभाव्यता के बारे में अध्ययन किया। असोस्परिल्लम (50ग्राम) और फोस्फोबैक्टीरिया (50 ग्राम) अलग ही संस्तुत मात्रा में अजैव उर्वरक के साथ जोड़ने पर काली मिर्च और इलायची की उपजता में वृद्धि हुई। परंपरागत पोषण स्रोत जैसे तप्त मिट्टी (10 कि ग्राम) लकड़ी की राख (2 कि ग्राम) ब्रह्म के साथ लगाने से काली मिर्च

उपजता (6.43कि ग्राम/बेल) में आशाजनक वृद्धि हुई। संस्तुत उर्वरक के साथ असोस्परिल्लम (50 ग्राम) लगाने पर अदरक एवं हल्दी की उपजता में उत्तम वृद्धि हुई। अदरक एवं हल्दी में अजैव खेती परीक्षण करने पर उर्वरकों की संस्तुत मात्राएं राइगड में अधिकतम उपजता अदरक में 17.87 टन/ हेक्टर और हल्दी 26.02 टन/ हेक्टर तथा पोटांगी में, अदरक में 18.65 टन/ हेक्टर और हल्दी में 18.29 टन/ हेक्टर और पुंडिबारी केन्द्र में हल्दी में 25.03 टन/ हेक्टर अंकित की, जबकि धोली केन्द्र में FYM 10 कि ग्राम अ पोनागामिया ऑयल केक अ नीम ऑयल केक अ स्टारमील अ रोक फॉस्फट अ लकड़ी का राख लगाने पर अदरक में 23.67 टन/ हेक्टर की उपजता में 250 ग्राम अधिक उपजता अंकित की। धोली केन्द्र में सिंक सल्फेट 25.0 कि ग्राम/ हेक्टर की दर में लगाने पर अदरक की उपजता अधिकतम (20.27टन/ हेक्टर) हो गयी।

धनिया में, सूक्ष्मपोषण जैसे., Zn 504+FeSO4 + CuSO4 +MnSO4 (प्रत्येक 0.5%) आदि छिड़कने पर अधिकतम उपजता (940 कि ग्राम/हेक्टर) अंकित की। अजैव नाइट्रोजन के 100% + अजोस्परिल्लम @1.5 कि ग्राम/हेक्टर अ 5 टन ब्रह्म/हेक्टर लगाने से धनिया (3.45टन/हेक्टर), जीरा (323 कि ग्राम / हेक्टर) और सौंफ (1.16 टन / हेक्टर) में अधिकतम बीज उपजता प्राप्त हो गयी, जबकि 100% अजैव नाइट्रोजन खुद लगाने पर जोबनर केन्द्र में मेथी में अधिकतम उपजता (1.256 टन/ हेक्टर) प्राप्त हुई। फिर भी, कुमारगंज (उ प्र) की दशा में FYM 10 टन/हेक्टर अ अजोस्परिल्लम 1.5 कि ग्राम/हेक्टर बीज उपचार के रूप में लगाने पर धनिया, सौंफ और मेथी में अधिकतम उपजता प्राप्त हुई। कोयंपतोर (तमिलनाडु) की दशा में FYM 5 टन/हेक्टर+अजोस्परिल्लम 1.5 कि ग्राम/हेक्टर बीज उपचार के रूप में अजैव नाइट्रोजन 50% और 100% के साथ लगाने पर क्रमशः धनिया (738कि ग्राम/ हेक्टर) और मेथी (685कि ग्राम/हेक्टर) अधिकतम उपजता प्रदान की। धोली की दशा में, धनिया में बयोरगुलेटर, ट्रायकन्टानोल 0.5% के दर में बोने के बाद 40,60,80 दिनों के अन्तराल में तीन बार छिड़कने से उपजता में महत्वपूर्ण वृद्धि (1.46 टन/हेक्टर) हुई, जबकि उच्चतम उपजता (1.50 टन / हेक्टर) बोने के बाद 40,60 और 80 दिनों के अन्तराल में ट्रायकन्टानोल 1.05 के दर में तीन बार छिड़कने से प्राप्त हुई। फिर भी गुंटूर की दशा में NAA 10 ppm 40 और 60 दिनों के अन्तराल में दो बार छिड़कने से 1.01 टन/ हेक्टर की अधिकतम उपजता प्राप्त हुई।

फसल संरक्षण

काली मिर्च कतरनों को ट्राइकोडरमा हर्जियानम 1 ग्राम/ कि ग्राम मृदा के दर में और VAM इनोकुलम 100 cc/कि ग्राम मृदा के दर में आरक्षित सोलाराइसुड मृदा में रोपण करना चिन्तापल्ली और पाम्पाडुमपारा केन्द्रों में स्वस्थ मूल लगाए कतरनों के उत्पादन के लिए आशाजनक देख लिया। मेटालक्सिल गोल्ड MZ (2.5ग्राम/ लिटर) और टी हर्जियानम लगाने पर पत्रियूर केन्द्र के खेतों में खुरगलन रोग नियन्त्रण के लिए प्रभावी देख लिया। फिर भी, मुडिगरे केन्द्र में बोर्डियोक्स मिश्रण (1%) मई /जून और जुलाई/अगस्त में छिड़कना और भिगो देना अधिक प्रभावी हो गया। उच्च तुंगता के क्षेत्रों में, कारबन्डासिम अ मानकोजेब 0.1% पत्तों पर छिड़कने से या कारबन्डासिम 0.1% या बोर्डियोक्स मिश्रण 1% तीन बार छिड़कने से पाम्पाडुमपारा केन्द्र और मुडिगरे केन्द्र में काली मिर्च में आन्त्राकनोस रोग की अधिकतम कमी प्राप्त की जा सकी, वही फल बोर्डियोक्स मिश्रण 1% मई , जुलाई और अगस्त के अन्तिम सप्ताह में छिड़कने से प्राप्त किया जा सकता है। पाम्पाडुमपारा के उच्च तुंगता के क्षेत्रों में काली मिर्च के शल्क कीटों के प्रबन्धन के लिए मोनोक्रोटोफोस 0.05% छिड़कना प्रभावी हो गया।

इलायची में इमिडाक्लोप्रिड (0.75 मि लि/लिटर) या क्लोरपिरिफोस (0.07%) दवा देकर रूट ग्रब की जांच प्रभावी ढंग से किया जा सकता है और उसमें अधिकतम उपजता (412 ग्राम / पौधे) और उच्चतम B:C अनुपात भी देख लिया जा सकता है।

बीज राइजोम को गरम पानी में 51°C में 10 मिनट और टी हर्जियानम को नीम केक के साथ मिश्रण करके 30 मिनट उपचार करके अदरक के राइजोम गलन को नियन्त्रित किया गया। फिर भी, हल्दी में संस्तुत मात्रा में NPK और FYM लगाने के साथ टी विरिडे और प्स्यूडोमोनस फ्लूरोसन्स क्रमशः 12.5 कि ग्राम और 25.0 कि ग्राम प्रति लिटर के दर में बीज ओर मृदा में लगाने पर राइजोम गलन की अधिकतम कमी प्राप्त हुई। महाराष्ट्र के कोंकण क्षेत्र में लौंग में होनेवाले अधिक साधारण रोग है पर्ण गलन, पर्ण चित्ती और पश्चमारी।

धनिया में, टी हर्जियाम बीज उपचार के रूप में और उसी प्रकार मृदा में लगाने से न्यूनतम म्लानी आपतन एवं अधिकतम उपजता (818 कि ग्राम/हेक्टर) अंकित की। कारबन्डासिम मृदा में लगाने से या छिड़कने (0.01%) से पाउडरी मिल्ड्यू को प्रभावी ढंग से नियन्त्रित किया जा सकता है। जीरा में, बने के बाद 40, 50, 60 और 70 दिनों के अन्तराल में 0.25% के दर में मानकोजेब के साथ ब्लाइट और म्लानी दोनों रोगों की जांच करके अधिकतम उपज प्राप्त हुई।

किसानों के खेत में तकनोलजी के मूल्यांकन करने पर, मसालों में कुल 20 साबित तकनोलजियों को 13 राज्य कृषि विश्वविद्यालय द्वारा 14 ए आई सी आर पी एस केन्द्रों में काम में लिया जा रहा है। अब, ए आई सी आर प एस के अन्तर्गत राज्य कृषि विश्वविद्यालय (SAU) / अन्य संगठनों में दस आई सी ए आर तदर्थ योजनाएं काम में हो रही हैं।

PROJECT COORDINATOR'S REPORT

The All India Coordinated Research Project on Spices (AICRPS) is the largest network in the country in the spices research, having 19 centers spread over in 14 states based at 15 Agricultural Universities. The budget of the project for the year 2004-2005 was Rs. 163.67 lakhs with Rs. 123 lakhs as ICAR share.

The mandate of the project is to evolve high yielding varieties with quality attributes, tolerant/resistant to pests and diseases for various agro-ecological situations; standardize agro-techniques for spice crops under different agro-climatic conditions; evolve cost effective and efficient pest and disease management practices and to work as interface between SAUs, IISR and ICAR. About 120 research projects covering 12 spice crops are being operated at various centers under AICRPS. During 2004-05, the major achievements are listed below:

CROP IMPROVEMENT

The AICRPS centers enhanced genetic resources of spice crops and the germplasm holdings of AICRPS centers consist of 612 accessions in black pepper, 273 in cardamom, 603 in ginger, 1332 in turmeric, 202 in tree spices and 3961 in seed spices. The promising germplasm were evaluated through new Coordinated Varietal Trials (CVTs) and Initial Evaluation Trials (IETs). Eighty-six lines for yield and 36 lines for quality attributes were identified through CVT/CYT/IET/germplasm evaluation.

CROP PRODUCTION

The possibilities of supplementing biofertilizer with inorganic fertilizer in spices production were studied. Inclusion of *Azospirillum* (50 g) and phosphobacteria (50 g) separately in combination with recommended inorganic fertilizer enhanced the yield of black pepper and cardamom. Addition of traditional nutrient sources like burnt earth (10 kg) and wood ash (2 kg) along with Farm Yard Manure (10 kg) was promising in increasing black pepper yield (6.43 kg/vine). Application of *Azospirillum* (50 g) along with recommended fertilizer schedule proved better in augmenting ginger and turmeric yield. Organic farming trial in ginger and turmeric, recommended dose of fertilizers registered maximum

yield of 17.87 t/ha in ginger and 26.02 t/ha in turmeric at Raigarh and 18.65 t/ha in ginger and 18.29 t/ha in turmeric at Pottangi and 25.03 t/ha in turmeric at Pundibari centre, while application of FYM 10 kg + Pongamia oil cake + Neem oil cake + Sterameal + Rock phosphate + wood ash, each 250 g/bed recorded higher yield of 23.67 t/ha in ginger at Dholi centre. Application of zinc sulphate @ 25.0 kg/ha produced maximum ginger yield (20.27 t/ha) at Dholi centre.

In coriander, micronutrient spray viz., $ZnSO_4$ + $FeSO_4$ + $CuSO_4$ + $MnSO_4$ (each at 0.5%) recorded the higher yield (940 kg/ha). Application of 100% inorganic N + *Azospirillum* @ 1.5 kg/ha + 5 t FYM/ha resulted in maximum seed yield in coriander (3.45 t/ha), cumin (323 kg/ha) and fennel (1.16 t/ha), whereas 100% inorganic N alone gave the highest yield (1.256 t/ha) in fenugreek at Jobner Centre. However, maximum yield was obtained in coriander, fennel and fenugreek with the application of 10t/ha of FYM + 1.5 kg/ha of *Azospirillum* as seed treatment at Kumarganj (U.P.) conditions. At Coimbatore (T.N.) conditions, application of FYM 5t/ha + *Azospirillum* 1.5 kg/ha as seed treatment along with inorganic N 50% and 100%, produced the highest yield in coriander (738 kg/ha) and fenugreek (685 kg/ha), respectively. In coriander, spray of bioregulator, Triacantanol @ 0.5%, thrice at 40, 60 and 80 days after sowing significantly increased the yield (1.46 t/ha) at Dholi conditions, while highest yield (1.50 t/ha) was achieved with spraying of Triacantanol @ 1.0%, thrice at 40, 60 and 80 days after sowing at Kumarganj conditions. However, maximum yield of 1.01 t/ha was obtained with spraying of NAA 10 ppm, twice at 40 and 60 days after sowing at Guntur conditions.

CROP PROTECTION

Planting of black pepper cuttings in solarized soil fortified with *Trichoderma harzianum* @ 1g/kg soil and VAM inoculum @ 100 cc/kg soil was found ideal for production of healthy rooted cuttings at Chintapalle and Pampadumpara centers. Application of Metalaxyl Gold MZ (2.5 g l⁻¹) and *T. harzianum* was effective for controlling foot rot disease in the field at Panniyur centre. However at Mudigere centre, spraying and drenching

with Bordeaux mixture (1%) during May/June and July-August was most effective. At high altitude areas, maximum reduction of anthracnose disease in black pepper could be achieved by spraying carbendazim + mancozeb 0.1% as foliar spray or carbendazim 0.1% or Bordeaux mixture 1% thrice (Pampadumpara Centre) and at Mudigere Centre, the same results could be achieved by three sprays of 1% Bordeaux mixture during the last week of May, July and August. Spraying of monocrotophos 0.05% was effective for the management of scale insects of black pepper at higher altitudes at Pampadumpara

In Cardamom, root grub can be checked effectively by drenching with Imidacloprid (0.75 ml l^{-1}) or chlorpyrifos (0.07%) and maximum yield (412 g plant^{-1}) and highest B: C ratio (1:1.65) could be realized.

Rhizome rot of ginger was controlled by treating the seed rhizomes with hot water at 51°C for 10 minutes and *T. harzianum* mixed with neem cake for 30 minutes. However, in turmeric, maximum reduction of rhi-

zome rot was obtained by seed and soil application of *T. viride* and *Pseudomonas fluorescens* @ 12.5 kg and 25.0 kg/ha, as basal and top dressing, respectively along with recommended application of NPK and FYM. In clove, leaf rot, leaf spot and die back were the most common diseases in Konkan region of Maharashtra.

In coriander, minimum wilt incidence with maximum yield (818 kg/ha) was recorded with the *T. harzianum* applied as seed treatment as well as soil application. Powdery mildew could be effectively managed by applying carbendazim as soil drench and spray (0.01%). In cumin, maximum yield was obtained by checking both blight and wilt diseases with mancozeb @ 0.25% at 40, 50, 60 and 70 days after sowing.

Under the Assessment of Technology in farmer's field, a total of 20 proven technologies in spices are being operated in 14 AICRPS centers through 13 SAUs. At present, ten ICAR ad-hoc schemes are being operated at SAUs/other organizations under AICRPS.

PROGRESS OF WORK AND ACHIEVEMENTS

1. BLACK PEPPER

1.1. Genetic Resources and Crop Improvement

1.1.1 Germplasm collection, characterization, evaluation and conservation

(Dapoli, Panniyur, Pundibari, Sirsi and Yercaud)

Sixty seven accessions are being maintained at Dapoli centre. During the period, one black pepper type was collected from Sindhudurg District of Konkan region and added to the existing germplasm. The trial was initiated at Panniyur centre during 1972 with a plot size of 6-10 plants under each accession. At present, 147 cultivated types of black pepper and 22 wild types are being maintained in the field gene bank. During the year, the variety 'Angamali' recorded the maximum green berry yield of 4 kg/vine, followed by TMB IV (2.580 kg) and Chendayar (2.540 kg). Five cultivated and one wild type were added to the existing the germplasm, thus raising the total to 17 at Pundibari centre. This also includes seven new genotypes collected from Sub-Himalayan region adjoining Bhutan border (including Totopara). At Sirsi, total germplasm collection of black pepper has raised to 117. During the year, four promising accessions namely, Ademane pepper, Karimensu/Mallisara, Uddakare and Kudragutta were collected from farmers' field. The spike length was maximum in Ademane pepper (16.80 cm) and produced fresh yield of around 15

kg berries with dry recovery of 18.1 %. At present in Yercaud, a total of 132 accessions including 122 cultivated and 10 wild types are maintained at the germplasm block. PN 57 recorded the yield of 9.0 kg and 2.7 kg for green and dry berry yield, respectively.

1.2 Hybridization Trial

1.2.1 Inter-varietal hybridization to evolve high yielding varieties (Panniyur)

Intervarietal hybridization and open pollinated progeny evaluation are in progress in this station. Among the hybrids planted during 2000, KM III x P 5 is found to be promising with regard to number of laterals, early spiking, more number of spikes and compact setting of berries. The intervarietal crosses (KM I x Neelagiris), (Valiyaramundi x Neelagiris), (Neelagiris x Valiyaramundi), (Uthirankotta x Panniyur 7) and (Valiyaramundi x Cul 5128) were made and the seeds so obtained were sown.

1.3 Coordinated Varietal Trial (CVT)

1.3.1 CVT 1987 Series - III (Sirsi)

At Sirsi, the pooled data (1997-98 to 2002-03) revealed that among the entries, Cul. 239 registered the highest fresh yield (2.097 kg/vine) with 32.72% dry recovery, followed by Panniyur-1 (1.940 kg/vine) with 27.33% dry recovery (Table 1).

Table 1. Yield and its attributing characters in black pepper under CVT – Sirsi

Cultivar	Fresh berry yield (kg/vine)		Mean yield (kg/vine)	Dry recovery(%)		Mean dry recovery (%)
	2001-02	2002-03		2001-02	2002-03	
Karimalligesara	2.52	2.17	2.35	33.58	33.31	33.45
Uddakare	2.46	2.33	2.40	31.25	31.28	31.27
Panniyur-1	3.45	4.17	3.81	28.20	26.45	27.33
Culture-812	2.70	2.95	2.83	30.08	30.00	30.04
Culture-331	2.73	2.98	2.86	33.45	32.05	32.75
Culture-239	3.97	3.75	3.86	33.23	32.20	32.72
Culture- 856	2.45	2.79	2.62	31.37	31.25	31.31
KS- 88	2.37	2.11	2.24	34.10	30.33	32.22
KS- 14	2.77	2.05	2.41	33.48	31.80	32.64
KS-27	2.13	1.92	2.03	34.28	32.20	33.24
Culture -141	2.45	1.89	2.17	32.82	31.50	32.16
SEm +	0.21	0.19	0.2			
CD (P=0.05)	1.16	1.09	1.13			
CV (%)	24.95	24.20	24.58			

1.3.2 CVT-1991- Series IV

(Ambalavayal, Dapoli and Yercaud)

The trial was started during 1992 with 14 entries in RBD at Ambalavayal. Pepper cultivars showed significant differences for all the characters studied. Panchami (0.801 kg), Panniyur- 4 (0.584 kg), ACC 2445 (0.514 kg), Panniyur- 3 (0.469 kg) and ACC 2426 (0.399 kg) were significantly superior to other cultivars with respect to wet weight of berries per standard. Regarding the dry weight of berries per standard, Panchami (0.254 kg), Panniyur-2 (0.180 kg), Panniyur-4 (0.166 kg), Panniyur-3 (0.165 kg), ACC 2445 (0.162 kg), Panniyur-1 (0.138 kg), ACC 2426 (0.127 kg) and Cul 239 (0.126 kg) showed their superiority over other cultivars. Panchami, Panniyur-4, Panniyur-3, ACC. 2445, ACC 2426 and Panniyur-2 were found promising for the high range region of Kerala. At Dapoli, among the cultivars 'Panniyur-1' recorded highest dried berries yield i.e. 1.256 kg/plant. Panniyur-3 performed well with a mean yield of 8.0 kg of green berry and 2.4 kg dry berry, respectively at Yercaud centre.

1.3.3 CVT 2000 - Series V

(Ambalavayal, Chintapalle, Pampadumpara, Panniyur and Sirsi)

The trial was initiated during 2001 in RBD with 13 entries at Ambalavayal. Among the entries, Panniyur-1 recorded the maximum dry weight of berries (0.170 kg/vine). Out of 12 entries, HP-105 showed 62 cm height with 9 no. of leaves/ vine and 14 nodes per vine on an average at Chintapalle centre. At Pampadumpara, out

of the twelve entries, seven entries started bearing and the wet berry yield ranged from 18 to 480 kg/ha, the maximum yield being in Coll. 1041. The dry recovery varied from 33.3 to 39.2%, the maximum being in Cul. 5308. At Panniyur, the spike yield/vine was maximum for Cul. 5308 (343 g /vine), followed by Panniyur 1 (320g/ vine). The trial was initiated during the year 2002-03 at Sirsi. The entry, PRS-22 attained maximum height (2.78 m), followed by HP-105 (2.6m) and C-1041 (2.35m).

1.4 Nutrient Management Trial**1.4.1 Effect of biofertilizer, *Azospirillum* on black pepper**

(Panniyur, Sirsi, Yercaud, and Ambalavayal)

In black pepper, crop production experiments were mainly focused on utilization of biofertilizers viz., *Azospirillum* and *Phosphobacteria* judicious for use of fertilizers. In addition to these trials, organic farming and developing organic packages for spices based cropping system were conducted. Inoculation of *Azospirillum* along with 100% inorganic sources of nitrogen schedule enhanced the yield of black pepper at Panniyur, Sirsi, Ambalavayal (Table 2).

1.4.2 Effect of biofertilizer, P - solubilizer (*Phosphobacteria*) on black pepper

(Panniyur, Yercaud, Ambalavayal, Thadiyankudisai and Sirsi)

Similar to *Azospirillum*, inoculation of phosphobacteria also increased the yield of black pepper at different centres (Table 3).

Table 2. Yield of black pepper in *Azospirillum* treatment

Treatment	Yield at centres (kg/vine)			Mean
	Panniyur	Sirsi	Ambalavayal	
Best treatment : Inorganic N 100% + <i>Azospirillum</i> 50g + 10 kg FYM	5.50	6.83	2.21	4.84
Control plot	2.23	6.12	1.76	3.37
Yield increase over control	3.33	0.71	0.45	1.49

Table 3. *Phosphobacteria* inoculation on black pepper yield

Treatment	Yield at Centres (kg/vine)			Mean
	Panniyur	Sirsi	Ambalavayal	
Best treatment : Inorganic P 75% + P-solubilizers 50g + 10 kg FYM	8.80	6.81	2.41	6.0
Control	5.57	0.56	0.14	2.08
Yield increase over control	3.23	6.25	2.27	3.92

1.4.3 Organic farming in black pepper

(Panniyur, Sirsi, Ambalavayal, Yercaud and Thadiyankudisai)

The demand for organic food among consumer is increasing. The experiments on organic farming were conducted showed that incorporation of organic manures like burnt earth, FYM wood ash increased the yield of black pepper (Table 4).

Table 4. Organic nutrition on black pepper yield

Treatment	Centres		
	Sirsi	Yercaud	Panniyur
Best treatment	FYM 10 Kg + Burnt earth 10 Kg	FYM 10 kg+ 50 g <i>Azospirillum</i> + 50g phosphobacteria+ 200g VAM	FYM 10 kg + <i>Azospirillum</i> 50g + wood ash 2kg
Best treatment yield (kg/vine)	6.43	6.00	10.40
Control yield (kg/vine)	4.66	-	3.77
Yield increase over control (kg/vine)	1.77	-	6.63

1.5 Disease Management Trial

1.5.1 Management of *Phytophthora* disease in black pepper – Nursery

(Chintapalle and Pampadumpara)

The Effect of soil solarization and application of biocontrol agents and fungicides were evaluated for the

management of *Phytophthora* disease in black pepper nursery. At Chintapalle, planting black pepper in solarized soil fortified with *T. harzianum* @ 1g/kg soil and VAM inoculum @100 cc/kg soil was the best package for production of healthy rooted cuttings in the nursery (Table 5).

Table 5. Evaluation of solarization, biocontrol agents and fungicides on production of black pepper cuttings in the nursery – Chintapalle

Treatment	No. of cuttings sprouted	Cuttings infested with disease (%)	Mortality of cuttings (%)	Biomass of 25 cuttings (g)
T1- Planting in solarized soil	130	0.5	7	177.8
T2 - Planting in non solarized soil	73	1.1	17	122.3
T3 - T1+ <i>Trichoderma harzianum</i> +VAM	164	0.4	5	247.5
T4 - T2+ <i>Trichoderma harzianum</i> +VAM	121	0.7	13	183.2
T5 - T1+Ridomil MZ-72 spray and drench	142	0.5	11	187.3
T6 - T2+Ridomil MZ-72 spray and drench	102	0.5	12	161.9
T7 - T1+ COC 0.2% drench+1% BM spray	125	0.7	8	214.8
T8 - T2+ COC 0.2% drench+1% BM spray	98	1.4	11	133.3
T9 - T1+ <i>T. viride</i>	142	0.6	10	187.6
T10 - T2 + <i>T. viride</i>	130	1.1	13	164.1
Mean	123	0.7	11	178.0
CD (P=0.05)	31	0.3	4	52.2
CV (%)	15	25.8	20	17.1

COC = Copper oxychloride ; BM = Bordeaux mixture

At Pampadumpara, significantly more number of cuttings sprouted in solarized treatments and the number of diseased cuttings was low in solarized soil, the maximum being in solarized soil fortified with *Trichoderma* @ 1g kg⁻¹ + VAM @ 100cc kg of soil (Table 6). The population of fungi, bacteria and actinomycetes was significantly altered by soil solarization. The fungal

population was reduced by 44% which helped the growth of *Trichoderma* as evidenced by higher number of fungal colonies in solarized soil fortified with *Trichoderma*. The population of bacteria was higher in solarized potting mixture added with biocontrol agents while that of actinomycetes was less compared to that of non-solarized soil.

Table 6. Evaluation of solarization, biocontrol agents and fungicides on production of black pepper cuttings in the nursery – Pampadumpara

Treatment	Sprouting (%)*	No. of diseased cuttings**
T ₁ - Planting in solarized soil.	66.7 (54.76)	15.0 (3.84)
T ₂ - Non solarized soil	17.8 (24.81)	37.3 (6.07)
T ₃ - Solarized soil fortified with Trichoderma @ 1g kg ⁻¹ + VAM @ 100 cc kg ⁻¹ of soil.	85.0 (67.67)	9.0 (2.99)
T ₄ - Non solarized soil with Trichoderma and VAM	15.8 (22.96)	27.3 (5.15)
T ₅ - Ridomil spray and drench @ 1.25 g/l Ridomil MZ WP + T ₁	75.5 (60.36)	25.7 (5.05)
T ₆ - T ₅ + T ₂	7.50 (15.88)	36.0 (5.98)
T ₇ - COC @ 0.2% drench + T ₁	74.2 (59.49)	15.7 (3.94)
T ₈ - COC @ 0.2% drench + T ₂	19.7 (26.29)	39.0 (6.21)
CD (P=0.05)	5.81	1.19

*Values in parantheses are angular transformed values

**Values in parantheses are /X transformed values

COC = Copper oxychloride ; BM = Bordeaux mixture

1.5.2 Control of *Phytophthora* foot rot disease of black pepper in farmers field – observational trial

(Ambalavayal, Mudigere, Pampadumpara, Panniyur and Sirsi)

The efficacy of fungicides and *Trichoderma harzianum* for the management of *Phytophthora* foot rot disease of black pepper in the field. At Ambalavayal, the treatment Metalaxyl Gold @ 2.5 g/l recorded the highest yield (1.286 kg/vine). At Mudigere, spraying

and drenching of Bordeaux mixture 1% during May/June and July/August was most effective. At Pampadumpara no significant difference in yellowing index, defoliation index and yield could be observed (Table 7). At farmer's field, significant difference among the treatments in defoliation index could be observed. Application of *Trichoderma harzianum* and 1 kg neem cake and *Trichoderma harzianum* and potassium phosphonate (5 ml/l) spray and drench showed 100% reduction in defoliation which was on par with potassium phosphonate spray and drench (Table 8).

Table 7. Management of *Phytophthora* foot rot disease of black pepper - Pampadumpara

Treatment	% reduction in yellowing	% reduction in defoliation index	Yield (g/vine)
Metalxyl Gold MZ 68 (2.5 g/l) spray and drench	15.5 (19.20)	37.6 (36.83)	186.67
Potassium phosphonate (5ml/l) spray and drench	37.9 (21.23)	66.7 (60.00)	475.0
<i>Trichoderma harzianum</i> (50 g) (cfu 10 ⁷) and 1kg Neem cake	15.5 (19.20)	28.2 (27.07)	211.67
Soil application of <i>T. harzianum</i> and spray and drench with Ridomil	33.3 (30.27)	33.3 (30.00)	201.67
<i>T. harzianum</i> and potassium phosphonate (5ml/l) spray and drench	20.8 (22.50)	25.0 (25.00)	558.33
Neem cake @ 1kg per vine	24.1 (24.37)	45.5 (37.10)	268.33
Untreated check	0 (0)	0 (0)	301.67
CD (P=0.05)	NS	NS	NS

Values in parenthesis are arc sine transformed

Table 8. Management of *Phytophthora* foot rot disease of black pepper (Farmers Field, Vallakkadavu)

Treatment	% reduction in yellowing	% reduction in defoliation index
Metalxyl Gold MZ 68 (2.5 g/l) spray and drench	72.48 (63.41)	37.1 (36.94)
Potassium phosphonate (5ml/l) spray and drench	33.3 (30.00)	83.3 (75.00)
<i>Trichoderma harzianum</i> (50 g) (cfu 10 ⁷) and 1kg Neem cake	88.9 (78.25)	100.0 (90.00)
Soil application of <i>T. harzianum</i> and spray and drench with Ridomil	33.3 (30.00)	33.3 (30.00)
<i>T. harzianum</i> and potassium phosphonate (5ml/l) spray and drench	0 (0)	100.0 (90.00)
Neem cake @ 1kg per vine.	46.3 (38.54)	47.0 (43.29)
Untreated check	0 (0)	0 (0)
CD (P=0.05)	NS	43.76

Values in parenthesis are arc sine transformed values

At Panniyur, Metalaxyl Gold MZ (2.5 g/l) and *Trichoderma harzianum* were effective in controlling foot rot disease followed by application of Potassium phosphonate (3 ml/l) and *Trichoderma harzianum*. The

highest yield (13.166 kg) was recorded in the plots treated with Metalaxyl Gold MZ @ 2.5g/l and *T. harzianum*, followed by Potassium phosphonate (3 ml/l) and *Trichoderma harzianum* (Tables 9 and 10).

Table 9. Management of *Phytophthora* foot rot disease of black pepper – Panniyur (At Padiyur)

Treatment	Disease incidence (%)								
	May Y	Y	September D	LI	CI	Y	December D	LI	CI
Metalaxyl Gold MZ (2.5 g/l) spray & drench	9.5	8.4	6.4	13.9	5.0	5.1	5.1	7.2	0.0
Akomin - spray& drench (3ml/l)	10.0	7.9	6.6	14.5	0.0	6.6	5.2	7.5	0.0
<i>Trichoderma harzianum</i> (50 g/vine)	8.6	7.3	6.4	11.3	5.0	5.3	5.1	6.7	0.0
Metalaxyl Gold MZ (2.5 g/l) spray & drench + <i>T. harzianum</i>	9.0	6.3	5.4	11.0	0.0	4.3	4.6	5.0	0.0
Akomin -spray& drench (3ml/l)+ <i>T. harzianum</i>	9.0	6.4	5.8	11.0	0.0	4.7	4.8	5.8	0.0
Neem Cake (1 kg/vine)	11.3	10.2	8.3	17.6	10.0	8.4	6.3	12.9	5.0
Control	14.6	13.5	12.6	21.9	15.0	12.5	12.5	23.2	20.0
CD (P=0.05)	1.0	1.0	2.1	1.2	1.2	1.3	1.4	1.3	2.2

Y=Yellowing ; D=Defoliation ; LI =leaf infection ; CI=Collar infection

Table 10. Management of *Phytophthora* foot rot disease of black pepper - Panniyur (At Valiamapara)

Treatment	Disease incidence (%)								
	May Y	Y	September D	LI	CI	Y	December D	LI	CI
Metalaxyl Gold MZ (2.5 g/l) spray & drench	11.9	10.1	8.5	15.9	5.0	7.1	7.1	9.1	0.0
Akomin (spray& drench (3 ml/l)	12.0	10.0	8.5	16.1	0.0	8.6	7.1	9.5	0.0
<i>Trichoderma harzianum</i> (50 g/vine)	10.9	9.0	8.1	13.2	5.0	7.2	7.0	8.5	0.0
Metalaxyl Gold MZ (2.5 g/l) spray & drench + <i>T. harzianum</i>	10.7	8.1	7.4	13.0	0.0	6.1	6.5	7.0	0.0
Akomin spray & drench (3 ml/l) + <i>T. harzianum</i>	11.0	8.4	7.7	13.0	0.0	6.2	6.9	7.9	0.0
Neem Cake (1 Kg / vine)	13.3	12.1	10.1	19.4	10.0	10.1	8.3	14.9	5.0
Control	16.6	15.6	15.0	23.9	15.0	14.2	14.7	25.2	20.0
CD (P=0.05)	1.1	1.1	2.0	1.3	1.1	1.5	1.4	1.4	2.1

Y=Yellowing ; D=Defoliation ; LI =leaf infection ; CI=Collar infection

At Sirsi, black pepper vines were free from leaf infection, collar infection, defoliation, with minimum foliar yellowing and maximum yield (1.12 kg dry yield/ vine) when Ridomil Gold (@ 2.5 g/l) was as sprayed (2 l/vine) and drenched (3 l/vine) along with the soil application of *Trichoderma harzianum* @ 50 g in 1 kg of neem

cake during first week of June and second week of August. A combination of potassium phosphonate (5 ml / l) as spraying and drenching and soil application of *Trichoderma harzianum* @ 50 g in 1 kg neem cake twice during the season was also effective in combating the disease (Tables 11 and 12).

Table 11. Management of *Phytophthora* foot rot disease in farmers field – Sirsi (At Hosable)

Treatment	Mean foliar infection (%)	Collar infection (%)	Mean foliar yellowing (grade) Dec/Jan (Post monsoon)	Dry yield (kg/vine)
Ridomil Gold (2.5 g/l)	0.0	5.0	0.83	0.97
Potassium Phosphonate (5 ml/l)	3.6	10.0	0.67	0.85
<i>T. harzianum</i>	6.6	15.0	1.07	0.68
T1+T3	0.0	0	0.44	1.12
T1+T4	0.0	0	0.58	0.87
Neem cake	11.2	15.0	1.00	0.72
Control	15.9	20.0	1.12	0.67
CD (P=0.05)	7.8	-	0.32	0.20

Table 12. Management of *Phytophthora* foot rot disease in farmers field – Panniyur (At Edahalli)

Treatment	Mean foliar infection (%)	Collar infection (%)	Mean foliar yellowing (grade) Dec/Jan (Post monsoon)	Dry yield (kg/vine)
Ridomil Gold (2.5 g/l)	0.0	0	0.00	0.97
Potassium Phosphonate (5ml/l)	0.0	0	0.33	0.80
<i>T. harzianum</i>	4.4	5	1.08	0.68
T1+T3	0.0	0	0.00	1.12
T1+T4	0.0	0	0.00	0.89
Neem cake	7.0	15	0.75	0.56
Control	16.1	20	1.00	0.43
CD (P=0.05)	3.3	-	NS	0.23

1.5.3. *Phytophthora* foot rot incidence in black pepper under different plant densities in arecanut garden (Panniyur and Sirsi)

Black pepper vines with four levels populations viz., 25, 50, 75 and 100% were trained on arecanut standards to study the relation of *Phytophthora* foot rot incidence with respect to population of black pepper under arecanut cropping system. Recommended practices for the management of the *Phytophthora* foot rot was fol-

lowed. At Panniyur, the establishment and height of the vines were maximum for the treatments 25% and 50% population of arecanut. The disease incidence was minimum in 25% population of arecanut (Table 13).

At Sirsi, the disease incidence was less in 25% population density of black pepper (0.15 grade) as compared to 100% (0.35 grade) and 75% (0.40 grade) populations of black pepper. Black pepper in 25% population of arecanut showed good response to plant characters and fresh berry yield (1.36kg/vine) (Table 14).

Table 13. *Phytophthora* foot rot incidence in black pepper under different densities in arecanut garden - Panniyur

Treatment	Establishment (%)	Height of vine (m)	Disease incidence (%)
Pepper in 25% population of arecanut	94.6	4.34	0.98
Pepper in 50% population of arecanut	93.4	3.03	2.06
Pepper in 75% population of arecanut	83.6	2.73	2.22
Pepper in 100% population of arecanut	75.2	2.00	1.26
CD (P=0.05)	2.56	0.78	0.34

Table 14. Incidence of *Phytophthora* foot rot on black pepper under different densities in an arecanut garden – Sirsi

Treatment	Disease incidence (Grade)	Plant height (m)	Fresh yield (kg/vine)
Black pepper in 25% population of arecanut	0.15	3.49	1.36
Black pepper in 50% population of arecanut	0.25	3.36	1.30
Black pepper in 75% population of arecanut	0.40	3.27	1.08
Black pepper in 100% population of arecanut	0.35	3.17	1.02
CD (P=0.05)	0.21	NS	0.13

*Diage was 29.5%

1.5.4 Incidence, epidemiology and management of anthracnose disease of black pepper

(Chintapalle, Dapoli, Mudigere and Pampadumpara)

Evaluation of fungicides at Chintapalle indicated that the incidence of anthracnose disease in the treatment spraying of 1% Bordeaux mixture thrice (June, July and August), was less (8.7%) when compared to that of the control (14.9%) (Table 15).

Table 15. Effect of fungicides on anthracnose disease of black pepper - Chintapalle

Treatment	% disease Incidence	% reduction in disease incidence	B:C ratio
1% Bordeaux mixture (twice)	10.5	29.5	3.47
1% Bordeaux mixture (thrice)	8.7	41.6	3.84
0.2% Mancozeb (twice)	12.8	14.0	3.39
0.1% Propiconazole (Twice)	11.1	25.5	3.5
Control	14.9	--	3.1
CD (P=0.05)	11.6		
CV (%)	10.0		

At Dapoli, slow wilt, foot rot, and *Phytophthora* leaf blight were the major diseases observed throughout the region. Anthracnose was of less severity and was observed only around Dodamarg (Sindhudurg Dist.) on local variety (3.7%).

At Mudigere, incidence of anthracnose disease

ranged from 2.6% to 8.2% on leaves and was maximum (8.2%) during July. Evaluation of various fungicides at Mudigere indicated that three sprays of Bordeaux mixture 1% during the last week of May, July and August were effective in controlling the disease (Table 16).

Table 16. Effect of fungicides on anthracnose disease in black pepper – Mudigere

Treatment	* PDI (Before treat.)		Mean PDI	PDI (After treat.)		Mean PDI
	2003	2004		2003	2004	
Bordeaux mixture 1% (twice) (May-June & Aug.-Sept.)	9.00	5.40	7.20	4.14	2.20	3.17
Bordeaux mixture 1% (Thrice) (May, July, Aug.)	7.00	6.40	6.70	2.74	1.40	2.10
Mancozeb (DM-45) 75 WP 2g/l	6.20	10.40	8.30	3.80	3.00	3.40
Propiconazole 25EC (Tilt) 1 ml/l	5.75	09.80	7.78	2.80	1.75	2.28
Control	7.60	13.60	10.60	6.47	9.40	7.94
CD (P=0.05)				0.56	1.74	
CV (%)				9.08	31.85	

* Percent disease incidence

At Pampadumpara, three hot spot panchayats were surveyed for the occurrence of foliar infection of anthracnose on black pepper at high ranges of Idukki District (Table 17). The occurrence of the disease ranged from 8.3% (Kumily) to 27.1% (Chakkupallom). The disease occurred mainly on the older leaves and the new

flushes and spikes were not infected. The disease incidence was severe at altitudes above 1100 metres above MSL. Evaluation of various fungicides for the management of the disease indicated that spraying of Carbendazim + Mancozeb 0.1%, Carbendazim 0.1% and Bordeaux mixture 1% (thrice) were promising.

Table 17. Effect of fungicides on anthracnose of black pepper - Pampadumpara

Treatment	% disease reduction on leaves	% disease reduction on spikes
Bordeaux mixture 1% (Twice foliar spray)	46.2 (42.35)	58.9 (50.29)
Bordeaux mixture 1% (Thrice foliar spray)	60.3 (50.99)	33.3 (30.0)
Mancozeb 0.2% (Twice foliar spray)	39.7 (34.19)	62.7 (52.7)
Propiconazole (0.1 foliar spray)	42.7 (40.03)	43.2 (36.23)
Carbendazim (0.1% foliar spray)	86.6 (68.51)	87.3 (69.16)
Carbendazim + Mancozeb 0.1% (foliar spray)	86.8 (71.22)	91.7 (80.0)
Control	22.5 (23.42)	7.2 (12.49)
CD (P=0.05)	28.55	24.29

Values in parenthesis are arc sine transformed values

1.6 Pest Management Trial

1.6.1 Survey for the incidence of insect pests on black pepper at high altitudes

(Pampadumpara)

Twenty-three panchayats in four taluks viz., Udumbanchola, Peermade, Devikulam and Thodupuzha of Idukki District, Kerala were surveyed for the occurrence and distribution of insect pests on black pepper during 1999 to 2001. The most predominant insect pest observed was marginal gall thrips, *Liothrips karnyi* (Bagn.) in all the panchayats, ranging from 28.9% in Nedumkandam to 6.7% in Karimkunnam. Damage caused by marginal gall thrips was very severe in high ranges than in low elevations of the district. Four different types of scale insects were recorded in the survey. Highest incidence of mussel scale, *Lepidosaphes piperis* Gr was noticed in the plains at Karimkunnam (49.3%). Soft scale, *Marsipococcus marsupiale* (Gr.) and as well as coconut scale, *Aspidiotus destructor* Sign was observed mostly in the high ranges the maximum being 41.2% in Nedumkandam. Top shoot borer was observed in one garden at Pampadumpara panchayat.

Root mealy bug, *Planococcus* sp. was observed in one garden at Nariyampara, Kattapana. Vines infested by mealy bug were infected by foot rot pathogen and nematodes causing death of the vine immediately. Two tailed mealy bug, *Ferrisia virgata* was recently observed at eight panchayats ranging from 0.7% to 3.7% infesting the leaves and berries. Bagworm, *Clania crameri* was observed in Konnathady panchayat and stem borer, *Pterolophia griseovaria* was noticed from Ottakathalamedu, Kumily Panchayat. Pollu beetle was found infesting black pepper at high ranges of Idukki district for the first time at Vazhathopu and Karimkunnam. It is the final report of the concluded trial.

1.6.2 Management of scale insects of black pepper with organic products

(Pampadumpara)

Evaluation of botanicals and insecticides for the management of scale insects indicated that all treatments reduced the scale population in both leaves as well as twigs significantly. In leaf, the scale population was reduced from 20.2 to 7.0 in monocrotophos (0.05%) - treated plants after the first spray. Scale population in vines treated with Neem Gold (0.5%), fish oil (3%) and

thiamethoxam (0.013%) were at par. After the second/ fourth spray scale population was reduced to 1.7 in monocrotophos (0.05%)-treated vines followed by vines treated with thiamethoxam (0.013%) (3.3). Application of neem oil was inferior compared to that of Neem Gold (0.5%) and fish oil (3%) in reduction of scale population.

A similar trend was observed in scale population in twig that was reduced from 39.9 to 7.9 in monocrotophos (0.05%) -treated vines after the first spray. Scale population in neem oil (0.5%) and fish oil (3%) -treated vines were non-significant and inferior compared to that of vines treated with Neem Gold (0.5%) and thiamethoxam (0.013%). After second / fourth spray vines treated with monocrotophos (0.05%) resulted in least population of scale insects (1.9) followed by 3.1 in thiamethoxam (0.013%) -treated vines. Among the botanicals evaluated, Neem Gold (0.5%) was effective in the suppression of scale population and the least scale population was recorded in vines treated with monocrotophos (0.05%).

2. CARDAMOM

2.1 Genetic Resources

2.1.1 Germplasm collection, characterization, evaluation and conservation

(Mudigere and Pampadumpara)

At present, 132 replanted germplasm collections are being maintained at Mudigere centre. Out of 132 cardamom germplasm evaluated, maximum number of suckers per plant was found in CL-622 (36.00) and Pothamedu (36.00). Other top ranking entries were Darmala, K-4, M-2, CL-692 and Green Gold.

Presently, a total of 141 accessions are conserved in the field gene bank of Pampadumpara station. The highest fresh yield of capsules (2665g/plant) and dry yield (674 g/plant) of capsules was recorded in CRS-14. The second highest fresh yield (2654 g/plant) and dry yield (578 g/plant) was observed in the accession, PS- 27. Thrips infestation was less in the accessions, PS-27 (4.85%) and CRS-14 (5.47%). Infestation of capsule borer was rather less in PS- 26 (0.98%) and PS- 27 (1.17%). Hundred capsule weight was high in PS -27 (80g) followed by CRS - 14 (78g). Volatile oil content (volume to dry weight of capsules) was high in PS-27 (7.3%), followed by CRS-14 (7.2%).

2.2 Hybridization and selection

2.2.1 Evaluation of OP progenies under intensive management

(Mudigere)

Eight promising cardamom clones at Mudigere centre which were identified as better general combiners were planted during 1995-96 with closer spacing (6'x3') and allowed for open pollination in order to collect the crossed seed by open pollination. Totally thirty genotypes (OP seedlings) were identified from the crosses made out of the said parents which were crossed by open pollination and these are planted in the main field during the year 2000. Cardamom OP progeny 5C was the tallest (289.33cm), compared to check M-2 (274.77 cm), followed by 6C (256.33 cm) and 11 C (256.22). More number of suckers per plant was recorded by OP

progeny 18C (37.33), followed by 19C (35.67) and 8C (34.33).

2.2.2 CVT 1991/1998 - Series III with Malabar Types (Sakleshpur)

At Sakleshpur, four years (2000-01 to 2003-04) yield data showed that SKP 170 (328.5 kg ha⁻¹) and SKP 169 (327.0 kg ha⁻¹) had significantly more yield than other genotypes, followed by ICRI 3 (282.8 kg ha⁻¹) (Table 18). Oil content was significantly more in SKP 170 (7.1%) and in CL 683 (7.0%). Maximum percentage of bold capsules (capsules retained in 8 mm sieve) are found in CL 683 (60.4 %), followed by SKP 169 (58.6 %) (Table 19). Leaf blotch incidence was zero in CCS 872, CCS 893. SKP 72 had maximum incidence of chenthal leaf spot (50%). Shoot fly incidence was zero in CL 683 and shoot borer incidence in CL 726.

Table 18. Yield performance of cardamom entries (Malabar type) under CVT – Sakleshpur

Genotype	Yield (kg/ha)					% increase over check
	2000-01	2001-02	2002-03	2003-04	Mean	
CCS 872	208	163	105.8	198.0	168.4	-
CCS 893	81	112	90.3	96.6	94.4	-
CCS 800	310	108	125.5	99.3	159.1	-
PV 1	367	177	197.6	186.6	227.1	-
CL 679	393	222	178.2	185.3	246.2	-
CL 683	188	188	123.5	250.0	180.5	-
CL 726	291	241	184.7	226.0	236.6	-
MUD 1	303	158	156.6	172.3	197.5	-
MCC 34	241	122	164.3	198.0	172.8	-
ICRI 3	453	326	208.4	332.6	282.8	-
SKP 72	272	156	184.3	146.6	198.2	-
SKP169	335	399	260.0	394.0	327.0	15.6
SKP 170	383	358	265.7	313.0	328.5	16.1
CD (P=0.05)	NS	74.7	46.96	71.85	53.17	-

Table 19. Quality attributes of Malabar type under CVT – Sakleshpur

Genotype	Recovery of grades (%)					Oil (%)
	>8 mm	>7.5mm	>6.5 mm	>6 mm	<6 mm	
CCS 872	45.2	19.7	25.9	6.2	3.2	6.4
CCS 893	53.2	19.9	14.4	8.9	3.8	6.4
CCS 800	45.1	17.9	25.3	7.9	3.6	6.4
PV 1	29.0	25.1	22.3	21.4	3.4	6.6
CL 679	31.7	22.4	32.3	9.8	3.8	6.5
CL 683	60.4	16.6	14.3	5.4	3.4	7.0
CL 726	54.3	18.2	18.5	6.2	2.9	6.5
MUD 1	44.7	20.8	24.2	7.6	2.7	6.7
MCC 34	27.2	20.9	23.8	13.9	4.0	6.5
ICRI 3	44.3	23.4	26.4	8.2	2.8	6.9
SKP 72	31.4	23.9	28.2	13.2	3.2	6.1
SKP 169	58.6	15.8	17.6	5.8	2.2	6.9
SKP 170	52.9	13.9	16.6	6.9	2.5	7.1
CD (P=0.05)						0.62

2.2.3 CVT-1991/1998 - Series III with Mysore types (Sakleshpur)

Four years (2000-01 to 2003-04) yield data at Sakleshpur showed that yield was significantly more in MCC 85 (132.3 kg ha⁻¹) (Table 20). Oil percentage was significantly more in MCC 61 (6.9%) followed by MCC 21 (6.8 %). Maximum percentage of bold capsules (capsules retained in 8 mm sieve) are found in MCC 85 (39.8 %), followed by MCC 61 (33.8%) (Table 21)

Table 20. Yield performance of cardamom (Mysore type) - Sakleshpur

Genotype	Yield (kg/ha)				Mean
	2000	2001	2002	2003	
MCC 12	73	52	68.7	159	132.3
MCC 21	106	55	75.6	126	93.2
MCC 61	76	75	63.2	106	92.3
MCC 85	85	71	108.7	251	83.1
SKP 51	69	50	53.1	124	82.3
CD (P=0.05)	NS	14.6	14.59	32.3	22.32

Table 21. Quality attributes of Mysore type of cardamom - Sakleshpur

Genotype	Recovery of grades (%)					Oil (%)
	> 8 mm	> 7.5 mm	> 6.5 mm	> 6 mm	< 6 mm	
MCC 12	26.2	16.3	35.6	16	7.5	5.9
MCC 21	27.3	21.3	26.6	18.7	7.2	6.8
MCC 61	33.8	18.5	33.9	12.7	3.6	6.9
MCC 85	39.8	19	28.2	11.7	2.5	6.2
SKP 51	14.8	16.3	38	27.3	4.8	6.2
CD (P= 0.05)						0.47

2.2.4 CVT 2000 - Series IV

(Mudigere, Pampadumpara and Sakleshpur)

At Mudigere, among the clones, the dry capsule yield data indicated that clone MHC-18 (236.7 kg/ha), SKP-165 (187.6 kg/ha) and CL-692 (172.1kg/ha) were superior to Mudigere-2 (123.79 kg/ha). At Pampadumpara, the number of tillers ranged from 28.56 in MCC 18 to 56.25 in S1. The number of panicles per clump was found to be highest in S-1 (72.15) and lowest in RR-1 (30.41). Infestation by thrips was significantly lowest in RR 1 and the variety was found to be tolerant. Shoot borer damage was found to be lowest in Green Gold (0.54%). Higher and significant number of tillers and panicles resulted in the highest yield for S-1. Highest dry yield recorded in S-1 (528.3 kg ha⁻¹) was found to be significantly superior than other accessions. At Sakleshpur, ICRI 3 had significantly maximum number of tillers (25.3). However, bearing tillers were significantly more in MHC 10 (6.3)

2.3 Varietal Evaluation Trial (VET)

2.3.1 Initial evaluation trial-I

(Mudigere)

Among the 15 clones tested, Clone, 7-24-D11 recorded more number of suckers per plant (34.82), compared to checks, Mudigere-1 (23.35) and Mudigere-2 (30.69).

2.3.2 Initial evaluation trial -II

(Mudigere)

Open pollinated seedling of promising clones were screened, better performing seedlings progenies were multiplied and their suckers were planted during 1999. The clones CL-726 (388.71 kg/ha), CL-722 (328.99), CL-692 (284.72), CL-691 (266.67) and HS-1 (206.61) were superior for dry capsule yield compared to Mudigere-1 (138.25 kg/ha) and Mudigere-2 (153.99 kg/ha). Thus, CL-726, CL-722, CL-692, CL-691 and HS-1 were found promising for yield and most of the yield attributes.

2.3.3 Screening cardamom clones for abiotic stress

(Mudigere)

Among the selected clones, 31 genotypes showed less than 60 per cent survivability and 26 clones are highly susceptible to moisture stress conditions. However, non significant differences were observed on average number of suckers produced per clump in all survived cardamom clones.

2.4 Nutrient Management Trial

2.4.1 Integrated nutrient management in cardamom

(Mudigere)

The combination of organic and inorganic fertilization showed that application of inorganic fertilizer alone

yielded maximum (105.42 kg/ha) compared to organic alone (42.3 kg/ha), control (52.99 kg/ha) and other combinations of organic and inorganic at Mudigere.

2.4.2. Effect of biofertilizer, *Azospirillum* on cardamom

(Mudigere, Pampadumpara, Myladumpara and Sakleshpur)

In all the centres inclusion of *Azospirillum* along with 100% inorganic nitrogen + 5 kg FYM per plant increased

the yield (Table 22) compared to other combinations and control.

2.4.3 Effect of biofertilizer, P - solubilizer on cardamom

(Mudigere and Myladumpara)

Application of phosphate solubilizers @ 50 g along with 100% P and 5 kg FYM gave maximum yield (Table 23) compared to control and other treatments.

Table 22. *Azospirillum* application on yield of cardamom

Treatment	Yield at Centres (kg/ha)			Mean
	Mudigere	Pampadumpara	Myladumpara	
Best treatment : Inorganic N (100%) + <i>Azospirillum</i> (50g) + 5kg FYM	158.78	785.0	433	458.9
Control	158.08	365.0	31.6	279.69
Yield increase over control	0.70	420.0	117	179.23

Table 23. Phosphobacteria application on fresh yield of cardamom (kg/ha)

Centre	Yield at best treatment (100% P + P-Sol + 5 kg FYM/Pt) (kg/ha)	Control yield (kg/ha)	Yield increase over control (kg/ha)
Mudigere	186.82	155.81	31.01
Myladumpara	232.0	175.0	57.0
Mean	209.41	165.41	44.0

2.4.4 Effect of neem cake on the productivity, pest and disease incidence in cardamom

(Mudigere and Pampadumpara)

The experiment was started during August 2003 with five treatments in RBD at Mudigere. The experiment was initiated during 2003 in RBD at Pampadumpara centre. Higher dose of neem cake (1 kg) as well as application of neem cake two times could significantly increase the number of tillers and plant height. Among the neem cake treatments, application of neem cake twice @ 1 kg resulted in significantly more number of tillers (38.6) and higher plant height (199.7 cm). Minimum number of tillers (25.2) and lowest plant height (176.0 cm) were recorded in plants treated with 0.5 kg neem cake once. It was clearly evident from the table that maximum number of tillers (45.10) and the tallest tillers (211.4 cm) was observed in plants treated with recommended schedule of fertilizers.

2.5 Pest Management Trial

2.5.1 Management of root grub of cardamom

(Pampadumpara)

Field trials were conducted during 2001-2004 at Pampadumpara on 3 year old cardamom plants (PV-1, Malabar type) to evaluate the efficacy of insecticides for the management of root grub of cardamom. The insecticides were applied two times (April-May and September-October) in a year (Table 24).

During the first season (April-May), all the treatments significantly reduced the grub population compared to that of control. Maximum reduction was observed in carbofuran (150 g plant⁻¹) treated plots (76.9%) followed by those plots treated with imidacloprid (0.75ml litre⁻¹) (74.2%) and chlorpyrifos 0.07% (72.6%). At lower concentration of insecticides, carbofuran (100 g plant⁻¹) treated plots recorded the maximum suppression of root grub and plots drenched with chlorpyrifos 0.05% recorded the minimum (Table 25).

Table 24. Evaluation of insecticides for the management of cardamom root grub (I season - Pooled)

Treatment	Initial grub* popn. (No.)	Grub popn. after treatment (No.)*	% reduction after drenching**
Chlorpyrifos 0.05%	10.64 (3.26)	4.86 (2.20)	55.1 (46.76)
Chlorpyrifos 0.07%	11.52 (3.39)	2.75 (1.66)	72.6 (58.45)
Carbofuran (100g plant ⁻¹)	11.11 (3.33)	4.77 (2.18)	56.5 (48.77)
Carbofuran (150g plant ⁻¹)	11.09 (3.33)	2.52 (1.58)	76.9 (61.37)
Imidacloprid (0.5ml per litre)	11.86 (3.45)	5.15 (2.27)	55.1 (47.96)
Imidacloprid (0.75ml per litre)	9.89 (3.14)	2.33 (1.52)	74.2 (59.55)
Control	10.89 (3.30)	9.33 (3.05)	15.8 (23.03)
CD (P=0.05)	N.S.	0.21	7.43

* Value in parenthesis are square-root transformed values

** Value in parenthesis are arc-sine transformed values

Table 25. Evaluation of insecticides for the management of cardamom root grub (Season II Pooled)

Treatment	Grub population (No.)		% reduction after treatment**	Yield (g plant ⁻¹)
	Before treatment *	After treatment*		
Chlorpyrifos 0.05%	8.78 (2.96)	4.41 (2.10)	50.8 (45.47)	235.33
Chlorpyrifos 0.07%	8.79 (2.96)	1.99 (1.40)	65.8 (54.28)	300.33
Carbofuran (100g plant ⁻¹)	9.22 (3.03)	4.08 (2.02)	60.9 (51.34)	319.90
Carbofuran (150g plant ⁻¹)	9.03 (3.00)	2.26 (1.50)	70.1 (56.91)	318.10
Imidacloprid (0.5ml litre ⁻¹)	9.19 (3.03)	4.11 (2.03)	59.3 (50.48)	319.90
Imidacloprid (0.75ml litre ⁻¹)	9.12 (3.01)	1.82 (1.33)	71.5 (57.72)	411.87
Control	9.78 (3.13)	8.19 (2.85)	26.1 (30.29)	169.80
CD (P=0.05)	NS	0.309	8.32	59.39

* Value in parenthesis are square-root transformed values

** Value in parenthesis are arc-sine transformed values

During the second season (September-October) also all the treatments significantly reduced the grub population compared to that of control. Maximum reduction was observed in imidacloprid (0.75ml litre⁻¹) treated plots (71.5%) followed by those plots treated with carbofuran (150g plant⁻¹) (70.1%) and chlorpyrifos 0.07% (65.8%). At lower concentration of insecticides, carbofuran (100 g plant⁻¹) treated plots recorded the maximum suppression of root grub and plots drenched with chlorpyrifos 0.05% recorded the minimum. Therefore, all the treatments were effective in reducing the grub population to more than 59%. Highest yield of cardamom (411.87 g

plant⁻¹) was realized in imidacloprid (0.75ml litre⁻¹) treated plots and lowest in control (209.33 g plant⁻¹). Among the insecticide treatments, lowest yield was recorded in those plots drenched with chlorpyrifos 0.05% (235.33 g plant⁻¹).

The trials indicated that all the insecticide treatments are effective in reducing root grub; however, plots drenched with imidacloprid (0.75ml litre⁻¹) recorded the maximum yield of cardamom. Cost analysis revealed highest BC ratio for chlorpyrifos 0.07% treated plots (1.68) followed by those plots treated with imidacloprid 0.75ml litre⁻¹ (1.65) (Table 26).

Table 26. Management of cardamom root grub - cost analysis and benefit-cost ratio

Treatment	Treatment cost per ha (Rs.)	Total cost (Rs./ha)	Income generated per ha (Rs.)	BC ratio
Chlorpyrifos 0.05%	4,376	56,564	77,785	1.38
Chlorpyrifos 0.07%	6,126	59,189	99,409	1.68
Carbofuran (100g plant ⁻¹)	12,000	68,000	1,05,887	1.56
Carbofuran (150g plant ⁻¹)	18,000	77,000	1,05,258	1.37
Imidacloprid (0.5ml litre ⁻¹)	14,500	71,750	1,05,887	1.48
Imidacloprid (0.75ml litre ⁻¹)	21,750	82,625	136,306	1.65
Control	0	50,000	56,204	1.12

Average cardamom price is Rs 331/kg

2.5.2 Bioecology of natural enemies of major pests of cardamom

(Mudigere and Pampadumpara)

At Mudigere, observations were recorded at fortnightly intervals on natural enemies of major pests of cardamom. General predators like spiders, larvae of *Chrysoperla* sp. and unidentified species of mites were observed as predators on thrips. However, their population was very low. The larvae of *Conogethes punctiferalis* were parasitized by an *Xanthopimpla* sp. and by an unidentified species of Ichneumonid.

Surveys conducted at Pampadumpara revealed the occurrence of larval-pupal parasitoids of shoot and capsule borer as well as entomopathogenic nematodes (*Heterorhabditis indicus*) from root grub. Resurgence of thrips was noticed in a few gardens where synthetic pyrethroids were extensively used. Highest parasitization of shoot and capsule borer was observed in February (77.8%) and lowest in June (31.3%). Extent of parasitism was lowest coinciding South-West monsoon (June-July). During January to April, 2005 parasitization was higher than 60%. Parasitization of cardamom shoot borer larvae by ichneumonids ranged from 24 to 100% and occurred during all months under investigation. Highest parasitization was recorded during July (100%). Parasitization by other dipteran parasitoids was observed during all months except July. Occurrence of dipteran parasitoid during South-West monsoon was minimum, while the highest incidence was observed in October (76%). The study indicated that that 61.2% of shoot

and capsule borer was parasitized by ichneumonids as well as dipteran parasitoids.

Entomopathogenic nematodes were recovered from two soil samples (5.6%) out of 36 collected from Pampadumpara and Thodupuzha. The putative new species from Pampadumpara resembled to that of *Heterorhabditis indicus*? and infected *G. mellonella*. The toxicity of *H. indica* (CRS isolate) on *B. fulvicorne* was also determined (Table 27).

The LC₅₀ and LC₉₀ values decreased with increase in the exposure time of *H. indicus* (CRS isolate). The LC₅₀ value was highest (92.85 IJ) at 72 h and lowest (41.64 IJ) at 120 h after treatment. A similar trend of LC₉₀ was found; the highest being 945.26 IJ at 72 h and the lowest being 324.05 IJ at 120 h after treatment. Slope of the regression equation had progressively increased from 1.272 to 1.438 with increase in the exposure time.

2.5.3 Estimation of quantitative and qualitative losses due to thrips damage in cardamom

(Mudigere and Pampadumpara)

At Mudigere, the capsules collected from the field were dried and analysed for quality parameters. There was not much change in the quality parameters for the samples of fresh and thrips affected. Hence, the quality parameters are not affected by the thrips damage.

At Pampadumpara quantitative parameters and qualitative parameters such as acid phosphatase, trypsin-like protease activity, protein and volatile oil contents were evaluated in healthy and itchy capsules (Table 28).

Table 27. Probit analysis of dosage mortality relationship of *Basilepta fulvicorne* to *Heterorhabditis indicus* (CRS isolate)

Time	Heterogeneity		Regression equation (y)	LC ₅₀	LC ₉₀	Fiducial limit	
	χ^2	df				Lower	Upper
72 h	9.86	5	2.497 + 1.272x	92.85	945.26	65.22	132.20
96 h	10.14	5	2.445 + 1.427x	61.69	487.71	47.19	80.66
120 h	7.13	5	2.671 + 1.438x	41.64	324.05	32.29	53.69

Chi square table value (P=0.05) = 11.044

Table 28. Quantitative parameters of healthy and thrips infested capsules

Treatment	Fresh 100 capsule wt (g)	No. of seeds/capsule	Dried 100 capsule wt. (g)	No. of capsules in 100 cc	Driage (%)
Category 0 (Healthy)	114.33	18.85	22.54	166.7	19.83
Category 1 (10% itchy)	98.32	16.58	18.45	197.7	19.75
Category 2 (11-33% itchy)	79.68	16.10	15.67	228.0	21.67
Category 3 (>33% itchy)	71.25	17.4	12.53	257.3	19.23
CD (P=0.05)	13.45	ns	4.78	51.3	ns

The weight of 100 fresh as well as dried capsules decreased significantly as the severity of thrips damage increased. The weight of 100 fresh capsules ranged from 114.33 g in category 0 (healthy) to 71.25 in category 3 (>33% scab). A similar trend of was also recorded in dry weight of 100 capsules ranging from 22.54 in Category 0 (healthy) to 12.53 in Category 3 (>33% scab). The number of dried capsules in 100 cc progressively increased with increase in thrips damage. It was found that 166.7 healthy capsules could be accommodated in 100 cc which increased to 257.3 capsules for thrips-infested capsules (Category 3). However, there was no significant difference in the number of seeds per capsule as well as diage percentage in healthy and itch capsules.

Volatile oil content was 5.9% and 5.7% in healthy and thrips infested capsules, respectively. Both activity and specific activity of acid phosphatase at three stages viz., fresh white seed, fresh black seed and dried black seed in healthy capsules was higher than that of itch capsules. Peptidase activity of healthy capsules declined progressively as maturity advanced.

2.5.4 Shoot fly infestation in cardamom – observational trial (*Mudigere*)

Observations were recorded on the activity of shoot fly in cardamom through out the year at Mudigere from January-December 2004. The population ranged from 1.00 to 8.37 maggots per damaged shoot. Maximum population was recorded in February, March and May, and the minimum during July. Observations on the population fluctuation of shoot fly indicated three peaks in March, May and October.

3. GINGER

3.1 Genetic Resources

3.1.1 Germplasm collection, characterization, evaluation and conservation in ginger

(*Dholi, Kumarganj, Pottangi, Pundibari, Raigarh and Solan*)

At Dholi, yield of the germplasm varied from 0.25 kg (RG-27) to 14.00 kg (RG-13) in the area of 7.2 m². At Kumarganj, out of 45 genotypes evaluated maximum yield was observed in NDG-28 (14.09 t./ha), followed by NDG-27 (12.59 t./ha) and NDG-9 (12.37 t./ha) over

checks Mahima and Varada (7.6 and 6.39 t./ha). None of germplasm was found free from rhizome rot disease. However, minimum incidence of disease was observed in NDG-8 and NDG-9 (4.76%), each.

Out of total 172 ginger accessions conserved in the repository of Pottangi centre, 145 accessions were evaluated in two replications of which only 22 accessions yielded more than 8 kg/ 3 m², the range of yield being 1.6 kg to 11.6kg/3 m². The highest fresh rhizome yield was recorded by V E -4 (11.6) kg/3m², followed by KG-42 (11.2) kg/3m² and PGS-8 (11.0/ 3m²) respectively.

At Pundibari centre, 38 accessions of ginger are being maintained. Lowest infection of rhizome rot was recorded in GCP-30 (10.0%), GCP-10 (21.05%) and GCP-20 (22.22%). Highest rhizome yield per plant was recorded in GCP – 31 (307.02 g), followed by GCP-32 (289.11 g), GCP-08 (270.71 g) and GCP-20 (260.71 g). Considering percent disease index (PDI) and rhizome yield, GCP-20 was having low disease and appreciable plant yield.

Among the entries evaluated at Raigarh centre IG-1, IG-5 performed well with an yield of 8 kg/3m² bed, followed by IG-3 with 7–3 kg/bed. At present, 288 accessions including two exotic types are being maintained in the filed gene bank of Solan centre. The maximum yield among ten top lines was obtained (7.50 kg per plot) in 51/04 and minimum in 17/04 (5.50 kg/plot). Disease incidence was minimum in 51/04 and maximum in SG 780, 50/04, 27/04 and 17/04. The dry matter and oleoresin contents were maximum in 50/04 and SG 827, respectively.

3.2 Coordinated Varietal Trial (CVT)

3.2.1 CVT 2000 - Series V

(*Chintapalle, Pottangi, Pundibari, Raigarh and Solan*)

At Chintapalle, over the years (2001-02 to 2004-05), IISR-Varada recorded the highest rhizome yield of 17.5 t/ha (Table 29).

At Pottangi, pooled data (2000-01 to 2004-05) revealed that there was significant difference for fresh rhizome yield among the entries. Highest fresh rhizome yield was recorded by V₁E₈-2 (24.43 t/ha), followed by V₃S₁-8 (22.86 t/ha) V₁E₈-2 (24.43 t/ha) & V₃S₁-8 (22.86 t/ha) (Tables 30 and 31).

Table 29. Performance of ginger entries under CVT – Chintapalle

Entry	Pl. height (cm)	No. of tillers/plant	No. of leaves/ plant	Leaf length (cm)	Leaf width(cm)	Yield per plant (g)	Yield (t/ha)
ACC 35	63.9	8.7	79.0	21.4	2.1	106.0	12.2
ACC 117	75.0	8.3	89.7	21.0	2.2	124.3	14.1
V1S1 2	67.5	9.3	86.0	19.6	2.0	120.0	13.0
V1C8	67.7	8.1	77.0	21.6	2.0	90.0	10.1
VARADA	71.3	9.9	90.0	20.2	2.1	144.0	17.5
J LOCAL	62.3	9.2	72.0	19.2	2.2	93.0	10.9
SUPRABHA	69.0	10.0	92.0	21.0	2.1	121.0	13.3
C LOCAL	60.0	6.5	52.0	20.6	2.0	95.0	10.5
CD (P=0.05)	7.0	1.9	10.2	1.4	0.2	16.5	3.7
CV (%)	5.9	12.5	7.3	4.0	6.6	8.4	16.7
SEM ±	2.3	0.6	3.4	0.5	0.1	5.5	1.2

Table 30. Yield performance of ginger entries under CVT – Pottangi

Entry	Fresh Rhizome yield (kg/ 3 m ²)						Projected yield (t/ha)	Increase over control (%)
	2000-01	2001-02	2002-03	2003-04	2004 - 05	Mean		
V ₁ E ₈ - 2	11.68	11.13	9.12	8.57	12.61	10.62	24.43	34.82
V ₃ S ₁ - 8	10.49	11.43	7.41	9.33	11.01	9.94	22.86	26.15
V ₁ C -8	9.47	10.86	7.78	4.61	10.28	8.60	19.78	9.2
Acc - 35	7.7	7.84	6.28	4.59	9.41	7.17	16.49	11.64
Suprabha	8.2	8.68	6.65	6.72	9.15	7.88	18.12	2.64
Acc - 117	6.5	8.8	6.94	6.37	9.74	7.67	17.64	1.04
V ₁ S ₁ - 2	7.5	9.06	8.32	7.87	11.21	8.79	20.23	---
SG-666	6.1	8.46	7.14	4.24	8.82	7.96	18.31	---
CD (P = 0.05)	N.S	1.14	1.34	1.13	1.93	1.38	3.16	---

Table 31. Quality attributes and incidence of rhizome rot of ginger under CVT – Pottangi

Entry	Dry recovery (%)	E-oil (%)	Oleoresin (%)	Rhizome rot (%)
V ₁ E ₈ - 2	23.2	2.0	6.38	16.2
V ₃ S ₁ - 8	22.2	1.25	4.77	14.7
V ₁ C -8	23.4	1.0	4.04	12.2
Acc - 35	23.2	1.0	3.88	13.8
Suprabha	22.2	1.75	6.48	17.6
Acc - 117	20.2	1.0	3.72	21.2
V ₁ S ₁ - 2	21.4	1.0	4.97	13.2
SG-666	21.3	1.0	3.54	14.6

At Pundibari, significant difference between the entries was found for all the parameters except for plant height, pseudostem girth and leaf length. Lowest PDI was recorded in Gorubathan (31.11%), which was also reflected in rhizome yield. Highest rhizome yield was recorded in Gorubathan (14.83 ton/ha), followed by SG-692 (14.119 ton/ha). However, the rhizome yield of Gorubathan, SG-692 and V S -8 were statistically at par with each other.

At Raigarh, the pooled data over the years (2001-02

to 2004-05) revealed that all the out side entry did not perform well like previous years, However at some extent local entries showed good yield IG-1 (9.23 kg/3m² bed), followed by IG-2 (7.89 kg/3m²). At Solan, non-significant differences for yield were observed for the entries. None of the entries out yielded the check, Himgiri. Dry matter content was maximum (21.60%) in V S -2, while essential oil (2.00%) and oleoresin contents (7.73%) were in Himgiri. Crude fibre was minimum (4.00%) in ACC 117 and SG54.

3.3 Varietal Evaluation Trial

3.3.1 Comparative yield trial (CYT - I & II)

(Pottangi, Raigarh and Solan)

At Pottangi, pooled data (2000-01 to 2004-05) showed that highest fresh rhizome yield was recorded

by V E -2 (22.78 t/ha), followed by Singhjhara (21.16t/ha). However, highest dry recovery was registered with V E -2 (22.2%), essential oil, oleoresin content, and the least rhizome rot incidence with Vengara (2.0%), (5.83%) & (10.0%) respectively (Tables 32 and 33).

Table 32. Yield performance of ginger entries under CYT – Pottangi

Entry	Fresh Rhizome yield (kg/ 3 m ²)					Mean	Projected yield (t/ha)	Increase over control (%)
	2000-01	2001-02	2002-03	2003-04	2004-05			
S-646	10.6	8.63	7.04	7.10	8.61	8.39	19.31	31.32
V ₂ E ₅ -2	8.9	10.9	8.51	9.68	11.52	9.90	22.78	33.68
ZO - 17	8.1	9.05	7.86	8.55	10.61	8.83	20.31	19.19
V ₃ S ₁ -8	6.2	9.88	8.56	8.75	10.93	8.87	20.40	19.72
S-641	5.23	7.63	7.31	7.61	9.14	7.39	16.99	---
Singhjehara	5.51	9.03	6.88	7.78	9.48	9.20	21.16	24.18
Vengara	4.56	8.1	7.92	8.48	8.12	7.44	17.11	4.10
Suprabha	6.3	8.13	6.59	7.32	8.68	7.41	17.04	---
CD (P = 0.05)	1.64	1.99	1.02	N.S	1.73	1.78	4.11	

Table 33. Quality attributes and disease incidence of ginger under CYT – Pottangi

Entry	Dry recovery (%)	E- oil (%)	Oleoresin (%)	Rhizome rot (%)
S-646	22.2	1.0	3.81	19.6
V ₂ E ₅ -2	22.2	1.0	3.5	15.4
ZO - 17	21.2	1.0	4.01	18.2
V ₃ S ₁ -8	21.4	1.25	5.46	12.2
S-641	19.0	1.0	4.02	24.0
Singhjehara	20.2	1.0	4.96	17.2
Vengara	21.2	2.0	5.83	10.0
Suprabha	20.1	1.75	5.56	11.0

At Raigarh, the trial is considered to be failed like previous years due to severe occurrence of rhizome rot. However, local entries performed well viz., IG-1 (18.05 t/ha), IG-2 (15.68 t/ha) and IG-3 (15.18 t/ha). At Solan, yield per plot was found to be non-significantly influenced by the entries. All the entries recorded less yield than check, Himgiri. The dry matter content was maximum (20.10%) in SG 1071, while essential oil and oleoresins in Himgiri. SG 1071 also recorded minimum crude fibre (4%).

3.3.2 Initial evaluation trial (IET)

(Pottangi and Solan)

At Pottangi, there was significant difference for fresh rhizome yield, among the entries in the pooled data (2000-01 to 2004-05). Highest fresh rhizome yield was recorded by V S -8 (22.70 t/ha), followed by S-646 (22.50t/ha) (Tables 34 and 35). However, highest dry recovery (22.2%), essential oil (2.5%), oleoresin (6.4%)

and least incidence of rhizome rot (11.4%) was recorded with Vengara, Jugijan, Zo-2 and S-666, respectively.

Non- significant differences were observed for yield per plot at Solan. None of the entries showed increase in yield over the check, Himgiri. The dry matter was maximum in essential and oleoresin contents were maximum in SG 1075, while essential oil and oleoresin contents in Himgiri. Crude fibre was minimum in SG 825.

3.3.3 Comparative yield trial (CVT)

(Solan)

Non-significant differences for yield per plot, among the entries were observed. SG.878 gave maximum dry matter content (21.00%). Essential oil and oleoresin content was maximum (6.50%) in Himgiri, while SG 878 and SG 702 recorded minimum crude fibre (4.00%).

Table 34. Yield performance of ginger entries under IET – Pottangi

Entry	Fresh rhizome yield (kg/ 3 m ²)						Projected yield (t/ha)	Increase over control (%)
	2000-01	2001-02	2002-03	2003-04	2004-05	Mean		
S-558	9.44	10.33	9.46	9.70	9.85	9.75	22.43	8.04
Zo - 17	6.92	8.65	10.46	7.10	11.71	8.97	20.63	---
Vengara	7.16	7.65	7.08	6.98	10.35	7.85	18.05	---
Rajgarh	11.43	8.86	8.01	8.32	9.17	9.15	21.05	1.39
V ₂ E ₅ -2	8.67	9.85	10.36	10.09	7.88	9.38	21.57	3.90
Anamica	10.22	8.57	9.34	7.24	9.53	8.99	20.68	---
SS-1	9.41	7.35	10.44	7.61	9.93	8.95	20.58	---
V ₁ S ₁ -8	7.30	9.87	9.56	8.27	11.17	9.23	21.23	2.26
V ₃ S ₁ -8	11.64	10.96	9.17	7.04	10.54	9.87	22.70	9.34
Jugijan	7.52	7.60	5.89	7.32	10.70	7.80	17.95	---
Zo-2	9.81	6.71	10.58	7.08	12.28	9.29	21.37	2.93
S-646	10.76	8.09	9.67	8.78	11.60	9.78	22.50	8.38
S-666	9.62	7.33	9.52	6.50	12.56	9.10	20.94	0.8
Suprabha	10.78	9.27	10.12	6.55	8.40	9.02	20.76	---
CD (P=0.05)	1.94	2.54	0.99	3.61	2.46	2.31	5.30	---

Table 35. Quality attributes and disease incidence of ginger under IET – Pottangi

Entry	Dry recovery (%)	E-oil (%)	Oleoresin (%)	Rhizome rot (%)
S-558	22.4	1.5	5.34	21.2
Zo - 17	20.2	1.0	4.67	18.4
Vengara	22.2	1.5	5.04	22.2
Rajgarh	21.3	1.5	4.9	14.2
V ₂ E ₅ -2	22.1	1.0	4.63	13.4
Anamica	18.7	0.5	3.85	12.4
SS-1	20.2	1.0	4.63	16.6
V ₁ S ₁ -8	22.3	1.0	3.88	11.4
V ₃ S ₁ -8	21.4	1.0	5.57	14.6
Jugijan	21.4	2.5	6.08	21.3
Zo-2	20.4	1.8	6.4	20.3
S-646	20.2	1.5	5.36	23.2
S-666	20.1	1.0	3.96	26.3
Suprabha	21.2	1.0	4.5	16.4

3.4 Quality Evaluation Trial

3.4.1 Evaluation of ginger germplasm for quality (Solan)

Eighty six genotypes were evaluated for various quality attributes viz. dry matter, oleoresin and essential oil content. Out of 87 entries evaluated, the dry matter content varied from 14.1 to 27.5 per cent. The oleoresin and essential oil content ranged between 2.83 to 7.73 per cent and 21.00 to 2.00 per cent, respectively.

3.5 Nutrient Management Trial

3.5.1 Effect of biofertilizer *Azospirillum* on ginger

(Solan, Pottangi, Ambalavayal, Pundibari, Dholi and Raigarh)

Recommended nitrogen + 5 kg FYM and 50 g *Azospirillum* gave more yield compared to rest of the treatments in all the centres except Ambalavayal and Raigarh (Table 36).

3.5.2 Organic farming in ginger

(*Solan, Pottangi, Dholi and Raigarh*)

Combined application of all the organic sources *viz.*, FYM (10 kg), Pongamia oil cake, neem oil cake,

sterameal, rock phosphate and wood ash (each 250 gm/bed enhanced the ginger yield at Pottangi and Dholi, whereas recommended fertilizer recorded higher yield at Raigarh (Table 37).

Table 36. *Azospirillum* application on ginger yield

Centre	Best treatment	Yield (t/ha)	Yield under recommended dose (control) (t/ha)
Pottangi	100% N + <i>Azospirillum</i> + FYM 5 kg/ha	18.70	17.30
Raigarh	Recommended fertilizer dose 150:100:120 kg NPK/ha	18.93	-
Pundibari	100% N + <i>Azospirillum</i> + FYM 5 kg/ha	22.92	20.41
Ambalavayal	75% N + <i>Azospirillum</i> + 5 kg FYM	31.46	-

Table 37. Organic nutrition on ginger yield

Centre	Yield with organic (t/ha)	Yield in recommended dose (control) (t/ha)	Yield increase over control (t/ha)
Pottangi	12.95	8.65	4.30
Dholi	23.67	17.00	6.67
Raigarh	16.52	17.87	1.35

3.5.3 Effect of micronutrients on ginger

(*Dholi, Pottangi, Raigarh, Pundibari, Solan and Kumarganj*)

The micronutrients such as Zinc, Boron and Iron were tested on ginger yield at Dholi. Application of these micronutrient alone or their combinations enhanced the yield of ginger compared to control. It is the first year result.

3.6 Disease Management Trial

3.6.1 Disease surveillance and etiology of rhizome rot in ginger

(*Pundibari and Solan*)

A survey was conducted during July-September 2004 in different blocks of Kalimpong sub division of Darjeeling District namely, Kalimpong I, Kalimpong II and Kalimpong III (Gorubathan) for the occurrence of diseases of ginger. Among the varieties grown in the area, Gorubathan is most widely cultivated followed by Bhaisi and Nongrey. Kalimpong I Block is the hot spot for bacterial wilt disease (average 54.6%), followed by Kalimpong II (average 49.2%) and Kalimpong III (average 47.9%) blocks, respectively. *Phyllosticta* leaf spot disease was highest in Kalimpong III block (average 6.9%) followed by Kalimpong I (average 5.8%) and Kalimpong II block (average 4.2%).

Soil samples were collected from the surveyed areas and the pathogens were isolated in the laboratory. After isolation two types of pathogens were found namely, a gram negative bacterium and a fungal pathogen. The bacterium was identified as *Ralstonia* sp. and the fungus was identified as *Fusarium* sp. Soil samples (sick soil) were also collected from plain area of West Bengal (Pundibari, Coochbehar) and the pathogens were isolated from that soil. In the soil from plain area, two pathogenic fungi were found that were identified as *Pythium* sp. and *Fusarium* sp. Surveillance of ginger fields for incidence of rhizome rot disease in Himachal Pradesh indicated that the incidence of disease varied from 0.0 to 60 %. It was maximum in Bilaspur (40-60%) and Sirmour (0.0-50%) followed by Shimla (10.5-20.0%) and Solan (0.0-2.5%).

3.6.2 Biocontrol studies on rhizome rot of ginger (*Kumarganj, Pottangi and Raigarh*)

Trials were carried out to evaluate the efficacy of hot water treatment, fungicide and biocontrol agent for the management of rhizome rot disease of ginger. At Kumarganj, the trial indicated that minimum incidence of rhizome rot and maximum yield was observed in the treatment seed treatment (ST) with hot water at 51°C for 10 min. and *Trichoderma harzianum* for 30 min. with neem cake (Table 38).

Table 38. Management of rhizome rot disease of ginger - Kumarganj

Treatment	Sprouting (%)	Incidence of rhizome rot (%)	Yield (t/ha)	% increase in yield over control
Seed sown directly (Control)	68.7	95.3	0.199	-
ST with hot water (51°C for 10 min.)	58.7	76.0	0.499	150.8
ST with mancozeb (3g/l) for 10 min.	60.0	78.0	0.333	67.3
ST with <i>Trichoderma harzianum</i> (100 g inoculated/ 5l of water) – 30 min.	59.3	88.0	0.299	50.3
ST with hot water (51°C for 10 min.) + ST with mancozeb (3 g/l) for 30 min.	48.7	76.7	0.580	193.0
ST with hot water (51°C for 10 min.) + ST with <i>T. harzianum</i> mixed with neem cake	58.7	66.0	0.666	234.7
Soil application of neem cake at the time of planting and sowing	66.7	80.0	0.610	205.5
CD (P=0.05)	20.3	15.2	0.410	-
CV (%)	19.0	10.7	51.080	-

At Pottangi, there was no significant difference for yield among different treatments. The incidence of the disease was minimum in seed treatment with hot water (51°C for 10 min) + *T. harzianum* with neem cake (Table 39).

Table 39. Management of rhizome rot disease of ginger – Pottangi

Treatment	Germination (%)	Rhizome rot (%)	Rhizome yield (kg/3m ²)	Projected yield (t/ha)
No Seed Treatment	80.2	36.2	5.410	12.440
Seed Treatment with hot water (51°C for 10 minutes)	82.4	32.2	6.840	15.730
Seed Treatment with Mancozeb (3 g/l) + Carbendazim (1g/l) + Chloropyriphos (2ml/l for 30 min) & soil appln. of Thimet (10G) (1kg ai/ha)	85.0	28.0	8.210	18.890
Seed treatment with <i>Trichoderma</i> (2.5 g /l for 30 min) for 1kg seed	82.6	26.6	6.010	13.820
Hot water seed treatment + T ₃	87.0	24.2	7.610	17.500
Seed treatment with hot water + <i>Trichoderma</i> , FYM, neem cake soil appln	88.2	22.2	8.330	19.160
Soil appln. with <i>Trichoderma</i> (10 kg/ha)	86.0	26.2	7.640	17.570
Soil appln. with neem cake (1ton/ha) at planting.	83.0	25.4	6.080	13.980
CD (P=0.05)			NS	NS

At Raigarh, none of the treatments were effective in reducing the incidence of the disease (Table 40).

3.6.3 Effect of seed treatment on soft rot disease of ginger (Dholi)

A study to find out the effect of seed treatment with five fungicides on soft rot disease of ginger was

conducted at Dholi. The pooled data of three years (1997-98 to 1999-2000) showed that minimum disease incidence (16.4%) was recorded by 1 hour seed treatment with Ridomil MZ (3 g/l of water) followed by Indofil M-45 seed treatment (25.3%). It is the final report of the concluded project (Table 41).

Table 40. Management of rhizome rot of ginger - Raigarh

Treatment	Disease incidence after 100 days of planting	Disease incidence after 150 days of transplanting	Yield (kg/plot)	Projected yield (kg/ha)
Healthy looking seed sown directly – No treatment	75.3	82.7	.0.180	361.80
Seed treatment with hot water (51 °C for 10 min.)	64.0	83.3	0.116	234.49
Seed treatment with Mancozeb (3 g/l) 30 min	64.7	82.0	0.160	321.60
Seed treatment with bio agent (100 g/5l water for 30 min.)	74.7	86.0	0.056	113.89
Seed treatment with hot water (51°C for 10 min.) + T3	72.0	83.3	0.030	127.29
Seed treatment with hot water (51°C+100 g) + bioagent in 1 kg neem cake at sowing time.	78.7	82.6	0.136	274.69
Application of neem cake 1kg in soil at the time of sowing	58.7	80.7	0.266	536.99
Neem cake 1 kg + 100 g bio agent in 3 kg FYM (Mixed 7 days before sowing and watering regularly).	66.0	78.9	0.136	274.69

Table 41. Effect of seed treatment on rhizome rot of ginger - Dholi

Treatment	Disease incidence (%)			Mean
	1997-98	1998-99	1999-2000	
Ridomil MZ (3 g/l)	20.0	13.5	15.7	16.4
Indofil M-45 (2 g/l)	19.5	30.5	25.9	25.3
Bavistin (1 g/l)	30.0	35.5	34.3	33.3
Indofil M-45 (2g/l) + Bavistin (1 g/l)	26.5	26.5	26.4	26.5
Blitox-50 (2 g/l)	20.2	36.0	29.0	28.4
Control	50.2	58.5	57.5	55.4
CD (P=0.05)	13.9	16.1	4.1	7.4
CV (%)	24.3	27.9	7.1	13.2

3.6.4 Integrated management of *Pythium*, *Fusarium* and *Ralstonia* in ginger

(Kumarganj, Pundibari, Raigarh and Solan)

Trials were conducted to evaluate the efficacy of hot water treatment, fungicide and biocontrol agent for the management of various pathogens of rhizome rot dis-

ease of ginger. At Kumarganj lowest incidence of rhizome rot disease (54.0%) was observed with seed treatment of ginger rhizomes with mancozeb (0.3 %) with maximum yield (1.37 t/ha). Seed treatment of *Trichoderma harzianum* was at par with the above treatment (Table 42).

Table 42. Integrated management of rhizome rot disease in ginger - Kumarganj

Treatment	Sprouting (%)	Rhizome rot (%)	Yield (t/ha)	% disease control	% increase in yield over control (t/ha)
Seed treatment with Mancozeb (0.3%)	79.0	54.0	1.370	23.9	50.5
Seed treatment with <i>Trichoderma harzianum</i>	75.0	57.0	1.280	19.7	40.7
Seed treatment with Rhizome solarization	21.5	94.0	0.125	32.34	- 86.3
Seed treatment with Ridomil Mancozeb (Metalaxyl 100ppm)	67.0	61.5	1.330	13.4	46.2
Hot water seed treatment (51°C for 30 min.)	73.5	63.5	1.310	10.6	44.0
Control	65.5	71.0	0.910	-	-
CD (P=0.05)	8.8	26.7	1.050	-	-
CV (%)	13.4	38.8	96.67	-	-

At Pundibari, minimum disease incidence and maximum yield was recorded by hot water treatment at 51°C for 30 minutes followed by seed treatment with *Tricho-*

derma harzianum and were statistically at par with each other (Table 43).

Table 43. Integrated management of *Pythium*, *Fusarium* and *Ralstonia* on ginger - Pundibari

Treatment	Germination (%)	Disease Incidence (%)			% reduction over control	Yield (Kg/plot)	Projected yield (t/ha)
		1 st observation	2 nd observation	3 rd observation			
Mancozeb (0.3%)	88.3	4.52 (11.95)	8.14 (16.45)	10.39 (18.53)	39.8	2.400	4.840
Seed treatment with <i>Trichoderma harzianum</i>	91.1	3.70 (10.94)	5.16 (12.90)	7.41 (15.64)	49.2	4.480	9.030
Solarization of rhizomes (2 hours) before sowing	92.2	4.92 (12.62)	6.54 (14.72)	9.11 (17.50)	43.1	3.160	6.370
Hot water treatment (51°C for 30 minutes)	96.7	2.92 (9.71)	3.56 (10.75)	6.22 (14.37)	53.3	4.070	8.210
Ridomil Mancozeb (100 ppm Metalaxyl)	87.8	6.70 (14.91)	10.05 (18.43)	9.59 (17.90)	41.9	2.230	4.500
Control	77.8	13.14 (21.14)	14.37 (21.81)	26.56 (30.78)	-	1.430	2.880
SEm ±		1.24	1.70	1.69		0.142	
CD (P=0.05)		3.73	5.12	5.11		0.429	

At Raigarh there was no differences on the incidence of the disease due to treatments (Table 44).

Table 44. Integrated management of *Pythium*, *Fusarium* and *Ralstonia* of ginger - Raigarh

Treatment	Disease incidence after 100 days of transplanting* (%)	Disease incidence after 150 days of transplanting (%)	Yield (kg/plot)	Yield (kg/ha)
Mancozeb (0.3%)	71.3	77.3	0.273	548.73
<i>T. harzianum</i> 250 g formulation in 10 l of water for 10 kg of seed rhizome	70.0	82.0	0.080	163.43
Rhizome solarization (2 hr) before sowing	65.3	78.0	0.133	267.99
Ridomil Mancozeb (100 ppm of Metalaxyl)	73.3	81.3	0.266	536.99
Hot water treatment (51°C for 30 minutes)	70.0	78.0	0.173	348.39
Control	64.7	72.0	0.193	388.00

At Solan all the treatments increased sprouting and yield of ginger and decreased disease incidence (Table 45). Maximum sprouting (92.5%), reduction in incidence of *Pythium* (2.12%), *Fusarium* (2.37%), *Ralstonia* (3.18%) and increase in yield (13.188 kg/3m²) were obtained when rhizomes were hot water treated (45°C for 30 min.), followed by rhizome solarization at 45°C for 45 min. Mancozeb treated rhizomes however, decreased disease incidence of *Pythium* infection better than other treatments but failed to increase the yield of ginger (Table 45).

3.6.5 Survey and monitoring of diseases in ginger (Pundibari, Raigarh and Solan)

Surveys conducted in hills and plains of West Bengal indicated that in hills of West Bengal, rhizome rot complex started 2 months after sowing and caused maximum damage to the crop 3 months after sowing (i.e. in the rainy season). Whereas, in the plains, the disease started when the plants were 2½ month old and caused maximum damage at 3½ month age of the plant

Table 45. Integrated management of *Pythium*, *Fusarium* and *Ralstonia* on ginger - Solan

Treatment	Sprouting (%)	Disease incidence (%)			Yield (kg/3m ²)
		<i>Pythium</i>	<i>Fusarium</i>	<i>Ralstonia</i>	
Mancozeb (0.3%)	90.3 (9.50)	1.6 (1.27) ^a	5.2 (2.27)	8.3 (2.87)	11.18
<i>Trichoderma harzianum</i> (2.5 check)	91.3 (9.55)	4.4 (2.09)	3.1 (1.76) ^b	11.3 (3.36)	12.00 ^b
Rhizome solarization (45°C 45 min)	89.4 (9.45) ^b	3.4 (1.83)	3.1 (1.76) ^b	4.1 (2.03) ^b	12.06 ^b
Hot water treatment (45° C 30 min)	92.5 (9.62) ^a	2.1 (1.45) ^a	2.4 (1.56) ^a	3.2 (1.78) ^a	13.18 ^a
Copper oxychloride (0.3%)	87.3 (9.34)	3.3 (1.80)	5.3 (2.29)	7.4 (2.71)	8.18
Control	79.6 (8.92)	12.3 (3.51)	14.3 (3.77)	12.1 (3.48)	7.28
CD (P=0.05)	0.03	0.11	0.09	0.05	0.35

(as rainy season is very prolonged in the plains of terai region of West Bengal). *Phyllosticta* leaf spot disease started from 2 month age of the plant (June) and continued up to 4 month age of the plant in both hills (Kalimpong) and plains of West Bengal (Coochbehar district). The disease does not cause any serious loss of the crop. No disease occurred in storage even though no control measure were undertaken in storage. Only scale insect infested rhizomes during storage and it was estimated that 15 – 20% rhizomes in the storage are infected by this insect. Soil samples were collected from Kalimpong sub division of Darjeeling District and *Ralstonia* sp. and *Fusarium* sp were isolated. Soil samples (sick soil) were also collected from plain area of West Bengal (Pundibari, Coochbehar) and *Pythium* sp. and *Fusarium* sp were isolated.

Surveys carried out during 2004 in 28 locations in Raigarh District to record the incidence of diseases on ginger indicated that the incidence of rhizome rot disease was highest (52.5%) at Raigarh District and lowest at Dagaripada (7.5%).

Surveys conducted at Himachal Pradesh indicated that soft rot (*Pythium* spp.), yellows (*Fusarium oxysporum* f.sp. *zingiberi*), bacterial wilt (*Ralstonia solanacearum*), and bacterial soft rot (*Erwinia* sp) occurred at most of the areas in Killore in Sirmour District.

4. TURMERIC

4.1 Genetic Resources

4.1.1 Germplasm collection, characterization, evaluation and conservation

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

At Coimbatore, out of total 261 accessions, 255 accessions were evaluated which showed wide variation for yield, which ranged from 11.24 to 52.30 t/ha. The accession, CL 138 registered the highest yield of 52.30 t/ha, followed by CL 113 (50.48 t/ha). At Dholi, eighty five germplasm of turmeric were evaluated to identify promising lines in respect of yield and quality. Yield of germplasm varied from 6.0 kg (Rajapuri) to 43.50 kg (RH-2) in the area of 7.2 m². At present, 352 accessions are being maintained at Jagtial. During 2004-05, 79 germplasm were added from NBPGR, Hyderabad to the existing germplasm. At Kumarganj, among the medium maturing germplasm, NDH-18 expressed the highest fresh rhizome yield of 38.61 t./ha, followed by 36.53 t./ha NDH-14, whereas in early maturing germplasm, maximum yield was observed in NDH-79 (33.89 t./ha), followed by NDH-86 (33.05 t./ha). In late maturing germplasm, NDH-9 produced maximum fresh rhizome yield of 38.06 t./ha, followed by NDH-8 (33.06 t/ ha).

Among the germplasm, NDH-4 and NDH-95 were recorded as free from incidence of leaf spot disease. However, none of the germplasm was found free from leaf blotch disease of turmeric. At Pottangi, out of total 193 turmeric accessions, 173 were evaluated in two replications. Among 173 accessions evaluated during the year, 155 were *Curcuma longa*, 20 were *Curcuma aromatica* and 4 were *C. amada*. The range in fresh rhizome yield /3 m² in *C. longa* varied from 4.5 to 14.4 kg / 3 m² and forty accessions gave more than 10 kg / 3 m² in yield. In *C. aromatica*, the range in fresh rhizome yield varied from 5.62 to 10.4 kg / 3 m² and five accessions gave more than 7.5 kg/3m² yield. Out of four *C. amada* types, the range in yield was 6.2 to 11.5 kg/3 m². Pundibari centre is maintaining 140 accessions including 126 cultivated and 14 wild types. Rhizome yield of individual plant was maximum in TCP-107 (446.8 g), followed by TCP-66 (413.0 g), TCP-02 (396.0 g), TCP-104 (392.6 g) and TCP-84 (382.2 g), respectively. At Raigarh, out of 43 germplasm, the entries, IT- 1, 2, 3, 4, 5, 6, 7, 8 & 9 showed best performance with respect to yield (8.7, 8.6, 8.8, 8.5, 8.4, 8.6, 8.7, 7.5, 7.9 kg/3m² bed, respectively). Solan centre is maintaining 145 accessions of turmeric at present, which have to be transferred to

IISR/Pottangi, as per the recommendation of the XVII workshop of AICRPS held at Calicut during 2004.

4.2 Coordinated Varietal Trial (CVT)

4.2.1 CVT 2000 - Series V

(Jagtial, Pottangi, Pundibari and Raigarh)

Out of 24 entries tested at Jagtial centre, PTS-59 has recorded highest fresh rhizome yield (35.66 t/ha), followed by RH-5 (35.43 t/ha) in comparison to check, Duggirala red (31.76 t/ha). At Pottangi, pooled data (2000-01 to 2004-05) reveal that there was significant difference for fresh rhizome yield among the entries. Highest fresh rhizome yield was recorded by PTS-11 (25.88t/ha), followed by PTS-15 (24.53 t/ha) (Tables 46 and 47).

At Pundibari, lot of variability was found among the different growth characters except for leave number and pseudostem girth. TCP-1 recorded highest yield (12.477 kg) per 3m² plot, followed by RH-5 and TCP-2 (11.80 kg and 11.66, kg, respectively). At Raigarh, over the period of four years (2001-02 to 2004-05), TCP-2 (Suranjana), TCP-1, IT-1 and IT-2 were found significantly superior over the check for rhizome yield of 27.84, 27.54, 22.85 and 17.9 t/ha, respectively.

Table 46. Yield performance of turmeric entries under CVT – Pottangi

Entry	Fresh rhizome yield (kg/ 3 m ²)					Mean	Projected yield (t/ha)	Increase over control (%)
	2000-01	2001-02	2002-03	2003-04	2004-05			
RH-5	8.99	11.83	9.10	10.87	12.50	10.66	24.52	9.4
PTS-52	10.24	13.39	8.49	11.75	10.73	10.92	23.00	2.63
PTS-55	8.46	11.93	9.76	11.57	11.29	10.60	24.38	8.8
PTS-11	11.33	11.74	9.43	11.29	12.43	11.25	25.88	15.48
PTS-59	9.32	11.62	8.64	11.19	13.54	10.86	24.98	11.4
NDH-18	5.81	9.62	6.86	11.34	10.58	8.85	20.36	---
TCP-1	7.89	7.24	7.00	9.78	10.11	8.41	19.34	---
TCP-2	6.25	7.08	7.47	8.50	10.25	7.91	18.20	---
Acc-585	7.29	8.83	6.79	10.43	11.42	8.96	20.61	---
Acc-584	6.08	7.66	6.76	11.78	9.40	8.34	19.18	---
Tu. No.1	7.10	12.78	8.36	9.91	12.08	10.05	23.11	3.12
Surama	9.21	11.69	8.44	9.31	9.82	9.67	22.24	---
Roma	8.13	11.15	8.67	10.46	10.28	9.74	22.41	---
PTS-15	7.32	10.64	8.83	12.53	12.52	10.66	24.53	9.46
PCT-8	7.96	9.67	7.07	8.50	11.78	8.99	20.68	---
CD (P=0.05)	1.96	1.99	1.34	2.90	2.13	2.06	4.75	

Table 47. Quality attributes of turmeric under CVT – Pottangi

Entry	Dry recovery (%)	E. oil (%)	Curcumin (%)
RH-5	14.2	4.0	4.0
PTS-52	21.2	3.5	4.5
PTS-55	22.0	2.0	3.0
PTS-11	20.6	4.0	4.0
PTS-59	22.3	3.5	4.5
NDH-18	17.6	4.0	5.0
TCP-1	18.2	4.0	4.15
TCP-2	21.3	3.75	3.08
Acc-585	22.0	3.75	5.5
Acc-584	22.2	4.25	5.5
Tu. No.1	24.2	4.5	4.0
Surama	24.2	2.5	4.1
Roma	24.2	3.25	4.5
PTS-15	23.0	4.0	4.5
PCT-8	20.4	4.0	4.25

4.2.2 CVT 2004

(Coimbatore, Kumarganj and Raigarh)

At Coimbatore, Acc. 39 gave higher rhizome yield of 31.31 t/ha as against local-check, Roma (30.70 t/ha). At Kumarganj, among the entries, NDH-18 produced maximum fresh rhizome yield of 30.66 t/ha, followed by NDH-9 *i.e.*, 29.22 t/ha. Minimum incidence of leaf blotch disease was observed in NDH-18 and PTS-39. None of the entries was found free from leaf blotch and leaf spot diseases. At Raigarh, among the entries, IT-3 was found significantly superior than the check Prabha followed by IT-1 & IT-2.

4.3 Varietal Evaluation Trial

4.3.1 Comparative yield trial (CYT) (1999-2000)

(Jagtial, Pottangi, Pundibari, and Raigarh)

At Jagtial centre, in the long duration group, the entry, JTS 15 has recorded highest yield (27.20 t/ha), followed by JTS 11 (26.20 t/ha), JTS 14 (25.70 t/ha) against check-variety, Duggirala Red (21.0 t/ha). Among 14 medium duration entries tested, JTS 314 gave highest yield of 24.17 t/ha followed by JTS 319 (23.64 t/ha) in comparison to check-variety, CLI 317 (19.73 t/ha). Among 7 short duration entries tested, JTS 612 recorded highest yield of 28.0 t/ha followed by JTS 610 (26.5 t/ha) when compared to check variety, PCT-13 (25.10 t/ha). In long duration group, JTS 12, JTS 15 showed resis-

tant reaction to rhizome rot. In medium group, JTS 314, 320, 321, 325, 319 showed resistant reaction. In short duration, PCT 13, JTS 612, 607, showed resistant reaction. In CYT entries, JTS 408 recorded high fresh rhizome yield (38.43 t/ha), followed by JTS 407 (35.86 t/ha). The genotypes JTS 402 and JTS 401 recorded maximum yield of 33.43 t/ha and 31.56 t/ha, respectively in comparison to check-varieties of Duggirala Red (30.00 t/ha) and PCT 13 (27.43 t/ha). Among CYT entries, leaf spot disease severity was at resistant level in cultures JTS 401 and 402 and at moderate resistant level in rest of the cultures. Leaf blotch disease severity was at resistant level in JTS 406, 407, 408, 409, 410 and 411.

At Pottangi, the pooled data reveal that there was no significant difference for fresh rhizome yield among the entries. However, highest fresh rhizome yield was recorded by cultivar PTS-39 (24.21 t/ha), followed by PTS-34 (23.14 t/ha) and PTS-51 (23.0 t/ha). PTS-50 registered high curcumin content (6.0%).

At Pundibari, among 20 entries, TCP-119 (23.59 t/ha), TCP-104 (23.28 t/ha), TCP-107 (21.59 t/ha), TCP-56 (21.27 t/ha), TCP-82 (21.17 t/ha) and TCP-57 (21.17 t/ha) out yielded Suranjana (local-check) with more than 10%. At Raigarh centre, pooled data (1999-2000 to 2004-05) over six years reveal that IT-1&IT-2 were found significantly superior than both the checks Prabha and Pratibha (Table 48). Over all mean performance revealed that the entries, IT-1 & IT-2 performed well compare to other entries.

4.3.2 Initial Evaluation Trial (IET)

(Dholi and Pottangi)

At Dholi, genotype, RH-80 gave the maximum yield (64.12 t/ha), followed by RH-50 (63.66 t/ha), which is 18.89 percent and 18.04 percent, respectively, over check-variety, Rajendra Sonia. At Pottangi, overall performance (2000-01 to 2004-05) revealed that there was significant difference for fresh rhizome yield among the treatments. Highest fresh rhizome yield was recorded by cultivar PTS-39 (25.15 t/ha) followed by PTS-47 (24.75 t/ha) (Table 49). Roma registered high dry recovery (25.0%), while PTS-34 and Alleppey recorded with high curcumin (5.5%) (Table 50).

Table 48. Yield performance of turmeric entries under CYT– Raigarh

Entry	Yield (t/ha)						Mean (t/ha)
	2004-2005	2003-2004	2002-2003	2001-2002	2000-2001	1999-2000	
Prabha (check)	12.78	9.4	13.4	12.3	12.3	23.6	13.96
Pratibha (check)	14.33	10.18	11.6	20.1	11.3	22.1	14.93
ACC-584	10.11	7.70	8.6	6.5	10.6	22	10.91
ACC-585	14.79	11.38	6.7	6.1	11.2	20.6	11.79
ACC-126	7.83	2.61	10	12.1	12.7	20.4	10.94
IT-1	7.83	11.12	24.5	39.2	-	-	23.07
IT-2	17.48	12.46	16	36.8	-	-	20.66

Table 49. Yield performance of turmeric entries under IET– Pottangi

Entry	Fresh rhizome yield (kg/ 3 m ²)						Projected yield (t/ha)	Increase over control (%)
	2000-01	2001-02	2002-03	2003-04	2004-05	Mean		
PTS-39	9.43	12.8	9.71	11.66	11.07	10.93	25.15	13.64
Tu.No.6	6.46	9.95	7.39	10.44	10.07	8.86	20.38	---
PTS-51	7.21	11.29	6.61	11.71	10.04	9.38	21.57	---
PTS-29	6.59	9.60	7.73	10.31	8.48	8.54	19.65	---
PTS-50	8.21	8.27	7.62	10.39	8.7	8.64	19.87	---
Tu.No.3	10.61	8.51	11.05	11.76	9.44	10.28	23.64	6.8
Alleppey	6.11	9.95	7.08	8.78	9.38	8.26	18.99	---
PTS-13	7.21	11.58	8.50	10.27	7.13	8.94	20.56	---
PTS-47	6.13	12.89	10.12	12.75	11.93	10.76	24.75	11.83
PTS-27	5.84	7.59	5.57	10.83	10.49	8.07	18.56	---
PTS-4	7.32	10.93	7.77	10.15	9.2	9.07	20.87	---
PTS-16	6.75	8.24	7.37	7.18	8.96	7.7	17.71	---
PTS-34	9.93	11.50	8.25	9.46	9.98	9.82	22.59	2.04
Ranga	9.12	8.51	7.97	10.46	9.37	8.95	20.59	---
Roma	8.21	10.01	6.58	13.01	10.27	9.62	22.13	---
CD (P=0.05)	2.42	2.30	1.39	N.S	1.95	2.02	4.63	

Table 50. Quality attributes of IET entries of turmeric – Pottangi

Entry	Dry recovery (%)	E. oil (%)	Curcumin (%)
PTS-39	24.3	3.0	4.5
Tu.No.6	24.1	4.0	4.79
PTS-51	22.1	4.0	4.0
PTS-29	22.2	3.0	5.0
PTS-50	24.0	3.5	4.0
Tu.No.3	22.0	3.5	4.5
Alleppey	23.0	3.75	5.5
PTS-13	23.0	3.5	4.73
PTS-47	22.2	3.0	4.0
PTS-27	24.2	4.0	4.15
PTS-4	22.3	3.5	4.15
PTS-16	22.6	3.0	4.19
PTS-34	24.0	3.5	5.5
Ranga	23.4	4.0	4.3
Roma	25.0	3.0	5.2

4.4 Quality Evaluation Trial

4.4.1 Quality evaluation of germplasm

(Coimbatore)

At Coimbatore, CL 67 recorded with the highest curcumin content (6.05%), followed by CL 18 (6.0 %). Thirteen accessions recorded more than 5.0 per cent ranging from 5.01 – 5.50, and 117 accessions yielded more than 4.0 per cent curcumin ranging between 4.0 – 4.88.

4.4.2 Impact of environment on quality of turmeric

(Coimbatore and Pottangi)

At Coimbatore, cv. Suguna recorded the highest yield of 25.92 t/ha. At Pottangi, overall performance (1998-99 to 2004-05) showed that there was no significant difference for fresh rhizome yield among the entries. Highest dry turmeric yield was recorded by Roma (5.5 t/ha) with E. oil 4.0%, oleoresin 9.95% & curcumin 5.0% (Tables 51 and 52).

Table 51. Impact of environment on yield performance of turmeric entries – Pottangi

Entry	Fresh rhizome yield (kg/ 3 m ²)								Projected yield (t/ha)	Dry recovery (%)	Dry yield (t/ha)
	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	Mean			
Roma	8.76	5.5	9.5	11.29	8.15	9.85	11.33	9.2	21.16	26	5.5
R. Sonia	12.66	5.37	7.8	11.39	7.22	9.56	11.72	9.39	21.60	14	2.94
Alleppey	10.77	5.67	8.21	11.05	7.63	7.45	10.62	8.78	20.19	20	4.03
JTS-2	13.28	6.95	6.71	10.29	10.28	8.08	11.05	9.52	21.90	14	3.07
Acc-360	8.12	3.8	7.42	10.13	7.77	9.56	10.62	8.2	18.86	21	3.96
BSR-2	9.3	4.79	6.84	10.71	7.52	11.96	11.54	8.95	20.59	19	3.91
CD (P=0.05)	NS	2.38	NS	NS	0.89	NS	NS	1.64	3.76		

Table 52. Impact of environment on quality attributes of turmeric – Pottangi

Entry	Dry recovery (%)	E. oil (%)	Curcumin (%)
Roma	26.0	4.0	5.0
R. Sonia	14.0	3.5	4.58
Alleppey	20.0	3.0	4.75
JTS-2	14.0	4.0	3.06
Acc-360	21.0	3.0	3.9
BSR-2	19.0	4.0	3.16

4.5 Nutrient Management Trial

4.5.1 Effect of biofertilizer, *Azospirillum* on turmeric

(Coimbatore, Pottangi, Raigarh, Kumarganj, Solan, Pundibari and Ambalavayal)

Application of 100% N as inorganic and 5 kg FYM/plot and *Azospirillum* enhanced the turmeric yield in all the centres except Coimbatore. At Coimbatore, 50% N as inorganic, 5 kg *Azospirillum* and 5+FYM/ha recorded maximum yield (Table 53).

Table 53. Effect of *Azospirillum* application on turmeric yield

Centre	Yield with <i>Azospirillum</i> (best treatment) (t/ha)	Yield in recommended dose alone (control) (t/ha)	Yield increase over control (t/ha)
Kumarganj	36.33	30.7	5.63
Raigarh	28.93	28.22	0.71
Pottangi	18.95	16.86	2.09
Pundibari	23.83	21.75	2.08
Coimbatore	40.5	20.9	19.60
Mean	29.71	23.69	6.02

4.5.2 Organic farming in turmeric

(Raigarh, Pottangi, Pundibari and Bhavanisagar)

In all the centres application of recommended dose recorded higher turmeric yield compared organic manuring (Table 54).

Table 54. Effect of organic nutrition on turmeric yield

Centre	Yield at recommended dose (best treatment) (t/ha)	Yield at organic manuring (control)	Yield increase over control (t/ha)
Raigarh	26.02	19.76	6.26
Pottangi	18.29	15.66	2.63
Pundibari	25.03	20.10	4.93
Mean	23.11	18.51	4.60

4.6 Disease Management trial

4.6.1 Survey and identification of disease causing organisms in turmeric and screening of turmeric germplasm against diseases

(Coimbatore, Jagtial and Pundibari)

At Coimbatore all the 255 germplasm accessions were screened for their resistance against leaf spot and leaf blotch diseases. Among these, six accessions viz., CL 31, CL 32, CL 33, CL 34, CL 54 and CL 55 were resistant to leaf blotch and leaf spot diseases.

Among the 24 entries screened in the CVT at Jagtial, no incidence of rhizome rot disease was observed in RH-5 and Duggirala Red. The entries, IT-4, and 5 recorded highest rhizome rot incidence. The elite lines viz., IT-1, 2, 3, and 5 recorded highest disease incidence of leaf spot and the lines TCP-1, 2, NDH-18 and TCP-11 recorded no incidence of leaf spot. Among the 24 entries viz., ACC-584, PTS-59, 11, 55, 52, ACC-593, 595, 657, TCP-11, RH 13/90, 9/90, IT-1, 2, 3, 4, 5 and Duggirala Red recorded no incidence of *Taphrina* leaf blotch disease. All the CYT cultures were moderately resistant to rhizome rot disease. Leaf spot disease was resistant in entries, JTS 401 and 402. JTS 406, 407, 408, 409, 410 and 411 were resistant to leaf blotch disease.

A survey was conducted in two blocks of Coochbehar District (Coochbehar I and Coochbehar II block) to identify the diseases occurring in this region and to assess the severity of diseases of turmeric in this region. Three major diseases were found to be prevalent in this area namely, leaf blotch (*Taphrina spp.*), leaf spot (*Colletotrichum spp.*) and rhizome rot. Leaf spot dis-

ease caused by *Helminthosporium* sp was also observed during the survey. Leaf blotch disease severity was higher in Coochbehar I block (average 27.8%), than Coochbehar II block (23.8%). Leaf spot disease was higher in Coochbehar II Block (average 17.2%) than in Coochbehar I block (average 10.4%). Screening of the collected germplasm was done against both leaf blotch and leaf spot diseases. The germplasm found to be tolerant against leaf blotch disease are TCP 4, 9, 32, 37, 77, 90, 92, 94, 100, 109, 132, 137, TCP A, J 6 and KAST COL and the germplasm found to be tolerant against leaf spot disease are 31 – 1, 53, 92, 101, 152 and 173.

4.6.2 Investigation on the causal organism of rhizome rot of turmeric and screening of biocontrol agents for its management

(Coimbatore, Jagtial, Kumarganj and Pundibari)

Various biocontrol agents were evaluated for the management of rhizome rot of turmeric. At Coimbatore the results revealed that the biocontrol agents applied plots recorded significant reduction in disease incidence when compared to control. Among the different delivery system of biocontrol agents, seed and soil application of *T. viride* and *P. fluorescens* recorded the minimum disease incidence (2.4%). The highest yield (54.55 t/ha) was recorded in seed and soil application of *T. viride* and *P. fluorescens* that was on par with *B. subtilis* sprayed plot (53.41 t/ha) (Table 55).

The organisms isolated from diseased rhizomes of turmeric from Jagtial were sent to IISR, Calicut to confirm the pathogens. The pathogens recorded earlier from rhizome rot disease affected rhizomes include *Pythium* sp., *Fusarium* spp., *F. solani* and *Rhizoctonia* spp. At Jagtial maximum reduction in disease incidence

Table 55. Management of rhizome rot of turmeric with biocontrol agents - Coimbatore

Treatment	Disease incidence (%)	Yield (t/ha)	C:B ratio
T ₁ - Recommended NPK (Control)	64.0 ^e (53.14)	14.75a	1:1.18
T ₂ - Recommended NPK (Control)+FYM (12.5 ton/ha)	19.0 ^d (25.83)	23.46bc	1:1.87
T ₃ - Recommended NPK + <i>Trichoderma viride</i> + <i>Pseudomonas fluorescens</i> seed treatment (4g/kg of seed)	10.1 ^c (18.42)	31.86de	1:2.54
T ₄ - Recommended NPK + <i>T. viride</i> + <i>P. fluorescens</i> Soil application	10.7 ^c (18.97)	34.00e	1:2.78
T ₅ - T ₂ + T ₃	9.3 ^c (17.78)	20.56b	1:1.60
T ₆ - T ₃ +T ₄	6.0 ^b (14.14)	27.03cd	1:2.16
T ₇ - T ₂ +T ₃ +T ₄	2.4 ^a (8.8)	54.55f	1:4.44
T ₈ - T ₂ + <i>Bacillus subtilis</i> (1 ml/lit water- 500 lit/ha)	6.0 ^b (14.14)	53.41f	1:4.18

* Figures in parameters are transformed values

over control was observed in the treatment recommended NPK + farmyard manure and seed treatment with carbendazim (Table 56).

Table 56. Management of rhizome rot disease of turmeric with biocontrol agents - Jagtial

Treatment	PDI		% reduction over control	Yield (kg/plot)
T ₁ -Recommended NPK (Control)	19.88	37.02		2.770
T ₂ -Recommended NPK+FYM	20.67	21.20	42.7	7.570
T ₃ -Recommended NPK + FYM + <i>Trichoderma viridae</i> + <i>Pseudomonas flourescens</i> as seed treatment.	10.68	36.94	0.2	3.270
T ₄ -Recommended NPK + FYM + <i>T. viridae</i> + <i>P. flourescens</i> (12.5 kg ha ⁻¹ and 25.0 kg ha ⁻¹ as basal and top dressing respectively)	10.69	27.88	24.7	3.670
T ₅ -T ₂ +T ₃	14.04	21.34	42.4	6.700
T ₆ -T ₂ +T ₄	10.69	22.34	39.7	5.230
T ₇ -T ₂ +T ₃ +T ₄	16.95	19.80	46.5	5.930
T ₈ -T ₂ +Seed treatment with mancozeb 0.2%	11.88	21.72	43.0	7.530
T ₉ -T ₂ +Seed treatment with carbendazim 0.2%	14.56	16.31	55.9	7.170
T ₁₀ -T ₂ +Seed treatment with mancozeb + carbendazim 0.2%	17.56	18.14	51.0	7.500
CD (P=0.05)	7.85	9.33		

* PDI - Percent Disease Index

At Kumarganj soft rot disease was not observed in the field or in storage. Surveys were carried out to record the incidence of diseases of ginger in the field and storage and 31 samples were collected from Faizabad, Gonda and Lucknow Districts. All the samples were infected with rhizome rot. Samples collected from

storage godowns of traders from Baruasagar, Nepal, Maharashtra and Gauhati were also infected with rhizome rot. In storage godowns, ginger was stored in wet gunny bags in closely stacked unventilated room. These gunny bags were frequently moistened with water to maintain the fresh weight of ginger rhizome (Table 57).

Table 57. Effect of biocontrol agents on management of rhizome rot disease of turmeric - Kumarganj

Treatment	Germination (%)	Incidence		Rhizome rot (%)	Yield (t/ha)	Increase in yield over control (%)
		Leaf blotch (%)	Leaf spot (%)			
T ₁ = Recommended dose of NPK (Control)	91.3	6.3	7.6	0.0	22.220	-
T ₂ = T ₁ = Recommended dose of NPK + FYM	92.7	4.1	4.4	0.0	25.070	12.8
T ₃ = Recommended dose of NPK + <i>Trichoderma viridae</i> + <i>Pseudomonas florescence</i> (4 g/ kg as seed treatment)	94.7	3.8	4.7	0.0	26.660	20.0
T ₄ = Recommended dose of NPK + <i>T. viridae</i> + <i>P. florescence</i> (12.5 and 25 kg/ ha as basal and top dressing)	95.3	4.4	6.1	0.0	29.440	32.5
T ₅ = T ₂ + T ₃	96.0	3.2	3.2	0.0	31.660	42.5
T ₆ = T ₂ + T ₄	96.7	3.9	3.6	0.0	32.660	47.0
T ₇ = T ₂ + T ₃ + T ₄	97.3	3.4	3.7	0.0	42.660	92.0
T ₈ = T ₂ + <i>Bacillus subtilis</i> (1ml/l of water)	96.0	3.8	3.9	0.0	36.000	62.0
CD (P=0.05)	3.5	0.9	1.4	-	7.060	-
CV (%)	2.3	13.9	18.4	-	14.380	-

At Pundibari the causal organism of rhizome rot of turmeric was identified as *Fusarium* sp. A field trial on an evaluation of biocontrol agents for the management of rhizome rot disease was also undertaken. The inci-

dence of the disease was low in general. However, the best treatment was seed treatment + soil application of *Trichoderma viride* and *Pseudomonas fluorescens* + application of recommended NPK and FYM (Table 58).

Table 58. Evaluation of bio control agents on rhizome rot of turmeric - Pundibari

Treatment	Germination (%)	PDI at 90 days	PDI at 120 days	PDI at 150 days	% reduction over control	Yield (kg/plot)	Projected yield (t/ ha)
T ₁ = Recommended NPK (control)	93.3	10.37 (18.74)	18.63 (25.53)	21.86 (27.84)	-	6.670	13.450
T ₂ = Recommended NPK + farm yard manure	99.3	7.46 (15.82)	11.30 (19.56)	10.04 (18.42)	33.8	7.170	14.450
T ₃ = Recommended NPK + <i>Trichoderma viride</i> + <i>Pseudomonas fluorescens</i> as seed treatment	96.3	4.57 (12.10)	12.12 (20.30)	9.22 (17.62)	36.7	6.170	12.440
T ₄ = Recommended NPK + <i>Trichoderma viride</i> + <i>Pseudomonas fluorescens</i> (12.5 kg /ha and 25.0 kg /ha as basal and top dressing respectively)	94.8	4.66 (12.22)	6.60 (14.81)	6.14 (14.28)	48.7	7.670	15.460
T ₅ = T ₂ + T ₃	96.3	5.44 (13.39)	8.99 (17.40)	9.05 (17.42)	37.4	7.500	15.120
T ₆ = T ₂ + T ₄	95.6	4.65 (12.18)	5.69 (13.74)	6.84 (14.99)	46.2	5.830	11.750
T ₇ = T ₂ + T ₃ + T ₄	94.1	3.20 (10.12)	4.87 (12.48)	5.98 (14.10)	49.4	7.000	14.110
SEm $\pm$		1.430	1.398	1.224		0.705	
CD (P=0.05)		4.406	4.307	3.773		2.173	

(Figures in parentheses are angular transformed value)

5. TREE SPICES

5.1 Genetic Resources

5.1.1 Germplasm collection, characterization, evaluation and conservation of clove, nutmeg and cinnamon

(Dapoli and Yercaud/Pechiparai)

Dapoli:

Nutmeg : At present, 95 accessions are being maintained at this centre. Morphological characters did not differ significantly among different genotypes. The A-9/4 and A-9/79 produced large sized fruits in the current year.

Cinnamon : At this station, 11 accessions of cinnamon are maintained in the field gene bank. The vegetative growth characters did not differ significantly among genotypes under study. The spread showed significant differences among genotypes under study. The chemi-

cal analysis of cinnamon bark oil and leaf oil showed significant differences among genotypes. Significantly maximum bark oil (3.19%) was recorded in A-65, which was significantly superior to all other genotypes. The minimum bark oil was recorded in A-310 (1.22%). The significantly maximum leaf oil (3.05%) was recorded in A-203, which was at par with A-53 (2.73%).

Clove : IISR Calicut seedling type of clove recorded vigorous growth, maximum height (4.24 m), maximum girth (19.42 cm), maximum number of branches (39.35) and height spread (2.87 cm).

Pechiparai/ Yercaud :

Clove : This trial was initiated during 1992. In clove, 22 accessions are being maintained and among which, Sel.7 registered the highest dry flower and yield (102.20 g/tree).

Nutmeg : This trial was initiated during 1992. In nutmeg, 20 accessions are being maintained, among

which Sel.2 recorded the highest plant height of 6.04 m., stem girth of 28.30 cm. with the yield of 60.03 fruits/tree.

Cinnamon : This trial was initiated during 1992. In cinnamon, 12 accessions are being maintained, among which Sel.65 performed well both for growth and yield parameters.

5.2 Coordinated Varietal Trial (CVT)

5.2.1 CVT 1992 in clove

(Pechiparai/ Yercaud)

Nine genotypes collected from IISR, Calicut is being maintained at this station and growth parameters were studied. The suitability of elite lines of CVT is being evaluated under this climatic zone for its yield and yield attributes. Among the ten selections, Sel.7 was found to be promising with highest yield (102.20 g/tree).

5.2.2 CVT 1992 in cinnamon

(Ambalavayal)

Pooled analysis of wet and dry weight of quills / tree was carried out. SL-203 recorded the highest wet (0.617 Kg) and dry (0.258 Kg) weight of quills/tree. SL-44 recorded maximum leaf oil (4.0%), followed by SL-203 (3.2%). SL-53 recorded maximum bark oil (2.0%), followed by Acc. No.1 and 2 (1.5%).

5.2.3 CVT 2001 in nutmeg

(Dapoli and Pechiparai)

At Dapoli, the average spread differed significantly among the genotypes under study. The average spread (m) recorded by different genotypes ranged from 0.24 to 0.66 m. The genotypes 'A-9/150' and 'Male' recorded significantly maximum spread (0.66 m and 0.63 m respectively). At Pechiparai, among the six accessions, A9/20 has recorded the highest plant height (61.11 cm.), stem girth (7.98 cm.) and number of branches (7.16 nos.).

5.2.4 CVT 2001 Series in Cassia

(Ambalavayal, Dapoli and Yercaud/Pechiparai)

The experiment was started in June 2003 at Ambalavayal. The stand of the crop is satisfactory. At Dapoli, in general, genotypes C, D, D and D are vigorous in growth over KKV C¹SH¹ and KKV C¹SH² genotypes. At Pechiparai, among the four selections,² C1 was found to be promising with highest plant height (73.40 cm.) stem girth (6.32 cm.) and number of branches (4.48 nos.).

5.3 Propagation/Multiplication Trial

5.3.1 Vegetative propagation in nutmeg, clove and cinnamon

(Dapoli)

Clove : Softwood grafting was performed during 2004-05 on different root stocks in order to find out best suitable rootstock and also optimum season for grafting.

5.4 Disease Management Trial

5.4.1 Survey for disease incidence in tree spices

(Ambalavayal, Dapoli, and Yercaud/Pechiparai)

Surveys were conducted at Dapoli to record the incidence of various diseases on cinnamon and clove. On cinnamon shot hole disease (*Colletotrichum gloeosporioides*) was prevalent in all orchards and the disease incidence ranged between 0.1 and 1.6%. Sudden death of branch/twig/wither tip disease (*Fusarium solani* + *Rhizoctonia bataticola*) was observed in all orchards visited and the intensity of the disease ranged between 0.1 and 22.6%. Maximum incidence (22.6%) of disease was observed at Bhatye location. Low incidence of leaf blight and leaf spot was observed. Leaf blight incidence ranged between 0.4 and 1.9%. The incidence of leaf spot ranged between 0.2 and 0.9%.

In clove, leaf rot, leaf spot and die back of branches were the most common and serious diseases observed throughout the region. Maximum incidence of leaf rot was recorded (39.6%) at Dapoli. The disease intensity ranged between 8.6 and 39.6%. The leaf spot disease intensity ranged between 0.9 and 3.8%. The incidence of leaf rot of clove ranged between 9.1 and 40.6%. *Trichoderma harzianum* (8 g/l) gave maximum (55.8%) control of leaf rot in clove.

Surveys conducted in Kanyakumari District by Pechiparai centre indicated that leaf spot of clove was high in Keeriparai area (9.7%), when compared to Pechiparai area (1.2%). Seedling wilt caused by *Rhizoctonia* sp. was maximum at Thadikarankonam (13.0%), followed by Keeriparai (7.0%). Among the 7 clove types collected from different estates of Kanyakumari District, type 5 and type 6 recorded less incidence of 3.2% and 4.5% respectively, whereas, 8.0% was recorded in type 3. In nutmeg, fruit rot incidence was noticed at Pechiparai (3.0%) and Raja estate (4.2%).

6. CORIANDER

6.1 Genetic Resources

6.1.1 Germplasm collection, description, characterization, evaluation, conservation and screening against diseases

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

This project was started as early as 1975 at Coimbatore centre. Three accessions were added to the germplasm pool, thus raising the total to 230 and evaluated. The accessions, CS 18 and CS 33 have recorded the highest yield of 850 kg/ha, followed by CS 86, CS 110 and CS 131 which recorded an average yield of (820 kg/ha). In screening test against coriander powdery mildew disease using 0 – 5 scale, Acc. 225 was found to be resistant. Dholi centre is maintaining at present 85 accessions in the germplasm pool. The seed yield of the germplasm varied from 2.5 g (UD-37) to

resistant or tolerant to the disease. The minimum incidence was noticed in NDCor-51 (62.50%), followed by NDCor-57 (63.75 %), LCC-226 (63.75 %). At Jobner, UD-480 was found free from wilt, powdery mildew & stemgall diseases with the maximum yield (1167.33 kg/ha), followed by UD-118 where wilt is 1%, powdery mildew score is 1 and stem gall disease is 0 with seed yield of 980.90 kg/ha. Under screening against wilt and powdery mildew diseases, UD-728, UD-797 and UD-796 were found free from wilt, powdery mildew and stemgall.

Under screening against stemgall disease, only RCr-435, RCr-436 and UD-480 were found Immune. UD-118, UD-446, UD-684, UD-685 and UD-686 were found resistant and local-check was found highly susceptible. Under screening against root-knot nematode, RCr-20, UD-262, RCr-446 and UD-480 were found resistant and the rest were found moderately resistant to highly susceptible.

At Kumarganj, ND Cor-67 produced maximum seed yield of 1.94 t/ha, followed by ND Cor-2 (1.87t/ha. None

Category	Nature of disease reaction	Entry
Immune (I)	0	UD-435, UD-436 and UD-480
Resistant (R)	1	UD-118, RCr-446, RCr-684, RCr-685 and RCr-686

12.8 g per plant (UD-241). Guntur centre is conserving 249 accessions in the gene bank. Among the entries, LCC-236 recorded highest yield (1201 kg/ha), followed

of the germplasm was found free from either stem gall or powdery mildew disease in coriander except for K-selection and Pant-Haritima for stem gall disease.

Category	% galling	Entry
Immune (I)	No galls	Nil
Resistant (R)	1-10 galls	RCr-20, UD-262, UD-446 and UD-480

by LCC-177 (1196 kg/ha), LCC-181 (1150 kg/ha), LCC-179 (1089 kg/ha) and LCC-128 (1084 kg/ha) and the check, Sadhana has recorded an yield of 862 kg/ha. At present, 190 accessions are being maintained in Hisar centre. The most promising lines identified for seed yield were : DH-207, DH-211, DH-220, DH-221, DH-233, DH-239, DH-294, DH-312 and DH-317.

At Jagudan, a total 110 (108 + 2) entries received from Jobner, Kumarganj, Hisar, Guntur as well the entries of Jagudan centre were screened against powdery mildew disease under natural condition. The incidence of powdery mildew was reported very high and it ranged from 62.50 to 96.25 %. None of the entry was found

6.2 Inter-varietal hybridization for evolving high yielding varieties

(Jobner)

The programme was initiated and the crossing technique is standardized.

6.2.1 CVT 1996 – Series III

(Dholi)

The experiment was conducted from 1997 to 2000 in RBD at Dholi. Pooled data showed that except number of branches per plant all the genotype had significant differences for all characters. Genotype, UD-446 gave highest yield (1.83 t/ha), followed by UD-447 with

1.83 t/ha and 1.42 t/ha, respectively. The genotype UD-446 is most economic, followed by UD-447 with CBR of 1:2.29 and 1:1.78, respectively.

6.2.2 CVT 2001 Series V

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

At Coimbatore, twenty four accessions using CO-3 as check were evaluated for their growth and yield characters. The data on yield revealed that UD 743 recorded the highest yield of 766.6 kg/ha, followed by DH 208 and J Cor 283 with an yield of 736.6 kg/ha and 730.0 kg/ha, respectively. All the lines including local-check, CO 3 were screened for their resistance against powdery mildew disease incidence using 0 – 5 scale. The three accessions viz., J Cor 387, DH 246 and RD 120 were found to be resistant.

At Dholi, for last three consecutive years (2002-03 to 2004-05), there was significant differences among the genotypes for various characters. All the genotypes were not significantly superior over check-variety, Pant Haritima for yield. However, maximum grain yield (1.69 t/ha) was recorded with genotype RD-120, with 9.03 percent increase over check-variety, Pant Haritima. At Guntur, the pooled data over three years (2002-03 to

2004-05) indicated that there are significant differences for all the characters. Overall, LCC-174 recorded significantly maximum yield (845.1 kg/ha), followed by LCC-225 (812.7 kg/ha) which are on par with each other and significantly superior to all other entries.

At Hisar, significant differences were obtained for all the characters except seeds per umbellet. Maximum seed yield (1779 kg/ha) was recorded in DH-234, followed by DH-205 (1611 kg/ha) and K. Selection (1596 kg/ha). At Jagudan, the pooled over three years data (2002-03 to 2004-05) showed significant yield differences due to entries. But none of the entry gave significantly superior yield than check. However, an entry JCr-328 gave higher yield (1747 kg/ha) than check and it was 6.46 per cent increase over check (Table 59).

At Jobner, mean performance of the entries evaluated in CVT over 2002-2003 and 2003-2004 revealed superior performance of UD-480 yielding 1065.35 kg/ha, followed by UD-118 (934.95 kg/ha), RCr-435 check (875.69 kg/ha), DH-234 (874.02 kg/ha) and RCr-684 (854.33 kg/ha). At Kumarganj, maximum grain yield of 1.87 t/ha was obtained with ND Cor-30 over national check, Hisar anand (1.51 t/ha), followed by 1.76 t/ha seed yield in ND Cor -2. At Raigarh, ICS-2 was found significantly superior than rest of entries.

Table 59. Yield performance of coriander entries under CVT – Jagudan

Entry	Yield (kg/ha)			Mean	% IOC (GCo-2)
	2002-03	2003-04	2004-05		
JCr-328	1573	1939	1729	1747	6.46
JCr-360	1591	1835	1526	1650	0.55
LCC-174	950	1250	1362	1187	-
LCC-225	1005	1090	1400	1165	-
UD-118	1223	1545	1214	1327	-
UD-480	982	1337	1232	1184	-
NDCo-2	1127	1219	1274	1207	-
K. Selection	1181	1403	1185	1256	-
DH-205	1256	1542	1480	1426	-
DH-234	1401	1550	1496	1482	-
GCo-2 ©	1558	1835	1533	1642	-
GCo-1 ©	1442	1748	-	1595	-
Hisar Anand (Natl. check)	-	-	1228	1228*	-
S.Em. ±	87	103	69	73	
CD (P=0.05)	251	298	200	214	
CV (%)	13.68	13.58	10.10	12.58	

IOC - Increase over control

6.2.3 CVT 2004 Production of leafy type coriander during off-season

(Guntur)

The crop was sown on March 205 in RBD with seven entries at Guntur. Due to severe summer, despite repeated irrigations the entries failed to germinate. Hence, the experiment was planned to sow again during July 2005.

6.2.4 Initial evaluation trial

(Dholi, Guntur, Hisar, Jagudan and Jobner)

At Dholi, the genotypes, RD-366 RD-373, RD-154 and RD-121 were found significantly superior yield over-check variety, Rajendra Swati. However, genotype RD-366 gave the maximum yield (1.75 t/ha) with 78.57 percent higher yield over-check variety, Rajendra Swati. At Guntur, the pooled analysis of the three years (2002-2003, 2003-2004 and 2004-2005) data indicated that the genotypes under evaluation varied significantly for all the characters under study. LCC-216 recorded maximum yield (863.2 kg/ha), followed by LCC-212 (836.1 kg/ha) which are on par with each other and significantly superior to check Sadhana (624.8 kg/ha).

At Hisar over three years (2001-02 to 2003-04), DH-206 and DH-242 gave significantly better yield over Hisar Anand (check) showing 27.0 and 30.8% increase in yield, respectively (Table 60).

At Jagudan, data showed significant yield differences among entries however, an entry JCr-340 recorded maximum yield (1856 kg/ha). At Jobner, pooled mean (over three years viz. 2001-02, 2002-03 and 2003-04) indicated that the entries differed significantly for all the characters studied. Volatile oil yield varied from 1.55 l/ha (UD-119) to 4.03 l/ha (UD-797). Mean yield performance revealed superior performance of UD-728 yielding 1080.26 kg/ha, followed by UD-797 (1060.99 kg/ha), RCr-435 check (928.29 kg/ha) and UD-796 (845.61 kg/ha). Overall the entries UD-728, UD-797 and UD-796 were found superior in seed yield as well as volatile oil yield than all the checks, therefore these may be promoted to the next CVT.

6.3 Quality Evaluation Trial

6.3.1 Quality evaluation in coriander

(Jobner)

At Jobner, eighteen entries of coriander under CVT were analysed for volatile oil content during Rabi 2003-04, using Clevenger apparatus. The mean performance of two-year data indicated that the mean volatile oil content ranged from 0.35% to 0.51%. The promising entries for volatile oil content performed better than the best check, RCr-435 (0.47%) are, DH-234 (0.51%), UD-118 (0.50%), DH-205 (0.48%), ND-2 (0.48%) and LCC-174 (0.48%) (Table 61).

Table 60. Performance of coriander accessions under IET – Hisar

Accession Number	Seed yield (kg/ha)				% increase over check
	2001-2002	2002-2003	2003-2004	Mean	
DH-206	2005	2070	2018	2031	27.0
DH-210	1660	1795	1675	1710	06.9
DH-221	1695	1860	1807	1787	11.8
DH-227	1730	1930	1813	1824	14.1
DH-235	1700	1940	1740	1793	12.1
DH-242	2050	2170	2053	2091	30.8
DH-247	1640	1680	1590	1637	02.4
DH-251	1560	1780	1627	1656	03.6
DH-270	1585	1735	1646	1655	03.5
Hisar Anand (check)	1520	1685	1593	1599	-
CD (P=0.05)	146	155	219	-	

Table 61. Comparison of volatile oil content of coriander entries under CVT grown at Jagudan and Jobner centres

Entry	Volatile oil content (%)	
	Jagudan	Jobner
UD-118	0.40	0.46
UD-480	0.38	0.40
DH-205	0.40	0.46
DH-234	0.35	0.46
J.Cori-328	0.38	0.46
J.Cori-360	0.33	0.46
K.Sel.	0.40	0.40
N.D.2	0.38	0.40
LCC-174	0.33	0.46
LCC-225	0.30	0.40

Twelve entries of coriander from Jagudan (Gujarat) centre for volatile oil content ranged from 0.300 to 0.400%. Some common entries which were also grown at Jobner were compared for volatile oil content against Jagudan centre. There was not much variation found in volatile oil content in the entries grown at Jobner and Jagudan. However, most of the entries grown at Jobner were showing little more volatile oil as compared to those grown at Jagudan. Twenty entries of coriander under IET were analysed for volatile oil content which indicated that the mean volatile oil content ranged from 0.25% to 0.40%. The highest volatile oil content of 0.40% was found in UD-796, UD-92 and UD-42 and the mean volatile oil yield again indicated the superiority of the entries, UD-797 (4.03 l/ha), UD-796 (3.78 l/ha) and UD-42 (3.16 l/ha) over best-check, RCr-435.

6.4 Nutrient Management Trial

6.4.1 Response of coriander to micronutrients

(Guntur)

In coriander crop production, in the first year of experiment, micronutrient spray (viz., Zn So₄, Fe So₄, Cu So₄, Mn So₄ alone at 0.25% and 0.50% and all combined at 0.25% and 0.50%) were tested at Guntur centre. Combined spray of all the micronutrients at 0.5% was found promising.

6.4.2 Effect of biofertilizer, *Azospirillum* on coriander

(Coimbatore, Jobner, Kumarganj)

In another experiment conducted at Coimbatore, Jobner and Kumarganj Effect of biofertilizer was tested in combination with other nutrient sources. It was found that *Azospirillum* application reduced the application of inorganic fertilizer at Coimbatore whereas, it was not so at Jobner and Kumarganj centres (Table 62).

6.4.3 Effect of bio-regulators on coriander

(Dholi and Kumarganj)

Experiment on growth regulators spray at different stage of coriander on yield was studied at Dholi, Kumarganj and Guntur centre. Triacantanol @ 0.5% spray at 40, 60 and 80 DAS produced higher yield (1.46 t/ha) at Dholi. At Kumarganj, spray of NAA 50 ppm at 40, 60 and 80 DAS gave maximum yield (1.55 t/ha). In Guntur centre, it was NAA 10 ppm spray at 40 and 60 DAS recorded more yield (1.06 t/ha).

6.4.4 Identification of drought tolerant source in coriander

(Guntur and Kumarganj)

At Guntur centre 124 coriander germplasm was evaluated for drought tolerance and some of the promising lines are listed in Table 63.

Table 62. *Azospirillum* application on yield of coriander

Treatment	Yield at Centres (kg/ha)			Mean
	Coimbatore	Kumarganj	Jobner	
Best treatment :				
Inorganic N (50%) + <i>Azospirillum</i> (1.5 kg/ha) Seed treatment + 5 t FYM	738	2440	3457	2211
Control	651	1950	2036	868
Yield increase over control	86	490	1421	

6.5 Disease Management Trial

6.5.1 Management of wilt and powdery mildew diseases in coriander

(Jobner)

Various biocontrol agents and fungicides were evaluated for the management of wilt and powdery mildew

diseases in coriander. At Jobner the trial on bio-control of coriander wilt was started in *Rabi* 2001-02 and conducted for four years (2000-03). Minimum wilt incidence (5.6%) with maximum seed yield (818 kg/ha) was recorded in the treatment where *Trichoderma harzianum* was applied through seed treatment as well as soil application (Table 64).

Table 63. Screening of coriander germplasm for drought

Drought tolerant parameter	Range	Germplasm lines	
		Low	High
Biomass (g/5 plants)	98.0-12.5	LCC-154 (12.5), LCC-167 (12.8)	LCC-183 (98.0), LCC-242 (74.5)
Root length	20.4-3.8	LCC-156 (3.8), LCC-162 (6.8)	LCC-157 (20.4), LCC-243 (15.1)
Shoot length	83.0-44.8	LCC-158 (48.0), LCC-121 (48.4)	LCC-244 (83.0), LCC-243 (79.2)
Root-Shoot Ratio	1.88-0.08	LCC-156 (0.08), LCC-162 (.12)	LCC-184 (1.88), LCC-191 (1.55)
RWC at 45 days	56.74-85.99	LCC-147 (56.74), LCC-155 (61.54)	LCC-153 (85.99), LCC-156 (85.71)
RWC at 75 days	45.86-79.50	LCC-167 (45.86), LCC-130 (48.48)	LCC-157 (79.5), LCC-143 (78.03)
Chlorophyll stability index	0.18-0.88	LCC-158 (0.18), LCC-167 (0.30)	LCC-133 (0.88), LCC-161 (0.78)
Proline micromoles for gram of fresh leaf at 45 DAS	58-182	LCC-147 (58), LCC-163 (62)	LCC-165 (182), LCC-164 (176)
Proline micromoles for gram of fresh leaf at 75 DAS	75-240	LCC-133 (75), LCC-166 (76)	LCC-136 (240), LCC-158 (237)

Table 64. Management of wilt in coriander with biocontrol agents – Jobner

Treatment	Wilt (%)					Seed yield (kg/ha)				
	2000	2001	2002	2003	Mean	2000	2001	2002	2003	Mean
Carbendazim	16.3	6.8	7.0	11.3	7.5	625	626	798	669	680
<i>Trichoderma viride</i> + soil application	14.7	5.0	5.5	18.8	11.0	645	710	753	559	497
<i>T. harzianum</i> + soil application	10.7	3.5	3.0	5.7	5.6	688	863	906	813	818
<i>Bacillus subtilis</i> + soil application	21.7	8.0	8.5	25.0	15.8	480	585	671	444	545
<i>Pseudomonas fluorescens</i> + soil application	23.3	7.0	8.3	31.9	17.5	480	576	626	437	530
Seed treatment and soil drenching of carbendazim 0.1%	13.3	4.0	5.3	6.3	7.2	668	810	820	745	761
Control	28.3	10.0	11.0	33.8	20.8	355	531	525	339	438
CD (P=0.05)	3.1	1.1	1.7	4.1	-	36.0	54.0	46.2	28.14	-
CV (%)	11.0	11.0	14.9	18.0	-	8.70	5.31	3.7	4.02	-

6.5.2 Management of powdery mildew and stem gall in coriander

(Jagudan, Kumarganj and Raigarh)

At Jagudan incidence of powdery mildew was high and stem gall disease was not observed. Evaluation of various biocontrol agents and fungicides for the management of the disease did not give significant results (Table 65).

At Kumarganj, minimum stem gall disease was observed in the treatment carbendazim as soil drench and spray (0.1%) which was on par with Soil application of *Bacillus subtilis* and spray with *B. subtilis* after 60 days, whereas minimum powdery mildew disease was observed in the treatment spray with wettable sulphur (0.2%) (Table 66).

Table 65. Management of powdery mildew disease and stem gall diseases in coriander - Jagudan

Treatment	PDI PM	Yield (kg/ha)
Soil solarization + Soil application of <i>Trichoderma</i> (1 kg/plot) + Spray with Tridemorph (Calixin) 0.01 % 60 DAS.	59.17	482.1
Seed treatment with <i>Pseudomonas fluorescens</i> (IISR-6) + Spray with <i>Pseudomonas fluorescens</i> (IISR-6) 10^8 cfu 60 DAS.	66.25	468.5
Soil application of <i>Bacillus subtilis</i> (10^8 cfu) + Spray with <i>Bacillus subtilis</i> (10^8 cfu) 60 DAS	64.58	508.6
Seed treatment & Soil drench with Tridemorph (Calixin) 0.01 % + Spray with Tridemorph (Calixin) 0.01 % 60 DAS	44.58	719.8
Carbendazim (0.1%) as soil drench and spray	50.00	614.8
Spray with wettable sulphur (0.2%)	48.33	701.2
Control	70.00	774.7
CD (P=0.05)	NS	NS
CV (%)	18.79	29.14

Table 66. Management of stem gall and powdery mildew diseases in coriander – Kumarganj

Treatment	Stem gall disease (%)	Powdery mildew (%)	Yield (t/ha)	% decrease in disease over control		Increase in yield over control (%)
				Stem gall	Powdery mildew	
Soil solarization + soil application of <i>Trichoderma</i> (1kg/plot) + spray with tridemorph (Calixin) 0.1% 60 DAS	45.9	18.4	1.330	28.5	62.0	26.7
Seed treatment with <i>Pseudomonas fluorescens</i> (IISR-6) + spray with <i>Pseudomonas fluorescens</i> (IISR-6) (10^8 CFU) after 60 days	49.4	28.2	1.220	22.9	44.9	6.7
Soil application of <i>Bacillus subtilis</i> (10^8 CFU) + spray with B.s. after 60 days	42.6	21.6	1.540	33.7	57.6	46.7
Seed treatment, soil drench Tridemorph (Calixin) 0.1% + spray with Calixin 0.1% after 60 days	52.6	16.6	1.260	18.1	66.4	20.0
Carbendazim (Bavistin) (0.1%) as soil drench and spray	38.9	31.3	1.470	39.4	38.7	40.0
Spray with wettable sulphure (0.2%)	48.9	8.5	1.200	22.3	83.4	14.3
Control	64.2	51.0	1.050	-	-	-
CD (P=0.05)	5.4	3.8	0.310			
CV (%)	6.2	8.5	13.650			

At Raigarh, minimum incidence of powdery mildew (5.8%) was observed in treatment where carbendazim

0.1% was given as spray and drench that was on par with wettable sulphur 0.2% spray (Table 67).

Table 67. Management of powdery mildew and stem gall diseases in coriander -Raigarh

Treatment	Mean disease incidence (%)	Plot yield (4 x 2.7m) (kg)	Projected yield (kg/ha)
Soil solarization + Soil application of <i>Trichoderma</i> (1 kg/plot) + Spray with Tridemorph (Calixin) 0.1% after 60 days of sowing.	12.2	0.506	496.070
Seed treatment with <i>Pseudomonas fluorescens</i> (P.f.) (IISR-6) + Spray with P.f. (IISR-6) 10^8 cfu after 60 days.	16.3	0.420	419.940
Soil application of <i>Bacillus subtilis</i> (B.s.) 10^8 cfu + Spray with B.s. after 60 days.	15.5	0.396	3.66.360
Seed treatment, soil drench Tridemorph (calixin) 0.1% + Spray with calixin 0.1% after 60 days.	9.9	0.463	428.900
Carbendazim (Bavistin) as soil drench and spray (0.1%)	5.8	0.537	496.850
Spray with wettable sulphur (0.2%)	5.9	0.543	503.050
Control	17.9	0.330	305.550
CD (P=0.05)	0.8	0.110	

Stem gall symptom did not appear in the experimental field

7. CUMIN

7.1 Genetic Resources

7.1.1 Germplasm collection, characterization, evaluation, conservation and screening against diseases

(Jagudan, Jobner and Raigarh)

At Jagudan, 12 collections were made from the farmer's field of the state. The 207 entries of cumin were compared with two checks, i.e. GC-2 and GC-3 during *rabi* season. Among them, thirteen entries isolated as high yielder recorded more than 800 kg/ha⁻¹ grain yield. In order to identify promising lines for developing high yielding, early maturity, wilt resistance and better grain quality of cumin, crosses were made and advancement selections were made from F₂. Among the materials, 37 individual plants were selected for non-splitting seed habit type.

Screening against diseases:

***Alternaria* Blight Disease (*Alternaria burnsii*)**

: Seventy six (73 + 3) entries were screened for the resistance against blight disease. None of the entry was found free from blight disease incidence. The minimum incidence was noticed in JC-2000-55 (14 %) and followed by JC-2000-31 (20 %).

Powdery Mildew Disease (*Erysiphe polygoni*) :

A total 86 (83 + 3) entries were screened for resistance against powdery mildew disease under natural condition. The incidence of powdery mildew was reported very high and it was ranged from 37.50 to 93.75 %. None of the entries was found resistant or tolerant against the disease.

Wilt diseases : Total forty one (38+3) entries were screened under wilt sick plot conditions. Varieties such as GC-3 (43.09%), GC-4 (46.11%) and JC-2000-4 (47.42%) were found moderate resistant.

At Jobner, in field conditions, out of the ten entries screened minimum wilt incidence was in UC-341 (0 %) blight (0 %) and powdery mildew (0 score) with the maximum grain yield of 369.80 kg/ha followed by RZ-209. Out of the ten entries screened under IET, minimum wilt incidence (0 %) in UC-345, CMB-90 and RZ-209 (check) was recorded with the maximum seed yield of 395.84 kg/ha, 315.95 kg/ha and 237.85 kg/ha, respectively. At Raigarh, trial was conducted with entries from Jobner & Jagudan centres of AICRPS. Plants germinated and grew but at the time of flowering all plants dried off due to blast disease. Hence, the trial was considered to be failed.

7.2. Hybridization Trial

7.2.1 Mutation studies and hybridization programme in cumin

(Jagudan)

May be taken as University trial as per the decision of XVII Workshop of AICRPS.

7.2.2 CVT 2001 – Series IV

(Jagudan and Jobner)

At Jagudan, three years (2002-03 to 2004-05) data shown significant yield differences among the entries. An entry, JC-2000-72 recorded significantly higher yield (1066 kg/ha) than checks, which was 17.01 and 9.67 per cent higher above the GC-2 and GC-3, respectively (Table 68). On the bases of three years performance in CVT, entry JC-2000-72 was found best.

At Jobner, mean performance of the entries evaluated in CVT over 2002-2003 and 2003-2004 revealed superior performance of UC-341 yielding 315.03 kg/ha, followed by JC-2000-21 (292.85 kg/ha), UC-342 (280.35 kg/ha) and JC-2000-22 (260.15 kg/ha).

7.3 Varietal Evaluation Trial

7.3.1 Initial evaluation trial

(Jagudan and Jobner)

At Jagudan, the pooled over two years data showed significant yield differences among the entries. The en-

tries, JC-95-12 and JC-95-30 significantly outyielded (i.e. 1042 kg/ha and 1034 kg/ha) two checks, GC-2 and GC-3 but at par with another check, GC-4. Both these entries are 7-16 days earlier than the checks.

At Jobner, superior performance of UC-345 yielding 388.92 kg/ha, followed by CMB-79 (325.01 kg/ha), UC-343 (308.63 kg/ha), CMB-90 (305.16 kg/ha) and RZ-19 (Check) (263.38 kg/ha) was recorded.

7.4 Quality Evaluation Trial

7.4.1 Quality evaluation in cumin

(Jobner)

Ten entries of cumin under CVT were analysed for volatile oil content during Rabi 2003-04, using Clevenger apparatus. The mean performance of two-years data indicated that the mean volatile oil content ranged from 3.86% to 4.36%. The entry, UC-341 ranked first in terms of mean volatile oil yield of 12.16 l/ha, followed by JC-2000-21 (11.98 l/ha), UC-342 (11.63 l/ha), JC-2000-22 (10.12 l/ha) and JC-2000-72 (9.69 l/ha) (Tables 69 and 70).

The mean performance of two years (2002-03 and 2003-04) data indicated that volatile oil content in the entries ranged from 3.83% to 4.93%. All the entries except CMB-134 and Local performed better than best-check, RZ-19 with respect to mean volatile oil yield (Table 71).

Table 68. Yield performance of cumin entries under CVT – Jagudan

Entry	Yield (kg/ha)				% increase over check		
	2002-03	2003-04	2004-05	Mean	GC-2	GC-3	RZ-19 *
JC-2000-21	963	943	1047	984	8.01	1.23	0.41
JC-2000-22	978	940	1010	976	7.14	0.41	-
JC-2000-27	1035	903	999	979	7.46	0.72	-
JC-2000-72	1126	997	1075	1066	17.01	9.67	8.78
UC-341	856	946	806	869	-	-	-
UC-342	951	863	740	851	-	-	-
GC-2 (Ch)	971	829	933	911	-	-	-
GC-3 (Ch)	1021	856	1040	972	6.70	-	-
RZ-19 (NCh)*	-	-	980	980	-	-	-
S.Em. ±	24	35	74	40			
CD (P=0.05)	69	103	217	120			
CV (%)	4.78	7.72	15.48	10.41			

Table 69. Volatile oil content of cumin entries under CVT – Jobner

Entry	Seed yield (kg/ha)	Volatile oil content (%)			Volatile oil yield (l/ha)
		2002-03	2003-04	Mean	
UC-341	315.03	3.92	3.80	3.86	12.16
UC-342	280.35	4.29	4.00	4.15	11.63
JC-2000-21	292.85	4.58	3.60	4.09	11.98
JC-2000-22	260.15	4.58	3.20	3.89	10.12
JC-2000-27	223.39	4.33	3.60	3.96	8.85
JC-2000-72	225.99	4.58	4.00	4.29	9.69
RZ-19 C	231.58	4.58	3.60	4.09	9.47
Local C	168.73	3.92	4.80	4.36	7.36

Table 70. Comparison of volatile oil content of cumin entries under CVT grown at Jagudan and Jobner centres

Entry	Volatile oil content (%)	
	Jagudan	Jobner
UC-341	3.45	3.8
UC-342	3.50	4.0
JC-2000-21	3.60	3.6
JC-2000-22	3.05	3.2
JC-2000-27	4.95	3.6
JC-2000-72	5.00	4.0
GC-3 (WR)	4.90	5.6

Table 71. Volatile oil content of cumin entries under IET – Jobner

Entry	Seed yield (kg/ha)	Volatile oil content (%)			Volatile oil yield (l/ha)
		2002-03	2003-04	Mean	
UC-343	308.63	4.50	4.8	4.65	14.35
UC-344	262.43	4.25	5.6	4.93	12.94
UC-345	388.92	4.00	4.0	4.00	15.56
CMB-79	325.01	4.25	3.4	3.83	12.45
CMB-88	248.89	4.25	5.2	4.73	11.77
CMB-90	305.16	4.00	4.8	4.40	13.43
CMB-134	217.12	3.75	4.8	4.28	9.29
RZ-19	263.38	4.00	4.0	4.00	10.53
RZ-209 C	228.93	4.00	4.4	4.20	9.61
Local C	138.92	3.50	4.8	4.15	5.76

7.5 Nutrient Management Trial

7.5.1 Effect of biofertilizer, *Azospirillum* on cumin

(Jobner and Jagudan)

At Jobner, maximum cumin yield of 323 kg/ha was recorded with application of 100% N as inorganic source

+ *Azospirillum* 1.5 kg/ha as seed treatment + 5 kg FYM/ha with maximum B:C ratio (1:39). Control recorded the lowest yield (179 kg/ha).

7.6 Disease Management Trial

7.6.1 Management of wilt and blight disease in cumin

(Jagudan and Jobner)

Field trial on management of wilt and blight diseases in cumin was initiated during 2004 at Jagudan. The data revealed that the incidence of blight disease was high, while wilt was very low. None of the treatments gave

significant results. The data of yield showed significant results among different treatments. The highest yield was in spray of mancozeb 0.25% at 40, 50, 60 and 70 DAS (136.36 kg/ha) with 10% wilt incidence. Others treatments were at par with each other. The yield was very low due to heavy incidences of blight and powdery mildew diseases and also frost during February (Table 72).

Table 72. Management of wilt and blight diseases in cumin - Jagudan

Treatment	PDI Blight	Wilt (%)	Yield (kg/ha)
Soil solarization + Soil application of <i>Trichoderma harzianum</i> + Spray Mancozeb 0.25% (60 DAS)	48.67	10.0	72.220
Soil application of <i>T. harzianum</i> + FYM + Spray Mancozeb 0.25% (60 DAS)	56.00	13.3	66.970
Vermicompost+ Soil application of <i>T. harzianum</i> + Spray Mancozeb 0.25% (60 DAS)	53.00	8.3	73.160
Neem Cake+ Soil application of <i>T. harzianum</i> + Spray Mancozeb 0.25% (60 DAS)	53.33	11.7	43.130
Soil drench with carbendazim 0.1%+ Spray mancozeb 0.25% (60 DAS)	60.33	8.3	46.460
<i>Pseudomonas fluorescens</i> (IISR-6) (10^8 cfu) as seed treatment and spray (60 DAS)	76.33	5.0	21.460
<i>Bacillus subtilis</i> as soil application and foliar spray (60 DAS)	60.33	8.3	40.400
<i>P. fluorescens</i> (IISR-6) (10^8 cfu) as seed treatment + soil application of <i>T. harzianum</i> + <i>P. fluorescens</i> as spray	71.67	6.7	30.300
<i>B. subtilis</i> as soil application + soil application of <i>T. harzianum</i> + <i>P. fluorescens</i> as spray	68.67	6.7	32.320
Control	60.33	8.3	30.800
Spray Mancozeb 0.25% (40,50,60 & 70 DAS)	30.00	10.0	136.360
CD (P=0.05)	NS	NS	20.120
CV (%)	32.70	52.9	20.0

8. FENNEL

8.1 Genetic Resources

8.1.1 Germplasm collection, characterization, evaluation, conservation and screening against diseases

(Dholi, Hisar, Jagudan, Jobner and Kumarganj)

At Dholi, thirty one germplasm are maintained and tested for identifying promising lines for higher yield. Out of thirty one genotypes, only three namely, RF-18, RF-31 and JF-303 produced higher yield varying from 0.10 kg to 0.13 kg per plant. At Hisar, the most promising lines were HF-107, HF-116, HF-118, HF-122, HF-123, HF-125, HF-143, HF-147, HF-151, HF-163, HF-173, HF-180, HF-182 and HF-184. These lines were maintained by sib mating under muslin cloth and self seed of all the lines have been harvested. At Jagudan, twelve

accessions were added to the existing germplasm, thus raising the total to 119. The promising lines identified for yield were JF-200, JF-478, JF-539-1, JF-544, JF-564& JF-575.

The variability in fennel was observed at field of breeding materials raised during kharif 2004-05. Among them, plant progeny of 101 entries were selected for different useful characters and seeds were harvested from open pollination field for further study. In a screening against *Ramularia* blight disease, none of the entries were found free from disease incidence. The minimum incidence of only one percentage was reported in GF-2 (Ch), JF-544, ACC-1567, ACC-1372, ACC-1627, ACC-1657, ACC-1655 and ACC-1677. At Kumarganj, out of 39 germplasm accessions screened, NDF-6 produced maximum yield of 1.06 t/ha, followed by NDF-5 (1.20 t/ha).

8.1.2 Intervarietal hybridization for evolving high yielding varieties

(Jobner)

The hybridization breeding programme was started in fennel at Jobner with the standardization of crossing technique.

8.2 Coordinated Varietal Trial

8.2.1 CVT 2001 - Series V

(Jobner and Hisar)

At Jobner, the mean performance (over three years viz. 2001-02, 2002-03 and 2003-04) indicated that entries differed significantly for all the characters studied. Volatile oil content varied from 2.13% (UF-178) to 2.48% (UF-177) and volatile oil yield from 20.17 l/ha (Local check) to 34.14 l/ha (UF-177). Mean performance of the entries revealed superior performance of UF-178 yielding 1601.57 kg/ha, followed by UF-177 (1382.21 kg/ha), JF-332 (1302.83 kg/ha). Overall, the entry, UF-178 was found superior for seed yield as well as for volatile oil yield than all the three checks, therefore UF-178 may be recommended for release in the state of Rajasthan (Table 73).

At Hisar, significant differences were obtained for all the parameters. On the basis of average yield of three years (2001-02 to 2003-04), the maximum seed yield was recorded as 1967 kg/ha in UF-178, followed by HF-116 (1871 kg/ha) and HF-107 (1726 kg/ha).

8.2.2 CVT 2004

(Jagudan and Kumarganj)

At Jagudan, the entries, JF-444-1 and JF-376 significantly outyielded the National check, RF-101 by producing 50.14 and 48.53 per cent higher yield, respectively. At Kumarganj highest yield of 1.96 t/ha was obtained in NDF-5, followed by 1.82 t/ha in RF-31.

8.3 Varietal Evaluation Trial

8.3.1 Initial evaluation trial

(Hisar, Jagudan and Jobner)

At Hisar, the trial in fennel was conducted with ten accessions along with GF-1 as check during 2001-2002 to 2003 - 2004 and the results indicated that HF-118 and HF-125 gave significantly better yield over GF-1 (check) showing 24.0 and 31.6 % increase in yield, respectively. At Jagudan, non significant yield differences were observed among the entries. At Jobner, mean

Table 73. Yield and its attributes in fennel under CVT – Jobner

Entry	Days to flowering	Plant height (cm)	Branches per plant	Umbels per plant	Umbellets per umbel	Seeds per umbel	Test wt. (gm)	Volatile oil (%)	Volatile oil yield (l/ha)	Seed yield (kg/ha)
UF-177	116.44	129.43	8.59	31.37	18.98	268.98	5.91	2.48	34.14	1601.57
UF-178	114.88	130.53	9.77	36.39	22.48	332.82	6.82	2.13	34.11	1382.21
UF-179	115.10	125.97	8.04	23.17	23.24	248.96	6.69	2.32	29.35	1265.30
JF-234	119.11	143.29	6.69	23.97	19.97	215.51	5.95	2.32	26.84	1156.72
JF-303	117.53	137.98	7.33	23.54	21.77	239.20	4.96	2.45	27.90	1138.63
JF-332	116.56	146.17	7.17	27.21	22.69	267.33	5.92	2.32	30.23	1302.83
HF-107	119.15	136.02	7.40	18.14	20.32	257.64	5.34	-	-	1267.69
HF-116	121.62	133.93	7.99	21.12	23.81	254.02	5.48	2.37	20.42	861.51
NDF-5	120.67	121.60	7.90	17.40	21.17	199.32	3.95	-	-	1252.60
NDF-6	118.35	118.15	7.50	20.27	19.14	213.35	4.13	-	-	1144.50
RF-18	114.67	123.00	7.93	22.33	22.20	180.20	5.37	-	-	850.70
RF-21	117.67	136.33	8.47	28.87	22.93	184.40	4.36	-	-	979.33
RF-31	115.33	145.33	8.20	25.07	20.80	192.47	4.55	-	-	1182.33
RF-101 (ch)	117.33	125.02	8.15	27.67	21.75	236.63	6.20	2.23	28.44	1275.24
RF-125 (ch)	113.00	112.29	9.40	34.52	28.73	268.89	5.28	-	-	1234.40
Local check	123.09	133.20	6.83	17.85	18.18	172.69	4.75	2.47	20.17	816.48

performance of the entries evaluated over 2002-2003 and 2003-2004 revealed superior performance of UF-175, yielding 1090.33 kg/ha, followed by UF-145 (1053.00 kg/ha), UF-33 (1004.84 kg/ha), UF (M)-1 (1000.83 kg/ha).

8.3.2 Comparative yield trial (CYT)

(Dholi)

At Dholi, the genotypes had significant differences for yield and yield parameters. All genotypes were observed non-significant over check-variety, Rajendra Saurabh. However, genotype, RF-31 was higher yielder with 1.21 kg per plot (1.35 t/ha) with 13.45 percent more grain yield over check, Rajendra Saurabh.

8.5 Nutrient Management Trial

8.5.1 Effect of biofertilizer, *Azospirillum* and P. solubiliser in fennel

(Kumarganj, Jobner and Jagudan)

The maximum fennel yield of 1.36 t/ha was recorded by the application of FYM 10 t/ha + *Azospirillum* (1.5 kg/ha as seed treatment) at Kumarganj. At Jobner, pooled data for four years indicated that application of 100% N as inorganic along with *Azospirillum* and FYM (5 t/ha) recorded the maximum yield (1.16 t/ha) (Table 74).

Table 74. *Azospirillum* application on yield of fennel

Treatment	Centres		Mean
	Kumarganj	Jobner	
Best treatment	FYM 10 t/ ha + <i>Azospirillum</i> 1.5 kg/ha as seed treatment	Inorganic N (100%) + <i>Azospirillum</i> (1.5 kg/ha as seed treatment) + 5 t FYM/ ha	
Yield of best treatment (kg/ha)	1360	1158	1259
Control (kg/ha)	800	778	789
Yield increase over control (kg/ha)	560	380	

8.4 Quality Evaluation Trial

8.4.1 Quality evaluation in fennel

(Jobner)

At Jobner, sixteen entries of fennel under CVT were analysed for volatile oil content during Rabi 2003-04, using Clevenger apparatus. The mean performance of three years data indicated that the volatile oil content ranged from 2.13% to 2.48%. The entries, UF-178, UF-177, UF-179 and JF-332 performed better than the best check, RF-101 in terms of volatile oil yield. Fourteen entries of fennel under CVT received from Jagudan (Gujarat) centre were analysed for volatile oil content. The oil content was found in the range of 1.65% to 2.35%. The common entries grown at Jobner and Jagudan were compared for volatile oil content. There was not much variation found in volatile oil content in the entries grown. However, some entries grown at Jobner were showing slightly higher volatile oil as compared to those grown at Jagudan. Under IET, the entry, UF (M)-1 recorded maximum volatile oil content (2.95%) and also performed better in sense of grain yield as compare to best check local.

8.5.2 Identification of alkalinity tolerant source in fennel – observational trial

(Kumarganj)

Among 10 fennel varieties tested at four levels of Exchangeable Sodium Percent (ESP) at Kumarganj, it was found that NDF-6 at 10 ESP level recorded maximum yield (53.00 g/plant).

9. FENUGREEK

9.1 Genetic resources

9.1.1 Germplasm collection, characterization, evaluation, conservation and screening against diseases

(Dholi, Guntur, Hisar, Jagudan, Jobner and Kumarganj)

At Dholi, 97 accessions of fenugreek are being maintained at this centre. Out of this, 91 germplasm evaluated in which the seed yield varied from 2.8 g (M-22) to 8.8 g per plant. Among the genotypes RM-5/90 produced the maximum grain yield of 0.92 t/ha. At Guntur, 126 accessions are being maintained in the repository.

Among the fifty seven accessions evaluated, LFC – 112 recorded the highest yield of 1632 kg/ha, followed by LFC-102 (1466 kg/ha) and are significantly superior to the check-variety, Lam Selection I (1113 kg/ha).

Hisar centre is maintaining 112 accessions of fenugreek in the germplasm bank. Out of this, seventy nine collections evaluated, the seed yield ranged from 0.370 t/ha (GC-172) to 2.11t/ha (GC-94). Five lines gave higher yield than Pusa Early Bunching and only one out yielded Hisar Sonali. The most promising lines were GC-7, GC-14, GC-17, GC-20 and GC-94. Jagudan centre is maintaining 63 accessions in the gene pool. All the 63 entries including GM-1 as check were evaluated for different characters. Among them, eleven entries found promising for yield i.e. more than 2600 kg/ha.

Powdery Mildew disease (*Erysiphe polygoni* and *Leveillula taurica*) : In a screening test against powdery mildew disease under natural condition at Jagudan, the disease incidence was minimum and it ranged from 10 to 81.25 %. None of the entries were found free from disease incidence.

Out of 14 entries evaluated in CVT at Jobner, minimum root rot (0.0%), downy mildew (0 score) and powdery mildew (0 score) in UM-351, followed by UM-352 with the minimum root rot (0 score), downy mildew (2 score) and powdery mildew (0 score) was observed with the maximum seed yield of 1670.17 and 1534.77 kg/ha, respectively. Under IET, NS 2003-1, NS 2003-4 found free from root rot, downy mildew and powdery mildew diseases with the maximum seed yield of 1443.67 kg/ha, and 1429.33 kg/ha, respectively.

At Kumarganj, out of 65 germplasm accessions screened, NDM-25 out yielded all the germplasm producing 2.73 t/ha of grain yield over check, Hisar Sonali (2.08 t /ha), followed by NDM –19 (2.27 t/ha).

9.2 Hybridization Trial

9.2.1 Evolving varieties resistant to powdery mildew

(Jobner)

The hybridization breeding programme was started and the crossing technique in the crop has been standardized. In fenugreek, the crosses were made among adaptable varieties versus resistant lines and also among determinate versus indeterminate type to get good trans-

gressive segregants. By pedigree method, few lines were identified as promising one and will be included in IET. Besides this, inheritance of multipodedness and determinate type was also determined.

9.3 Coordinated Varietal Trial

9.3.1 CVT 1999 - Series IV

(Dholi)

At Dholi, for three consecutive years (1999-2000 to 2001-02), genotype HM-291 proved superior with 1.86 t/ha grain yield, over check-variety, Rajendra Kanti.

9.3.2 CVT 2001 Series V

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

At Coimbatore, out of 27 fenugreek accessions evaluated the genotypes, the Acc. JF 270 gave the highest yield of 606 kg/ha, followed by HM 346 (573.3 kg/ha). At Dholi, for three years (1999-2000 to 2001-2002), there were significant differences among the genotypes for yield. High grain yield was recorded with genotype, HM-350 (1.96 t/ha), followed by UM-305 (1.94 t/ha). At Guntur, all the genotypes except JF-244 performed well below the performance of the check, Lam Selection-1 indicating their inability to give good yields under lam agro-climatic conditions. Maximum grain yield was recorded in JF-244 (1009.1 kg/ha), which is significantly superior to all other entries. At Jobner, mean performance of the entries evaluated in CVT over 2001-2002 to 2003-2004 revealed superior performance of UM-351 yielding 1760.95 kg/ha, followed by UM-352 (1693.92 kg/ha), NDM-25 (1645.11 kg/ha), JF-244 (1606.92 kg/ha), RMT-1 Check (1566.21 kg/ha). At Kumarganj, out of 20 entries tested, NDM-19 produced maximum grain yield of 2.16 t/ha, followed by 2.13 t/ha in NDM-25 over National-check, Hisar Sonali (1.87 t/ha).

9.4 Varietal Evaluation Trial

9.4.1 Comparative yield trial (CYT)

(Dholi)

Genotype, H.M.-444 produced 16.67 percent higher yield over-check variety, Rajendra Kanti.

9.4.2 Initial evaluation trial

(Dholi, Guntur, Hisar, Jagudan, Jobner)

At Dholi, genotype, RM-70 proved better and

produced 22.06 percent higher grain yield over check-variety, Rajendra Kanti. At Guntur, among the entries evaluated for yield, LFC-84 recorded highest yield of 1366 kg/ha, followed by LFC - 87 (1354 kg/ha), which were on par with each other and significantly superior to check, Lam Selection-1 (1068 kg/ha). At Hisar over three years (2001-02 to 2003-04), maximum seed yield was recorded in HM-292 (2787 kg/ha), followed by HM-219 and HM-232 showing an increase of 32.08, 23.55 and 20.71 %, respectively (Table 76).

At Hisar, significant differences were obtained for all the parameters. Maximum seed yield was recorded in

HM-444, which was statistically at par with HM-376, JF-244, JF-270 and UM-351. At Jagudan, an entry, JFg-244 recorded significantly superior yield (2011 kg/ha) than check, GM-1 and it was 10.74 and 3.08 per cent higher than the checks, GM-1 and Hisar Sonali, respectively (Table 75).

At Jagudan, entry, JFg-239 recorded significantly superior yield (2066 kg/ha) over check, GM-1 with 9.14 per cent, followed by JFg-273 and JFg-232. At Jobner, the analysis of variance revealed significant differences among the entries for all the characters. The entry, NS-

Table 75. Yield performance of fenugreek entries under CVT - Jagudan

Entry	Yield (kg/ha)			Mean	% increase over control	
	2002-03	2003-04	2004-05		GM-1	His. Sonali
J.Fg244	2049	1906	2079	2011	10.74	3.08
J.Fg270	1838	2030	2000	1956	7.71	0.28
UM-351	1822	1575	1772	1723	-	-
UM-352	1809	1674	1630	1166	-	-
HM-65	1361	1734	1566	1554	-	-
HM-372	1544	1730	1815	1696	-	-
HM-376	1880	1947	2059	1962	8.04	0.56
HM-444	1931	1900	1797	1876	3.30	-
NDM-19	1657	1678	1786	1707	-	-
NDM-25	1649	1683	1676	1569	-	-
GM-1©	1838	1760	1846	1815	-	-
Hisar Sonali	-	-	1951	1951 *	7.49	-
S.Em. ±	71	80	102	52		
CD (P=0.05)	205	231	295	145		
CV (%)	8.08	8.98	11.21	9.56		

Table 76. Yield performance of fenugreek entries under IET – Hisar

Acc. No.	Seed yield (kg /ha)			Mean	% increase over check
	2001-2002	2002-2003	2003-2004		
HM-202	2700	2400	2050	2383	12.94
HM-214	2025	2153	2210	2126	0.76
HM-219	3000	2562	2260	2607	23.55
HM-232	2900	2622	2125	2547	20.71
HM-241	2000	2125	1800	1975	- 6.40
HM-247	2500	2250	1903	2217	5.07
HM-292	3000	2860	2500	2787	32.08
HM-325	2850	2540	2000	2463	16.73
HM-348	2250	2425	2150	2275	7.82
Hisar Sonali (C)	2320	2060	1950	2110	-
CD (P=0.05)	320	190	225	-	-

2003-1 recorded the maximum seed yield of 1443.67 kg/ ha, followed by NS-2003-4 (1429.33 kg/ ha).

9.5 Nutrient Management Trial

9.5.1 Effect of biofertilizers, *Azospirillum/Rhizobium* on fenugreek

(Coimbatore, Jagudan, Jobner and Kumarganj)

The combination biofertilizer viz., *Azospirillum* was tested along with inorganic source of nitrogen and FYM

on yield of fenugreek at Jobner, Coimbatore, Kumarganj and Jagudan. The results are presented in Table 77.

9.5.2 Identification of source of drought tolerance in fenugreek

(Guntur)

Screening fenugreek germplasm for drought tolerance was studied at Guntur and some of the promising lines for different characters studied are listed in Table 78.

Table 77. *Azospirillum* application on yield of fenugreek

Treatments	Centres			Mean
	Jobner	Coimbatore	Kumarganj	
Best treatment combination	Inorganic N (100%) alone	Inorganic N (100%) + <i>Azospirillum</i> (1.5 kg/ha) as seed treatment+ 5 t FYM	FYM 10t/ ha + <i>Azospirillum</i> (1.5 kg/ha as seed treatment)	
Yield of best treatment (kg/ha)	1256	685	2100	1345
Control (kg/ha)	964	548	1430	980
Yield increase over control (kg/ha)	292	137	670	

Table 78. Screening of fenugreek germplasm against drought – Guntur

Drought tolerant parameter	Range	Germplasm lines	
		Low	High
Biomass (g/5 plants)	8.6-43.1	LFC-107 (8.6), LFC-76 (9.5)	LFC-122 (43.1), LFC-116 (42.9)
Root length	4.3-16.7	LFC-92 (4.3), LFC-78 (5.4)	LFC-89 (16.7), LFC-104 (14.8)
Shoot length	18.1-49.8	LFC-119 (18.1), LFC-92 (23.3)	LFC-121 (49.8), LFC-124 (47.8)
Root-Shoot Ratio	0.14-0.63	LFC-109 (0.14), LFC-113 (0.17)	LFC-119 (0.63), LFC-89 (0.53)

10. VANILLA

10.1 Genetic resources

10.1.1 Germplasm collection, characterization and evaluation of vanilla

(Sirsi and Panniyur)

The new programme was started during 2004-05 at Sirsi. Totally six accessions have been collected and maintained. These have been planted in the field for its further evaluation. At Panniyur, five collections have been made from farmers field and maintained in the station field.

11. PAPRIKA

11.1 Genetic resources

11.1.1 Germplasm collection, characterization, evaluation and conservation of paprika and paprika alike chillies

(Coimbatore)

At Coimbatore, twenty seven paprika accessions were evaluated for their growth and yield parameters and the results indicated that the Acc. 27 recorded the highest fresh fruit yield of 1797.10 g/plant, followed by Acc. 20 (1728.75 g/plant). Acc. 5 recorded minimum percent disease index of 6.57 against fruit rot disease caused by *Colletotrichum capsici*.

GENETIC RESOURCES OF SPICES AT AICRPS CENTRES (As on 31-03-2005)

Crop/Center	Indigenous		Exotic	Total
	Cultivated	Wild and related sp.		
Black pepper				
Panniyur	164	47	3	214
Sirsi	97	19	1	117
Chintapalle	58	-	-	58
Yercaud	122	10	-	132
Pundibari	16	1	-	17
Dapoli	67	-	-	67
Dholi	7	-	-	7
Total	531	77	4	612
Cardamom				
Pampadumpara	141	-	-	141
Mudigere	132	-	-	132
Total	273	-	-	273
Ginger				
Pottangi	167	2	3	172
Solan	286	-	2	288
Dholi	42	-	-	42
Kumarganj	45	-	-	45
Pundibari	38	-	-	38
Raigarh	15	-	-	15
Dapoli	3	-	-	3
Total	596	2	5	603
Turmeric				
Pottangi	171	22	-	193
Jagtial	352	-	-	352
Dholi	83	2	-	85
Raigarh	42	-	-	42
Kumarganj	114	-	-	114
Pundibari	126	14	-	140
Solan	145	-	-	145
Coimbatore	255	-	6	261
Total	1288	38	6	1332
Clove				
Pechiparai	22	-	-	22
Dapoli	3	-	-	3
Yercaud	13	-	-	13
Total	38	-	-	38
Nutmeg				
Pechiparai	20	-	-	20
Dapoli	95	-	-	95
Total	115	-	-	115

Crop/Center	Indigenous		Exotic	Total
	Cultivated	Wild and related sp.		
Cinnamon				
Pechiparai	12	-	-	12
Dapoli	11	-	-	11
Yercaud	16	-	-	16
Total	39	-	-	39
Cassia				
Pechiparai	4	-	-	4
Dapoli	6	-	-	6
Total	10	-	-	10
Coriander				
Jobner	693	-	102	795
Jagudan	74	-	21	95
Coimbatore	230	-	-	230
Guntur	244	-	5	249
Hisar	190	-	-	190
Dholi	85	-	-	85
Raigarh	20	-	-	20
Kumarganj	72	-	-	72
Total	1608	-	128	1736
Cumin				
Jobner	370	-	6	376
Jagudan	219	-	7	226
Kumarganj	19	-	-	19
Total	608	-	13	621
Fennel				
Coimbatore	3	-	-	3
Jobner	187	-	20	207
Jagudan	115	-	4	119
Hisar	86	-	-	86
Dholi	31	-	-	31
Kumarganj	39	-	-	39
Total	461	-	24	485
Fenugreek				
Jobner	353	-	12	365
Jagudan	63	-	-	63
Coimbatore	255	-	-	255
Guntur	126	-	-	126
Hisar	112	-	-	112
Dholi	97	-	-	97
Raigarh	13	-	-	13
Kumarganj	63	-	-	63
Solan	25	-	-	25
Total	1107	-	12	1119

Crop/Center	Indigenous		Exotic	Total
	Cultivated	Wild and related sp.		
Paprika				
Coimbatore	27	-	-	27
IISR, Calicut	37	-	26	63
Total	64	-	26	90
Vanilla				
Sirsi	06	-	-	06
Coimbatore	02	-	-	02
IISR, Calicut	69	13	-	82
ICRI, Myladumpara	35	-	-	35
Dapoli	02	-	-	02
Total	114	13	-	127
Grand Total				7200

Spice	Accession Nos.	
Major spices	-	2820
Tree spices	-	202
Seed spices	-	3961
Other spices (Paprika & Vanilla)	-	217
Grand Total	-	7200

Promising varieties/lines of spice crops identified for yield at AICRPS Centers

Centre	Crop	Entry	Yield	Type of trial
Sirsi	Black pepper	Ademane pepper	15.0 kg vine ⁻¹ (fresh)	Germplasm
		Kudragutta	8.0 kg vine ⁻¹ (fresh)	Germplasm
Dapoli	Black pepper	PN-57	9.0 kg vine ⁻¹ (fresh)	CVT
Yercaud	Black pepper	Panniyur-3	8.0 kg vine ⁻¹ (fresh)	CVT
Pampadumpara	Cardamom	CRS-14	2.665 kg plan ⁻¹ (fresh)	Germplasm
Sakleshpur	Cardamom (Malabar type)	SKP-170	328.5 kg ha ⁻¹ (dry)	CVT
		MCC-12	132.3 kg ha ⁻¹ (dry)	CVT
Pampadumpara	Cardamom	S1	528.3 kg ha ⁻¹ (dry)	CVT
Mudigere	Cardamom	CL-726	388.71 kg ha ⁻¹ (dry)	IET
Solan	Ginger	V E -4 1 5	11.6 kg 3 m ² bed	Germplasm
Pottangi	Ginger	V E -2 1 8	24.43 t ha ⁻¹ (fresh)	CVT
Coimbatore	Turmeric	CL-138	52.30 t ha ⁻¹ (fresh)	Germplasm
		CL-113	50.48 t ha ⁻¹ (fresh)	Germplasm
Pottangi	Turmeric	PTS-54	14.4 kg 3 m ² bed	Germplasm
Kumarganj	Turmeric	NDH-18	38.61 t ha ⁻¹ (fresh)	Germplasm
Raigarh	Turmeric	TCP-2 (Suranjana)	27.84 t ha ⁻¹ (fresh)	CVT
Pundibari	Turmeric	TCP-1	25.15 t ha ⁻¹ (fresh)	CVT
Coimbatore	Turmeric	ACC.39	31.31 t ha ⁻¹ (fresh)	CVT
Jagtial	Turmeric	JTS-408	38.43 t ha ⁻¹ (fresh)	CYT
		JTS-407	35.86 t ha ⁻¹	CYT
Dholi	Turmeric	RH-80	64.12 t ha ⁻¹ (fresh)	IET
		RH-50	63.66 t ha ⁻¹ (fresh)	IET
Pechiparai	Clove	Sel.7	102.20 g tree ⁻¹ (dry)	Germplasm
		SA-8	148.30 g tree ⁻¹ (dry)	CVT
Guntur	Coriander	LCC-236	1201 kg ha ⁻¹	Germplasm
Kumarganj	Coriander	NDCor-67	1940 kg ha ⁻¹	Germplasm
		ND Cor-2	1870 kg ha ⁻¹	Germplasm
Dholi	Coriander	UD-446	1830 k ha ⁻¹	Germplasm
Jagudan	Coriander	JCr-328	1747 kg ha ⁻¹	CVT
Dholi	Coriander	RD-366	1750 kg ha ⁻¹	IET
Hisar	Coriander	DH-242	2091 kg ha ⁻¹	IET
		DH-206	2031 kg ha ⁻¹	IET
Jagudan	Coriander	JCr-340	1856 kg ha ⁻¹	IET
Guntur	Coriander	LCC-216	863 kg ha ⁻¹	IET

Centre	Crop	Entry	Yield	Type of trial
Jobner	Coriander	UD-728	1080 kg ha ⁻¹	IET
		UD-797	1061 kg ha ⁻¹	IET
Jobner	Cumin	VC-341	370 kg ha ⁻¹	CVT
		VC-345	396 kg ha ⁻¹	IET
Jagudan	Cumin	JC-2000-72	1066 kg ha ⁻¹	CVT
		JC-2000-21	984 kg ha ⁻¹	CVT
		JC-95-12	1042 kg ha ⁻¹	IET
		JC-95-30	1034 kg ha ⁻¹	IET
		JC-96-18	1009 kg ha ⁻¹	IET
		HF-125	915 g plot ⁻¹	Germplasm
		HF-107	912 g plot ⁻¹	Germplasm
Jobner	Fennel	UF-177	1602 kg ha ⁻¹	CVT
Hisar	Fennel	UF-178	1967 kg ha ⁻¹	CVT
		HF-116	1871 kg ha ⁻¹	CVT
		RF-15	1833 kg ha ⁻¹	CVT
Kumarganj	Fennel	NDF-5	1960 kg ha ⁻¹	CVT
		RF-31	1820 kg ha ⁻¹	CVT
Hisar	Fennel	HF-125	2080 kg ha ⁻¹	IET
		HF-118	1960 kg ha ⁻¹	IET
Jobner	Fennel	UF-175	1090 kg ha ⁻¹	IET
		UF-145	1053 kg ha ⁻¹	IET
Jagudan	Fennel	JF-501-2	2404 kg ha ⁻¹	IET
		JF-472-3	2342 kg ha ⁻¹	IET
Dholi	Fennel	RF-31	1350 kg ha ⁻¹	CYT
		RF-21	1350 kg ha ⁻¹	CYT
Hisar	Fenugreek	GC-94	2110 kg ha ⁻¹	Germplasm
Guntur	Fenugreek	LFC-112	1632 kg ha ⁻¹	Germplasm
Kumarganj	Fenugreek	NDM-25	2730 kg ha ⁻¹	Germplasm
		NDM-5	2270 kg ha ⁻¹	Germplasm
Jobner	Fenugreek	UM-351	1670 kg ha ⁻¹	CVT
		UM-352	1535 kg ha ⁻¹	CVT
Dholi	Fenugreek	RM-5/90	920 kg ha ⁻¹	CVT
Guntur	Fenugreek	JF-244	1009 kg ha ⁻¹	CVT
Kumarganj	Fenugreek	NDM-19	2160 kg ha ⁻¹	CVT
		NDM-25	2130 kg ha ⁻¹	CVT
Coimbatore	Fenugreek	JF-270	606 kg ha ⁻¹	CVT

Centre	Crop	Entry	Yield	Type of trial
Jagudan	Fenugreek	JF-244	2011 kg ha ⁻¹	CVT
		JF-270	1956 kg ha ⁻¹	CVT
Dholi	Fenugreek	HM-350	1960 kg ha ⁻¹	CVT
		UM-305	1940 kg ha ⁻¹	CVT
Hisar	Fenugreek	HM-444	2050 kg ha ⁻¹	CVT
		JF-244	1960 kg ha ⁻¹	CVT
Dholi	Fenugreek	RM-70	1660 kg ha ⁻¹	IET
		RM-18	1530 kg ha ⁻¹	IET
Hisar	Fenugreek	HM-219	2607 kg ha ⁻¹	IET
		HM-232	2547 kg ha ⁻¹	IET
Jobner	Fenugreek	NS-2003-1	1444 kg ha ⁻¹	IET
		NS-2003-4	1429 kg ha ⁻¹	IET
Guntur	Fenugreek	LFC-84	1366 kg ha ⁻¹	IET
		LFC-87	1354 kg ha ⁻¹	IET
Jagudan	Fenugreek	JFg-239	2066 kg ha ⁻¹	IET
		JFg-273	2025 kg ha ⁻¹	IET

Promising lines identified for quality parameters at AICRPS Centers

Centre	Crop	Entry	Quality Parameters	Type of trial
Pampadumpara	Cardamom			
	(Malabar type)	PS-27	Volatile Oil (7.3%)	Germplasm
Sakleshpur	Cardamom			
	(Malabar type)	PS-27	Volatile oil (7.1%)	CVT
	Cardamom			
	(Mysore type)	MCC-61	Volatile oil (6.9%)	CVT
Solan	Ginger	50/04	Dry matter (21.00%)	Germplasm
		SG 827	Oleoresin (6.57%)	Germplasm
		V ₁ S ₁ -2	Dry matter (21.60%)	CVT
		ACC-117	Crude fiber (3.89%)	CVT
Pottangi	Ginger	V ₁ C-8	Dry recovery (23.4%)	CVT
Pottangi	Turmeric	Tur.No.1	Dry recovery (24.2%)	CVT
		Tur.No.1	Essential oil (4.5%)	CVT
		Acc-584, 585	Curcumin (5.5%)	CVT
Pottangi	Turmeric	Roma	Dry recovery (26.4%)	CYT
			Curcumin (6.0%)	CYT
Coimbatore	Turmeric	CL-67	Curcumin (6.05%)	-
Dapoli	Cinnamon	A-65	Bank oil (3.19%)	Germplasm
		A-203	Leaf oil (3.05%)	Germplasm
Ambalavayal	Cinnamon	SL-44	Leaf oil (4.00%)	CVT
Jobner	Coriander	UD-797	Volatile oil yield (4.03 l/ha)	IET
		UD-728	Volatile oil yield (3.78 l ha ⁻¹)	IET
		DH-234	Volatile oil (0.51%)	CVT
		UD-42	Volatile oil yield (4.79 l ha ⁻¹)	CVT
Jobner	Cumin	VC-341	Volatile oil yield (12.16 l ha ⁻¹)	CVT
Jagudan	Cumin	JC-2000-21	(11.98 l ha ⁻¹)	CVT
		JC-2000-72	Volatile oil (5.00%)	CVT
Jobner	Cumin	VC-344	Volatile oil (4.93%)	CVT
		VC-343	Volatile oil (4.65%)	CVT

Centre	Crop	Entry	Quality Parameters	Type of trial
Jobner	Fennel	VC-345	Volatile oil yield (15.56 l ha ⁻¹)	CVT
		VC-343	Volatile oil yield (14.35 l ha ⁻¹)	CVT
		UF-177	Volatile oil yield (34.14 l ha ⁻¹)	CVT
		UF-178	Volatile oil yield (34.11 l ha ⁻¹)	CVT
Jagudan	Fennel	RF-31	Volatile oil (2.35%)	CVT
Jobner	Fennel	RF-21	Volatile oil (3.0%)	CVT
		RF-31	Volatile oil (2.8%)	CVT
		UF (M)-1	Volatile oil (2.95%)	IET
		UF (M)-1	Volatile oil yield (29.52 l ha ⁻¹)	IET
		UF-175	Volatile oil yield (26.17 l ha ⁻¹)	IET

Reaction to Pest and diseases in spice crops at AICRPS Centres

Centre	Crop	Pest/disease	Entry	Reaction
Jobner	Coriander	Wilt, powdery mildew and stem gall	UD-480, UD-728, 797, 796	Immune
		Root-knot nematode	RCr-20, UD-262, UD-446 & 480	Resistant
Coimbatore	Coriander	Powdery mildew	Cor-387, DH-246, RD-120	Resistant
Jobner	Fenugreek	Root rot, downy mildew	UM-351 & powdery mildew	Immune
		Root rot, downy mildew	UM-352 & powdery mildew	Resistant
Coimbatore	Turmeric	Leaf spot & leaf blotch	CL-31, 32,33,34,54 & CL-55	Resistant
Jagtial	Turmeric	Rhizome rot	RH-5 & Duggirala Red	Resistant
		Leaf spot	JTS-401 & 402, TCP-1, TCP-2, TCP-11 & NDH-18	Resistant
		Taphrina Leaf blotch	ACC-584, PTS-59, 11,55,52, ACC-593, 595, 657, TCP-11, RH-13/90, 9/90, IT-1, 2,3,4,5 & Duggirala Red, JTS-406, 407, 408,409,410 & 411	Resistant

ICAR – ADHOC PROJECTS

- I. 1. Project title** : Identification and development of diagnostics for the viruses causing stunted disease in black pepper
- 2. Investigator (s)** : A. Ishwara Bhat
R. Suseela Bhai
- 3. Location** : Indian Institute of Spices Research, Calicut
- 4. Duration** : 1-7-2003 to 30-6-2006
- 5. Total cost of the scheme** : Rs.15, 29,616/-
- 6. Progress of work** :

Serological analysis of stunted disease of black pepper isolates revealed the association of *Cucumber mosaic virus* (CMV) and a badnavirus serologically related to *Banana streak virus*. CMV could be easily transmitted mechanically onto several hosts belonging to Chenopodiaceae, Cucurbitaceae and Solanaceae, while badnavirus failed to be transmitted mechanically onto any of the hosts tested.

The badnavirus particles were purified from infected black pepper leaves collected from IISR Farm, Peruvannamuzhi. Electron microscopy of negatively stained purified preparation showed the presence of bacilliform particles of about 120 x 30 nm in diameter.

The antiserum against badnavirus was raised in New Zealand white rabbit by injecting the purified virus particles. Immunoglobulin G (IgG) was purified from the crude polyclonal antiserum and coupled with the enzyme alkaline phosphatase. Double antibody sandwich (DAS) ELISA method was standardized for the detection of badnavirus in diseased black pepper leaves collected from different regions of Karnataka and Kerala.

In order to recover virus-free plants from the infected ones, meristem culture is being attempted. Meristem incubated in MS basal medium without any growth regulator regenerated the shoot system and is being maintained in the rooting medium for rooting. Death of meristem due to polyphenolic exudates, contamination due to endophytic bacteria and fungi are the major problems encountered during meristem culture. Efforts are underway to overcome these difficulties and establish meristem-regenerated plants.

- 7. Technologies/protocol/prototype/model/process/product developed** : A double antibody sandwich (DAS) ELISA based technique has been developed for the detection of Badnavirus in black pepper plants

- II. 1. Project title** : Bioecology and integrated management of root mealybug *Planococcus* sp. infesting black pepper
- 2. Investigator (s)** : S. Devasahayam
K.M. Abdulla Koya
M. Anandaraj
- 3. Location** : Indian Institute of Spices Research, Calicut
- 4. Duration** : 1-7-2003 to 31-6-2006
- 5. Total cost of the scheme** : Rs.10,84,616/-
- 6. Progress of work:**

Distribution : Surveys were carried out in 42 black pepper gardens at 14 locations in Wayanad District in Kerala to study the distribution of root mealybug (*Planococcus* spp.) on black pepper. The pest infestation was observed in 16 gardens at 8 locations. Apart from an undescribed species of *Planococcus*, *P. citri* was also observed to infest roots and bases of stems of black pepper vines.

Bioecology : The life histories of *Planococcus* sp. and *P. citri* were studied. The duration of egg, larva, and pupa, pre-oviposition period and fecundity of females and morphometrics of various stages were determined. Males were not recorded in the undescribed species of *Planococcus* and the females were ovoviparous.

Infestations of *Planococcus* spp. were observed on roots of 11 species of weed plants (belonging to the families Amaranthaceae, Araceae, Asteraceae, Cyperaceae, Euphorbiaceae, Fabaceae, Graminae, Malvaceae, Nephrolepidaceae, Scrophularaceae, Verbenaceae and Zingiberaceae) and also on banana,

coffee, *Erythrina* sp. and rosewood, especially during the summer period. Most of the infested vines were also infested with pathogens such as *Phytophthora capsici*, *Fusarium* sp., *Radopholus similis* and *Meloidogyne incognita*.

Natural enemies : The larval stages of the lycaenid, *Spalgis* sp. were observed to be associated with the root mealybug infested vines.

Evaluation of plant products : Alcoholic and water extracts of 13 plant species and 5 neem products were evaluated against root mealy bug in laboratory bioassays among which alcoholic extracts of leaves of *Azadirachta indica* and *Vitex negundo* and water extracts of custard apple seeds and tobacco leaves were found promising.

Evaluation of bacterial isolates : Twelve bacterial isolates (promising against *P. capsici* and nematodes) were evaluated against root mealybug in laboratory bioassays. However, none of the isolates was promising in reducing the population of root mealybug.

Evaluation of entomopathogens : *Evaluation of 10 isolates of entomopathogenic fungi including 5 commercial formulations in laboratory bioassays indicated that none of them were found promising in reducing the population of root mealybug.*

- III. 1 Project title :** Conservation and evaluation of ajwain (*Trachyspermum ammi* L.) germplasm for identification of high yielding quality oil genotypes
- 2. Investigator (s) :** R.V. Paliwal
Rajesh Pandya
S. R. Ahmad
- 3. Location :** Agricultural Research Sub-station, Maharana Pratap University of Agriculture & Technology, Pratapgarh Dist., Chittorgarh
- 4. Duration :** 1-8-2003 to 31-7-2006
- 5. Total cost of the scheme :** Rs. 10,88,240/-
- 6. Progress of work:**

During April and May, 2004 94 germplasm collections of Ajwain were made from farmer's fields in various districts of Rajasthan and Gujarat. These 94 germplasm alongwith check G.A-1 were sown in augmented design (single row plot) at Agriculture Research Sub Station, Pratapgarh in August 2004 for screening and evaluation. Following observations were recorded for seed yield and its attributing characters :

Character	Range
Days to flower	90-100 days
Days to maturity	140-160 days
No. of primary branches per plant	7-9
Umbels per plant	40-48
Umbellets per umbel	16-22
Seeds per umbellet	15-18
Seed yield per plant	80-100 gms.

These collections were also screened against powdery mildew and leaf blight diseases. During April and May 2005, 101 germplasm collections were made from different districts of Rajasthan, Madhya Pradesh and Gujarat.

- IV. 1. Project title :** Studies on salt tolerance in seed spices (Fennel, Coriander and Fenugreek)
- 2. Investigator (s) :** A. C. Yadav
Avtar Singh
S. K. Sharma
- 3. Location :** Chaudhary Charan Singh, Haryana, Agricultural University, Hisar
- 4. Duration :** 1-4-2004 to 31-3-2007
- 5. Total cost of the scheme :** Rs. 7,52,790/-
- 6. Progress of work :**

Twenty five to twenty seven genotypes of fennel, coriander and fenugreek collected from NRCSS, Ajmer along with released variety of CCS HAU, Hisar were sown in three sets of experiments. The summary of the results of these experiments are as follows

A) Screen house experiment'

1. Fennel

- a) As the salinity level increased, germination was delayed.

- b) At 6.0 dSm⁻¹ ECe, only 9 genotypes (AF-1, AF-31, AF-64, AF-20, AF-50, AF-127, AF-74, JF-303 and HF-33) out of 26 sown could germinate.
- c) At 8.0 and 10.0 dSm⁻¹ ECe, seeds of none of the genotypes germinated.
- d) Growth characters like plant height and number of branches per plant decreased with the increase in salinity level.
- e) Seed yield per plant was higher in control (5.0 to 9.1 g) which reduced with the increase in salinity levels. At 6.0 dSm⁻¹ salinity AF-127 gave highest (3.1g) seed yield followed by AF-1 (3.0g).

2. Coriander

- a. Germination was delayed with increase in salinity level.
- b. At 6.0 dSm⁻¹ salinity, 8 genotypes (ACR-12, ACR-102, ACR-119, ACR-193, ACR-123, ACR-230, ACR-53 and Hisar Anand) were able to germinate.
- c. Growth parameters like branches per plant and plant height were higher in control which were decreased with the increase in salinity level.
- d. In non saline control, yield of 25 genotypes sown ranged from 3.9 to 7.7g per plant. However at 6.0 dSm⁻¹ salinity, per plant yield of the 8 genotypes survived ranged from 2.2 to 3.7g. ACR-12 gave maximum per plant (3.7 g) yield at 6.0 dSm⁻¹ salinity which was followed by ACR-53 (3.1g).

3. Fenugreek

- a. In non saline control all the 27 genotypes sown germinated on 6th day. At 6.0 dSm⁻¹ salinity level also, the seeds of all the 27 genotypes germinated but delayed (18 to 23 days).
- b. At 8.0 dSm⁻¹ ECe, only 12 genotypes were able to germinate (22 to 27 days). No genotypes could germinate at 10.0 dSm⁻¹ salinity level.
- c. After 30 days of germination, none could survive at 6.0 and 8.0 dSm⁻¹ ECe except in control and at 4.0 dSm⁻¹ salinity.

B) Induction of salt tolerance

- a. Germination of fennel and coriander could take place upto 8.0 dSm⁻¹ salinity in all the cycocel

treatments, although it was delayed at higher salinity level.

- b. At 10.0 dSm⁻¹ ECe the seeds of fennel and coriander could not germinate in any of the cycocel treatments. In case of fenugreek, with the seed treatments of cycocel the seeds were able to germinate even at 10.0 dSm⁻¹ salinity.
- c. Cycocel 500 ppm was most effective in terms of growth and yield of the three crops.
- d. In fenugreek cv. Hisar Sonali the plant could survive upto 6.0 dSm⁻¹ salinity with cycocel 500 ppm treatments which gave 6.2 g per plant yield.
- e. In case of salt solution dipping of seeds in 6.0 dSm⁻¹ EC was found effective in terms of growth and yield parameters in the three crops tested.

C) Growing of genotypes in natural land areas suffering from salinity

The genotypes (26 to 27) of the three crops were sown in half an acre of saline field (salinity ranged from 4.2 to 8.5 dSm⁻¹ ECe).

- a) In fennel, AF-1, AF-31, AF-64, AF-20, AF-50, AF-127 and HF-33 genotypes were found tolerant to salinity.
- b) In coriander, ACR-12, ACR-102, ACR-119, ACR-193, ACR-123, ACR-230, ACR-53 and Hisar Anand were found in general tolerant to salinity.
- c) In fenugreek the seeds of 15 genotypes AM-16, AM-191, AM-164, AM-113, AM-124, AM-1, AM-196, HM-3, HM-57, AM-149, AM-189, AM-109, AM-182, AM-170 and AM-61 were germinated but the plants upto harvest were survived only of five genotypes viz. HM-57, AM-196, AM-124, AM-113 and AM-191.

- V. 1. **Project title :** Investigations on the etiology and integrated management of rhizome rot of ginger and turmeric in northern Karnataka
- 2. **Investigator (s) :** Srikant Kulkarni
S. A. Kulkarni
R. V. Hegde
- 3. **Location :** Department of Plant Pathology, University of Agricultural Sciences, College of Agriculture, Dharwad – 580 005, Karnataka

4. **Duration** : 1.7.2003 to 30-6-2005

5. **Total cost of the scheme** : Rs. 16,16,307/-

6. **Progress of work:**

Incidence: The incidence of rhizome rot was very severe on ginger than turmeric in all the localities surveyed. The severity of this disease was up to 60 % in ginger and the maximum incidence was recorded in Uttara Kannada district in Karnataka. Whereas, on turmeric crop, the incidence was observed in sporadic form with the maximum incidence of 3 % in Belgaum district. None of the ginger varieties showed resistance to rhizome rot. The field experiments conducted at Bidar and Sirsi areas revealed that, integrated management approach with Metalaxyl-MZ, Neem cake, Copper oxychloride and *Trichoderma* recorded less incidence with high yield. Planting in March recorded less incidence indicating that early planting helped in escaping the crop from early infection leading to reduction in infection.

Surveys conducted for the incidence of rhizome rot of ginger and turmeric during *kharif* / *rabi* season of 2004 revealed that, rhizome rot incidence was observed in most of the ginger fields throughout the Karnataka. Maximum rhizome rot incidence (23.7 %) was recorded in Shimoga district followed by Kodagu (22.9%), Uttara Kannada (20.2%), Chickmagalur (19.0%) and Bidar (13.8%). Maximum incidence of 47.3% was recorded in Korlakotta village in Sirsi taluk of Uttara Kannada District. The severity of the disease is mainly attributed to poor drainage, heavy rainfall and use of infected rhizomes. Regarding the incidence on turmeric, most of the turmeric growing fields showed low incidence of the rhizome rot incidence throughout the state.

Screening: Among the ginger genotypes screened for their resistance against rhizome rot in sick soil, the

genotype *viz.*, Himachal Pradesh recorded lowest rhizome rot incidence of 16.5%.

Etiology: *Pythium aphanidermatum* (Eds.) Fitz., *Fusarium solani* (Mar.) Sacc., *Sclerotium rolfsii* Sacc., *Ralstonia solanacearum* Yabuuchi (Smith) and *Meloidogyne arenaria* (Neal) Chitwood were isolated from infected samples. *Sclerotium rolfsii*, *R. solanacearum* and *M. arenaria* were recorded for the first time in Karnataka.

Integrated management: *In vitro* screening of botanicals revealed that, asafoetida plant extract was effective against *P. aphanidermatum* and *F. solani*. Among the biocontrol agents tested *in vitro*, the native isolate of *Trichoderma harzianum* (Dharwad) was effective against the above mentioned pathogens. Among the systemic fungicides tested, carbendazim, iprodione + carbendazim (quintal), carboxin and among non systemic fungicides emissan were found best in inhibiting the growth of the pathogens (*P. aphanidermatum* and *F. solani*).

In field experiments conducted at farmers' field, near Sirsi (Uttara Kannada), rhizomes of ginger treated with metalaxyl MZ (0.6 %) + soil applied with talc based *Trichoderma harzianum* (10 kg powder mixed with FYM/ha) + *Eupatorium* as green manure and soil drenching of copper oxychloride (0.3%) as and when the disease appeared, recorded very less rhizome rot incidence (6.9%), compared to maximum incidence of 52.3% in control. Among the turmeric genotypes screened for their resistance against rhizome rot, CO 1 recorded the lowest rhizome rot incidence of 4.2%.

The population of *P. aphanidermatum* and *F. solani* was reduced after soil solarization. Among the different fungicides evaluated for the compatibility, metalaxyl MZ and captan showed maximum growth of *T. harzianum*.

LIST OF PUBLICATIONS

RESEARCH PAPERS

DAPOLI

- Haldankar, P.M., Joshi, G.D., Jamadagni, B.M. and Patil, B.P. 2004. Non-destructive estimation of leaf area in nutmeg (*Myristica fragrance* Houtt.). *Journal Maharashtra Agricultural University*, 29 (2): 146-148.
- Haldankar, P.M., Joshi, G.D., Jamadagni, B.M. and Patil, B.P. 2004. Association of tree architectural characters with yield in nutmeg. *Journal Maharashtra Agricultural University*, 29 (2): 148-151.
- Haldankar, P.M., Joshi, G.D., Patil, B.P. and Haldavnekar, P.C. 2004. Studies on variability of fruit characters in nutmeg (*Myristica fragrance* Houtt.). *Journal Maharashtra Agricultural University*, 29 (2): 152-154.
- Haldankar, P.M., Joshi, G.D., Patil, B.P. and Haldavnekar, P.C. 2004. Variability for growth, flowering and fruit set in seedling progenies of nutmeg (*Myristica fragrans* Houtt.). *Journal of Spices & Aromatic crops*, 13 (1): 28-33.
- Khandekar, R.G., Haldankar, P.M., Pande, V.S., Joshi, G.D., Bagade, D.S., Malve, D.B., Bhagwat, N.R., Rangwala, A.D., Jambhale, N.D. and Ramana, K.V. 2004. Studies on rapid multiplication of black pepper (*Piper nigrum* L.) on soil mound. *Journal of Spices & Aromatic crops*, 13 (1): 34-36.

HISAR

- Kamboj, O.P., Bhatia, A.K., Batra, V. K., Thakral, K.K and Makhan Lal 2004. Effect of weed control treatments on weed spectrum and nutrient uptake by weeds in fenugreek. *Haryana J. Hortic. Sci.*, 33 (1&2): 132-134.
- Tehlan, S.K., Thakral, K. K and Nandal, J.K. 2004. Effect of *Azotobacter* on plant growth and seed yield of fennel (*Foeniculum vulgare* Mill.). *Haryana J. Hortic. Sci.*, 33 (3&4): 287-288.

SOLAN

- Sood, R. and Dohroo, N. P. 2004. Viability of *Phyllosticta zingiberi* Ramakr. causing leaf spot of ginger. *Pl. Dis. Res.*, 19 (2): 163-166.

TECHNICAL PROGRAMMES

Project Code	Title	Centers
a) Ongoing projects		
BLACK PEPPER		
PEP/CI/1	Genetic Resources	
PEP/CI/1.1	Germplasm collection, characterization, evaluation and conservation	Chintapalle, Dapoli, Panniyur, Pundibari, Sirsi and Yercaud
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/3.2	CVT 1991 – Series IV	Dapoli, Yercaud and Ambalavayal, Chintapalle, Pampadumpara, Panniyur, Sirsi and Ambalavayal
PEP/CI/3.3	CVT 2000 – Series V	
PEP/CM/2	Nutrient Management Trial	
PEP/CM/2.1	Effect of biofertilizers, <i>Azospirillum</i> on black pepper	Panniyur, Sirsi, Yercaud and Ambalavayal
PEP/CM/2.2	Effect of biofertilizers, P-solubilizer on black pepper	Panniyur, Sirsi, Yercaud and Ambalavayal
PEP/CM/2.3	Organic farming in black pepper	Panniyur, Sirsi, Yercaud and Ambalavayal
PEP/CM/2.4	Development of organic package for spices based cropping system – Observational trial	Chintapalle, Panniyur, Dapoli and Sirsi
PEP/CP/1	Disease Management Trial	
PEP/CP/1.2	Management of <i>Phytophthora</i> disease in black pepper nursery	Chintapalle, Pampadumpara, Ambalavayal and Dapoli
PEP/CP/1.4	Control of <i>Phytophthora</i> disease of black pepper in farmers' field – observational trial	Mudigere, Pampadumpara, Panniyur, Sirsi and Ambalavayal
PEP/CP/1.5	<i>Phytophthora</i> foot rot incidence in black pepper under different densities in an arecanut garden	Panniyur and Sirsi
PEP/CP/1.6	Incidence, epidemiology and management of anthracnose disease of black pepper	Chintapalle, Dapoli, Mudigere and Pampadumpara
PEP/CP/2	Pest Management Trial	
PEP/CP/2.2	Survey for the incidence of insect- pests on black pepper at high altitudes	Pampadumpara

PEP/CP/2.3	Management of scale-insects of black pepper with organic products	Pampadumpara
CARDAMOM		
CAR/CI/1	Genetic Resources	Mudigere and Pampadumpara
CAR/CI/1.1	Germplasm collection, characterization, evaluation and conservation	
CAR/CI/2	Hybridization and Selection	
CAR/CI/2.1	Evaluation of OP progenies under intensive management	Mudigere
CAR/CI/2.2	Hybridization in cardamom	Mudigere
CAR/CI/3	Coordinated Varietal Trial	
CAR/CI/3.4	CVT 2000- Series IV	Mudigere, Pampadumpara, Myladumpara and Sakleshpur
CAR/CI/3.5	CVT 2004	Pampadumpara, Mudigere, Myladumpara, Thadiyankudisai and Sakleshpur
CAR/CI/4	Varietal Evaluation Trial (VET)	
CAR/CI/4.3	Initial evaluation trial - I	Mudigere
CAR/CI/4.4	Initial evaluation trial - II	Mudigere
CAR/CM/1	Nutrient Management Trial	
CAR/CM/1.3	Integrated nutrient management in cardamom	Mudigere
CAR/CM/1.4	<i>Effect of bio-fertilizer, Azospirillum on cardamom</i>	Mudigere and Pampadumpara, Myladumpara and Sakleshpur
CAR/CM/1.5	Effect of biofertilizers, P. solubilizers on cardamom	Mudigere, Pampadumpara, Myladumpara and Sakleshpur
CAR/CM/1.6	Effect of neem cake on productivity, pest and disease incidence in cardamom	Mudigere, Pampadumpara, Myladumpara and Sakleshpur
CAR/CP/2	Pest Management Trial	
CAR/CP/2.2	Management of root grub of cardamom	Myladumpara, Sakleshpur
CAR/CP/2.3	Bioecology of natural enemies of major pests of cardamom	Mudigere, Pampadumpara
CAR/CP/2.4	Estimation of quantitative and qualitative losses due to thrips damage in cardamom	Mudigere, Pampadumpara
CAR/CP/2.5	Shortly infestation on cardamom – observational trial	Mudigere, Myladumpara and Sakleshpur
GINGER		
GIN/CI/1	Genetic Resources	
GIN/CI/1.1	Germplasm collection, characterization, evaluation and conservation	Dholi, Kumarganj, Pottangi, Pundibari, Raigarh and Solan

GIN/CI/2	Coordinated Varietal Trial	
GIN/CI/2.2	CVT 2000 – Series V	Pundibari, Raigarh and Solan
GIN/CI/3	Varietal Evaluation Trial	
GIN/CI/3.1	Comparative yield trial (CYT-I & II)	Raigarh and Solan
GIN/CI/3.2	Initial evaluation trial (IET)	Solan
GIN/CI/3.3	Comparative yield trial (CYT-III)	Solan
GIN/CI/4	Quality Evaluation Trial	
GIN/CI/4.1	Evaluation of germplasm for quality	Solan
GIN/CM/1	Nutrient Management Trial	
GIN/CM/1.1	Effect of biofertilizer, <i>Azospirillum</i> on ginger	Pundibari, Solan and Ambalavayal
GIN/CM/1.2	Organic farming in ginger	Dholi, Solan
GIN/CM/1.4	Effect of micronutrients on ginger	Dholi, Kumarganj, Pottangi, Pundibari and Raigarh
GIN/CP/1	Disease Management Trial	
GIN/CP/1.1	Disease surveillance and etiology of rhizome rot in ginger	Dholi, Pundibari and Solan
GIN/CP/1.2	Biocontrol studies on rhizome rot of ginger	Dholi, Kumarganj, Pottangi, Raigarh and Ambalavayal
GIN/CP/1.3	Effect of seed treatment on soft rot disease of ginger	Pundibari
GIN/CP/1.4	Integrated management of <i>Pythium</i> , <i>Fusarium</i> and <i>Ralstonia</i> on ginger	Dholi, Kumarganj, Pundibari, Raigarh and Solan
GIN/CP/1.5	Survey and monitoring of diseases in ginger	Dholi, Kumarganj, Pottangi, Pundibari and Raigarh
TURMERIC		
TUR/CI/1	Genetic Resources	
TUR/CI/1.1	Germplasm collection, characterization, evaluation and conservation	Coimbatore, Dholi, Jagtial, Kumarganj, Pottangi, Pundibari and Raigarh
TUR/CI/2	Coordinated varietal trial	
TUR/CI/2.2	CVT 2000 - Series V	Chintapalle, Jagtial, Pundibari, Raigarh, Coimbatore and Kumarganj, Chintapalle, Coimbatore, Jagtial, Kumarganj, Pottangi, Pundibari and Raigarh
TUR/CI/2.3	CVT-2004	
TUR/CI/3	Varietal evaluation trial	
TUR/CI/3.1	Comparative yield trial (1999-2000)	Pundibari and Raigarh
TUR/CI/3.2	<i>Initial evaluation trial</i>	Dholi
TUR/CI/4	Quality evaluation trial	
TUR/CI/4.1	Quality evaluation of germplasm	Coimbatore
TUR/CI/4.2	Impact of environment on quality of turmeric	Coimbatore

TUR/CM/1	Nutrient Management Trial	Coimbatore, Kumarganj, Pundibari and Ambalavayal
TUR/CM/1.1	Effect of biofertilizer, <i>Azospirillum</i> on turmeric	
TUR/CM/1.2	Organic farming in turmeric	Pundibari
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	Coimbatore, Dholi, Jagtial, Pundibari and Raigarh
TUR/CP/1.2	Chemical control measures against leaf blotch disease of turmeric	Pundibari
TUR/CP/1.3	Effect of seed treatment on leaf spot and leaf blotch diseases of turmeric	Dholi, Kumarganj, Pundibari and Raigarh
TUR/CP/1.4	Investigations on the causal organism of rhizome rot of turmeric and screening of biocontrol agents for its management	Coimbatore, Jagtial, Pundibari, Dholi, Kumarganj, Pottangi and Raigarh

TREE SPICES

TSP/CI/1	Genetic Resources	
TSP/CI/1.1	Germplasm collection, characterization, evaluation and conservation of clove, nutmeg and cinnamon	Dapoli and Yercaud/ Pechiparai
TSP/CI/2	Coordinated Varietal Trial	
TSP/CI/2.1	CVT 1992 in clove	Pechiparai
TSP/CI/2.2	CVT 1992 in cinnamon	Ambalavayal
TSP/CI/2.3	CVT 2001 in nutmeg	Dapoli, Sirsi, Pechiparai and Ambalavayal
TSP/CI/2.4	CVT 2001 in cassia	Dapoli, Sirsi, Pechiparai and Ambalavayal
TSP/CM/1	Propagation/Multiplication Trial	
TSP/CM/1.1	Softwood grafting in clove	Dapoli
TSP/CM/2	Irrigation Trial	
TSP/CM/2.1	Drip irrigation in clove and nutmeg	Pechiparai
TSP/CP/1	Disease Management Trial	
TSP/CP/1.1	Survey for disease incidence in tree spices	Dapoli, Pechiparai and Ambalavayal

SEED SPICES

CORIANDER

COR/CI/1	Genetic Resources	
COR/CI/1.1	Germplasm collection, description, characterization, evaluation, conservation and screening against diseases	Coimbatore, Dholi, Guntur, Hisar, Jagudan, Jobner and Kumarganj

COR/CI/1.2	Inter varietal hybridization for evolving high yielding varieties	Jobner
COR/CI/2	Coordinated Varietal Trial	
COR/CI/2.1	CVT 1993 – Series II	Kumarganj and Raigarh
COR/CI/2.2	CVT 1996 – Series III	Kumarganj
COR/CI/2.3	CVT 1998 – Series IV	Guntur
COR/CI/2.4	CVT 2001 – Series V	Coimbatore, Hisar, Jobner, Kumarganj and Raigarh
COR/CI/2.5	CVT – Production of leafy type coriander during off-season	Coimbatore, Guntur, Hisar and Jagudan
COR/CI/3	Varietal Evaluation Trial	
COR/CI/3.2	Initial evaluation trial	Hisar
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 coriander to micronutrients	Kumarganj and Guntur
COR/CM/1.2	Effect of biofertilizer, Azospirillum on coriander	Coimbatore and Kumarganj
COR/CP/1	Disease Management Trial	
COR/CP/1.1	Survey to identify the disease incidence, collection and identification of causal organisms	Dholi
COR/CP/1.2	Management of wilt and powdery mildew diseases in coriander	Coimbatore, Dholi, Kumarganj and Raigarh
COR/CP/1.3	Management of powdery mildew and stem gall in coriander	Coimbatore, Dholi, Jagudan, Jobner, Kumarganj and Raigarh
COR/CM/1.3	Effect of bio-regulators on coriander	Coimbatore, Dholi, Guntur, Hisar, Jagudan, Jobner and Kumarganj
COR/CM/1.4	Identification of drought/alkalinity tolerant source in coriander	Coimbatore, Guntur and Kumarganj
CUMIN		
CUM/CI/1	Genetic Resources	
CUM/CI/1.1	Germplasm collection, characterization, evaluation conservation and screening against diseases	Jagudan, Jobner and Raigarh
CUM/CI/3	Coordinated Varietal Trial	
CUM/CI/3.3	CVT 2001-Series V	Jobner

CUM/CI/4	Varietal Evaluation Trial	Jobner
CUM/CI/4.1	Initial evaluation trial	Jobner
CUM/CI/5	Quality Evaluation Trial	
CUM/CI/5.1	Quality evaluation in cumin	
CUM/CM/1	Nutrient Management Trial	
CUM/CM/1.2	Identification of drought tolerance source in cumin	Ajmer
CUM/CP/1	Disease Management Trial	
CUM/CP/1.3	Management of wilt and blight diseases in cumin	Jagudan and Jobner
CUM/CP/2	Pest Management Trial	
CUM/CP/2.1	Integrated management of pests and disease of cumin	Jobner
FENNEL		
FEL/CI/1	Genetic Resources	
FNL/CI/1.1	Germplasm collection, characterization, evaluation, conservation and screening against diseases	Dholi, Hisar, Jagudan, Jobner and Kumarganj
FNL/CI/2	Hybridization Trial	
FNL/CI/2.1	Mutation studies and crossing programme in fennel	Jagudan
FNL/CI/2.2	Inter-varietal hybridization for evolving high yielding varieties	Jobner
FNL/CI/3	Coordinated Varietal Trial	
FNL/CI/3.2	CVT 2001– Series –IV	Hisar, Kumarganj
FNL/CI/3.3	CVT – 2004	Dholi, Hisar, Jagudan, Jobner and Kumarganj
FNL/CI/4	Varietal Evaluation Trial	
FNL/CI/4.1	Initial evaluation trial	Hisar, Jobner and Jagudan
FNL/CI/4.2	Comparative yield trial	Dholi
FNL/CI/5	Quality evaluation trial	
FNL/CI/5.1	Quality evaluation in fennel	Jobner
FNL/CM/1	Nutrient Management Trial	
FNL/CM/1.2	Effect of biofertilizer, <i>Azospirillum</i> on fennel	Jagudan and Kumarganj
FNL/CM/1.3	Identification of drought/ alkalinity tolerance source in fennel	Kumarganj

FENUGREEK**FGK/CI/1****Genetic Resources**

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

Dholi, Guntur, Hisar, Jagudan, Jobner and Kumarganj

FGK/CI/2**Hybridization Trial**

FGK/CI/2.1 Evolving varieties resistant to powdery mildew

Jagudan, Jobner and Kumarganj

FGK/CI/3**Coordinated Varietal Trial**

FGK/CI/3.1 CVT 1995 – Series III

Guntur, Kumarganj

FGK/CI/3.2 CVT 1999 – Series IV

Kumarganj

FGK/CI/3.3 CVT 2001 – Series V

Coimbatore, Hisar Jobner and Kumarganj

FGK/CI/4**Varietal Evaluation Trial**

FGK/CI/4.1 Comparative yield trial

Guntur, Hisar and Jobner

FGK/CI/4.2 Initial evaluation trial

Dholi

FGK/CI/5**Quality Evaluation Trial**

FGK/CI/5.1 Quality evaluation in fenugreek

FGK/CM/2**Nutrient Management Trial**

FGK/CM/2.2 Effect of biofertilizers, *Azospirillum* *Rhizobium* on fenugreek

Coimbatore, Jagudan and Kumarganj

FGK/CM/2.3 Identification of drought/tolerance source in fenugreek

Coimbatore and Guntur

FGK/CP/1**Disease Management Trial**

FGK/CP/1.1 Biocontrol of root rot in fenugreek

Coimbatore

VANILLA

VAN/CI/1.1 Germplasm collection, characterization, evaluation and conservation

Panniyur, Pechiparai, Ambalavayal, Myladumpara, Coimbatore, Mudigere, Dapoli and Sirsi

PAPRIKA

PAP/CI/1.1 Germplasm collection, characterization,

Pechiparai, Myladumpara, Guntur, Coimbatore and Yercaud

b) Closed projects**BLACK PEPPER**

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

Pampadumpara

CARDAMOM

CAR/CI/3.2 CVT 1991/1998 –Series III with Malabar types
CAR/CI/3.3 CVT 1991/1998 –Series III with Mysore types

Sakleshpur
Sakleshpur

CAR/CI/4.1	Yield evaluation of open pollinated seedling progenies (VET-I)	Mudigere
CAR/CI/4.2	Yield evaluation of promising cardamom selection (VET-II)	Mudigere
CAR/CI/5.1	Screening cardamom clones for abiotic stress	Mudigere
CAR/CP/2.1	<i>Evaluation of plant based insecticides for the control of thrips and fruit borers in cardamom</i>	Mudigere
CAR/CP/2.2	Management of root grub of cardamom	Pampadumpara
GINGER		
GIN/CI/2.2	CVT 2000- Series V	Chintapalle and Pottangi
GIN/CI/3.1	Comparative yield trial	Pottangi
GIN/CI/3.2	Initial evaluation trial	Pottangi
GIN/CM/1.1	Effect of biofertilizer, <i>Azospirillum</i> on ginger	Pottangi and Raigarh
GIN/CM/1.2	Organic farming in ginger	Pottangi and Raigarh
GIN/CP/1.2	Biocontrol studies on rhizome rot of ginger	Pundibari
GIN/CP/1.3	Effect of seed treatment on soft rot disease of ginger	Dholi
TURMERIC		
TUR/CI/2.2	CVT 2000 – Series V	Pottangi
TUR/CI/3.1	Comparative yield trial (1999-2000)	Jagtial and Pottangi
TUR/CI/3.2	Initial evaluation trial	Pottangi
TUR/CI/4.2	Impact of environment on quality of turmeric	Pottangi
TUR/CM/1.1	Effect of biofertilizer, <i>Azospirillum</i> on turmeric	Pottangi and Raigarh
TUR/CM/1.2	Organic farming in turmeric	Raigarh
CORIANDER		
COR/CI/2.2	CVT 1996 – Series III	Dholi
COR/CI/2.4	CVT 2001 – Series V	Dholi, Guntur and Jagudan
COR/CI/3.2	Initial evaluation trial	Dholi, Guntur, Jagudan and Jobner
COR/CM/1.2	Effect of biofertilizers, <i>Azospirillum</i> on coriander	Jobner
COR/CP/1.2	Management of wilt and powdery mildew diseases in coriander	Jobner and Jagudan
CUMIN		
CUM/CI/3.3	CVT 2001 Series V	Jagudan
CUM/CI/4.1	Initial evaluation trial	Jagudan

CUM/CI/4.2	Initial evaluation trial	Jagudan
CUM/CM/1.1	Effect of biofertilizers, <i>Azospirillum</i> on cumin	Jagudan and Jobner
CUM/CP/2.1	Integrated management of pests and disease of cumin	Jagudan
FENNEL		
FNL/CI/3.2	CVT 2001-Series –IV	Jobner
FNL/CM/1.2	Effect of biofertilizers, <i>Azospirillum</i> and P-solubilizers on fennel	Jobner
FENUGREEK		
FGK/CI/1.1	Sub project : Genotypes for un-irrigated areas	Dholi
FGK/CI/3.2	CVT 1999 Series IV	Dholi
FGK/CI/3.3	CVT 2001 – Series V	Dholi, Guntur and Jagudan
FGK/CI/4.1	Comparative yield trial	Dholi
FGK/CI/4.2	Initial evaluation trial	Dholi and Jagudan
FGK/CM/2.2	Effect of biofertilizers, <i>Azospirillum</i> / <i>Rhizobium</i> on fenugreek	Jobner

ACRONYMS

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

STAFF POSITION
PROJECT COORDINATOR'S CELL
Indian Institute of Spices Research
Calicut – 673 012, Kerala

Project Coordinator	:	Dr K V Ramana (upto 27.01.2005) Dr V A Parthasarathy (w.e.f. 27.01.05)
Scientist SS (Hort.)	:	Dr K N Shiva
Technical Information Officer	:	Dr Johny A Kallupurackal
Personal Assistant	:	Ms Alice Thomas
Supporting Staff	:	Mr K Chandran

COORDINATING CENTRES

1. Cardamom Research Station, KAU, Pampadumpara

1. Assoc. Professor (Pl. Breeding)	:	Ms Susamma P George
(Posted at RARS Ambalavayal)	:	
2. Asst. Professor (Agron. /Hort.)	:	Dr K Vasantha Kumar
3. Asst. Professor (Ag. Entomology)	:	Dr A Joseph Rajkumar
4. Farm Assistant (Sel. Gr.)	:	Mr C G Pradeep
5. Lab Assistant (Grade II)	:	Mr C S Manoj
6. Peon	:	Mr Paulose Mathew

2. Pepper Research Station, KAU, Panniyur

1. Assoc. Professor (Pl. Pathology)	:	Dr K P Mammooty
2. Assoc. Professor (Pl. Breeding)	:	Dr V P Neema
3. Asst. Professor (Pl. Pathology)	:	Dr G Sivakumar
4. Asst. Professor (Agro./ Hort.)	:	Vacant
5. Farm Supervisor (Gr. I)	:	Mr P J Joseph
6. Farm Supervisor (Gr. II)	:	Mr K A Kurien
7. Farm Supervisor (Sr Gr)	:	Mr P P Muralidharan
8. Lab Assistant (Gr. III)	:	Ms Nirmala Chellath
9. Peon (Sel. Gr.)	:	K Rajeev

3. Regional Research Station, UAS (Bangalore), Mudigere

1. Pathologist	:	Mr L Arasumallaiah
2. Agronomist (Hort.)	:	Dr M Dinesh Kumar
3. Breeder	:	Dr B M Dushyantha Kumar

4. Jr. Entomologist : Dr D Jemla Naik
5. Technical Assistant : Mr Narayana
6. Technical Assistant : Mr V Mallikarjunappa
7. Messenger : Ms Savithri

4. Agricultural Research Station, UAS (Dharwad), Sirsi

1. Jr. Pathologist (Assoc. Prof.) : Dr. M S Lokesh
2. Jr. Horticulturist : Mr. Nagesh Naik
3. Technical Assistant : Mr G V Heregowder

5 Horticultural Research Station, TNAU, Yercaud

1. Agronomist (Hort.) : Dr V Lakshmanan
2. Jr. Breeder (Hort.) (Posted at HRS Pechiparai) : Dr Prem Jousha
3. Lab Assistant : Mr P Pappu

6 Department of Spices & Plantation Crops, TNAU, Coimbatore

1. Breeder (Horticulturist) : Dr S Subramanian (upto 11.5.05)
2. Jr. Pathologist : Dr E Rajeswari (upto 30.11.04)
(Research Associate)
Dr. K. Kumar (11.12.04 to 07.1.05)
Dr V Sendhilvel (w.e.f. 10.1.05)
3. Agricultural Assistant : Mr R Swaminathan

7 Regional Agricultural Research Station, ANGRAU, Chintapalle

1. Horticulturist : Sri D Lakshminarayana (w.e.f 19-1-2004)
2. Junior Pathologist : Smt V Prasanna Kumari
3. Technical Assistant : Vacant (since April 1990)

8 Regional Agricultural Research Station, ANGRAU, Jagtial

1. Jr. Pathologist : Dr M. Padma Sri
2. Jr. Horticulturist : Mr M Raja Naik
3. Technical Assistant : Mr K Shankarajah

9 Regional Agricultural Research Station, ANGRAU, Guntur

1. Horticulturist : Smt C Sarada
2. Jr. Breeder (Hort.) : Sri K Giridhar
3. Sub Assistant : Mr U Veerabhadra Rao

10 Department of Vegetable Crops, Dr YSPUHF, Solan

1. Breeder (Olericulturist) : Dr B N Korla
2. Jr. Plant Pathologist : Dr N P Dohroo

3. Jr. Biochemist : Dr Neerja Rana
4. Field Assistant : Mr Rajeshwar Chauhan

11 High Altitude Research Station, OUAT, Pottangi

1. Breeder : Dr. S. Rath (ADR in-charge) (Post Vacant)
2. Jr. Breeder : Mr D K Dash
3. Jr. Technical Assistant : Mr R C Dash
4. Jr. Technical Assistant : Mr B N Sahoo

12 Department of Plant Breeding, SKN College of Agriculture, RAJAU, Jobner

1. Sr. Breeder : Dr D L Singhania
2. Breeder : Dr Dhirendra Singh
3. Agronomist : Dr N L Jat
4. Jr. Agronomist : Dr. N K Jain (w.e.f. 18.10.2004)
5. Jr. Plant Pathologist : Mr. M P Jain
6. Jr. Biochemist : Dr Sanjeev Agrawal (on leave)
7. Sr. Technical Assistant : Dr S S Rajput
8. Jr. Technical Assistant : Mr S R Kumawat

13 Spices Research Station, GAU, Jagudan

1. Sr. Plant Pathologist : Dr K D Patel
2. Jr. Breeder : Mr G M Patel
3. Technical Assistant : Mr S R Chaudhari

14. Department of Vegetable Crops, CCS HAU, Hisar

1. Olericulturist/Horticulturist : Dr K K Thakkral
2. Assistant Scientist (VC) : Dr Suresh Tehlan

15. Tirhut College of Agriculture, RAU, Dholi

1. Horticulturist : Dr S P Singh
2. Pathologist : Dr. M.M. Jha (Contract staff)
Vacant (from 01.1.2001)
3. Technical Assistant : Contract staff
Vacant since inception of the project

16 Najendra Dev University of Agriculture and Technology, NDUAT, Kumarganj

1. Horticulturist : Dr J Dixit (upto 07.4.2004)
Dr V P Pandey (w.e.f. 28.4.2004)
2. Jr. Pathologist : Dr R P Saxena
3. Assistant Breeder : Mr V K Singh
4. Technical Assistant : Mr R K Gupta
Mr V K Singh

17 Uttar Banga Krishi Viswa Vidhyalaya, UBKV, Pundibari

- | | | |
|------------------------|---|--------------------------|
| 1. Horticulturist | : | Vacant (from 20.11.2003) |
| 2. Jr. Breeder | : | Dr S K Dash |
| 3. Jr. Pathologist | : | Mr S Bandyopadaya |
| 4. Technical Assistant | : | Mr B Mazumder |
| 5. Technical Assistant | : | Vacant |

18 Konkan Krishi Vidya Peeth, KKV, Dapoli

- | | | |
|--------------------------|---|---|
| 1. Horticulturist | : | Dr P M Haldankar |
| 2. Jr. Plant Pathologist | : | Dr V S Pande (upto 31.5.2004)
Prof U A Garde (w.e.f.14.6.2004) |
| 3. Jr. Breeder | : | Prof R G Khandekar |
| 4. Technical Assistant | : | Mr S D Tambe |
| 5. Technical Assistant | : | Mr A B Jadhav |

19 Indira Gandhi Krishi Vishwa Vidhyalaya, IGKV, Raigarh

- | | | |
|------------------------|---|----------------|
| 1. Horticulturist | : | Dr C R Gupta |
| 2. Jr. Breeder | : | Dr N S Tomar |
| 3. Jr. Pathologist | : | Dr A K Singh |
| 4. Technical Assistant | : | Mr D S Kshatri |
| 5. Technical Assistant | : | Vacant |

ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES
BUDGET PROVISION 2004-05

Name of the centers	Pay & Allowances					Total RC		Grand total	Grand Total	
	Estt.	ICAR share	TA	ICAR share	RC	ICAR share	Tech. Assmt. ICAR share		ICAR share	SAU share
Pampadumpara (KAU)	8.819	6.6140	0.292	0.219	1.982	1.4870		11.093	8.320	2.773
Panniyur (KAU)	11.147	8.3600	0.423	0.317	2.610	1.9580	0.10	14.280	10.735	3.545
Mudigere (UAS-B)	10.333	7.7500	0.423	0.317	2.610	1.9580		13.366	10.025	3.342
Sirsi (UAS-D)	3.533	2.6500	0.261	0.196	1.255	0.9410		5.049	3.787	1.262
Yercaud (TNAU)	5.973	4.4800	0.261	0.196	1.255	0.9410		7.489	5.617	1.872
Coimbatore (TNAU)	6.173	4.6300	0.261	0.196	1.255	0.9410	0.10	7.789	5.867	1.922
Chintapalli (APAU)	3.944	2.9580	0.261	0.196	1.255	0.9410		5.460	4.095	1.365
Jagtial (APAU)	4.853	3.6400	0.261	0.196	1.255	0.9410	0.05	6.419	4.827	1.592
Guntur (APAU)	4.280	3.2100	0.261	0.196	1.255	0.9410	0.05	5.846	4.397	1.449
Solan (YSPUHF)	7.727	5.7950	0.292	0.219	1.882	1.4120	0.05	9.951	7.476	2.475
Pottangi (OUAT)	6.305	4.7290	0.261	0.196	1.255	0.9410	0.10	7.921	5.966	1.955
Jobner (RAJAU)	4.539	3.4040	0.456	0.342	3.238	2.4290	0.15	8.383	6.325	2.058
Jagudan (GAU)	8.507	6.3800	0.262	0.196	1.255	0.9410	0.10	10.124	7.617	2.506
Hisar (HAU)	7.800	5.8500	0.262	0.196	1.255	0.9410	0.10	9.417	7.087	2.329
Dholi (RAU)	1.663	1.2470	0.262	0.196	1.255	0.9410	0.05	3.230	2.434	0.795
Kumarganj (NDUAT)	9.473	7.1050	0.392	0.294	1.882	1.4110		11.747	8.810	2.937
Pundibari (BCKVV)	5.151	3.8630	0.292	0.219	1.882	1.4110	0.05	7.375	5.543	1.831
Dapoli (KKV)	7.140	5.3550	0.292	0.219	1.882	1.4120	0.05	9.364	7.036	2.329
Raigarh (IGKV)	7.140	5.3550	0.292	0.219	1.882	1.4120	0.05	9.364	7.036	2.329
Grand Total	124.500	93.375	5.767	4.325	32.400	24.300	1.00	25.30	123.000	40.667

(Rs. in lakhs)

ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES
2004-2005

Statement of Fund Released During 2004-2005 (ICAR Share)

Centre	Allocation 2004-05	Amount released			Add. fund released	Grand total released
		First half	Second half	Total		
Pampadumpara (KAU)	8.320	4.160	4.160	8.320		8.320
Panniyur (KAU)	8.735	4.418	4.317	8.735	2.000	10.735
Mudigere (UAS-B)	11.194	5.597	4.428	10.025		10.025
Sirsi (UAS-D)	3.787	1.894	1.893	3.787		3.787
Yercaud (TNAU)	4.617	2.309	2.308	4.617	1.000	5.617
Coimbatore (TNAU)	4.867	2.484	2.383	4.867	1.000	5.867
Chintapalle (APAU)	4.767	2.384	1.711	4.095		4.095
Jagtial (APAU)	3.827	1.939	1.888	3.827	1.000	4.827
Guntur (APAU)	4.817	2.434	1.963	4.397		4.397
Solan (YSPUHF)	6.476	3.263	3.213	6.476	1.000	7.476
Pottangi (OUAT)	5.446	2.773	2.673	5.446	0.520	5.966
Jobner (RAJAU)	12.499	6.325	0.000	6.325		6.325
Jagudan (GAU)	4.867	2.484	2.383	4.867	2.750	7.617
Hisar (HAU)	5.797	2.949	2.848	5.797	1.290	7.087
Dholi (RAU)	4.817	2.434	0.000	2.434		2.434
Kumarganj (NDUAT)	7.060	3.530	3.530	7.060	1.750	8.810
Pundibari (UBKWV)	7.035	3.543	2.000	5.543		5.543
Dapoli (KKV)	7.036	3.543	3.493	7.036		7.036
Raigarh (IGKWV)	7.036	3.543	3.493	7.036		7.036
Grand Total	123.000	62.006	48.684	110.690	12.310	123.000

The sanctioned RE was Rs.130.00 L vide letter No.15-56-IA-V dated 12 January 2005 and the amount of Rs.7.00L has been surrendered to ICAR (limiting to Rs.123.00L as per X Plan EFC) vide letter No.Funds (1) Accts/2004-05 dated 28 February 2005. An amount of Rs.12.31 L obtained as savings from Mudigere (Rs.1.169 L), Chintapalle (Rs.0.672 L); Guntur (Rs. 0.42.0 L); Jobner (Rs. 6.174 L); Dholi (Rs.2.383 L); Pundibari (Rs.1.492 L). The overall savings of Rs.12.31 lakhs has been released to 9 centers as additional fund under pay & allowance and the RE limited to Rs. 123.00 Lakh including Rs. 1.00 Lakh spent for technology assessment.

METEOROLOGICAL DATA 2004**Pampadumpara**

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	31.6	2	25.1	15.9	91.3	53.7
February	31.2	2	26.9	16.4	85.0	40.8
March	53.4	2	28.8	18.6	91.2	49.7
April	117.6	7	29.9	19.2	91.5	49.3
May	216.4	17	23.8	18.1	96.8	79.4
June	331.4	22	22.9	17.9	97.5	84.6
July	186.0	21	22.5	17.8	97.9	87.3
August	253.2	16	22.7	17.4	97.7	82.0
September	138.8	10	25.0	17.8	96.9	76.1
October	232.0	13	24.3	18.1	95.3	76.8
November	120.4	10	22.7	17.2	94.4	78.4
December	9.8	1	23.6	15.4	91.5	64.6

Panniyur

Month	Rain fall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)
			Max	Min.	
January	-	-	34	22	88.1
February	-	-	35.8	23.6	80.7
March	-	-	36.5	25.8	85
April	93.3	5	36.5	26.5	83.5
May	829.7	21	31.4	25.3	90
June	1230.6	26	29.9	25.3	92.4
July	578.3	26	28.8	24.5	91.6
August	670.2	24	28.9	24.8	90.3
September	196.7	13	31.6	25.1	88.6
October	247.8	14	32.3	24.8	88.8
November	193.3	10	33.3	23.4	91.9
December	-	-	34.9	20.9	94.4

Mudigere

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	--	--	27.66	14.32	88.25	64.41
February	--	--	29.81	16.03	88.27	57.03
March	20.6	01	31.59	17.69	83.74	53.67
April	113.4	06	29.96	18.63	84.23	58.83
May	308.8	19	27.40	20.00	83.54	65.03
June	838.0	21	23.91	19.43	88.96	73.90
July	205.2	23	25.69	19.16	89.64	68.45
August	517.3	20	24.27	18.24	89.87	74.25
September	131.0	08	26.30	18.68	89.43	64.73
October	126.4	04	27.77	19.93	84.70	61.19
November	21.4	02	32.38	19.26	79.30	49.80
December	--	--	26.91	14.64	77.96	41.38

Sirsi

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	0	0	31.26	18.10	83.58	71.03
February	0	0	34.08	15.48	78.32	60.96
March	0	0	34.35	19.00	82.77	63.97
April	10.80	2	34.23	20.63	71.23	53.63
May	99.00	5	29.03	21.55	76.84	61.32
June	543.70	19	26.0	21.4	86.33	76.87
July	337.70	22	25.04	21.27	87.68	82.81
August	617.20	22	24.26	20.66	92.00	86.68
September	113.40	14	27.52	20.35	87.67	78.07
October	24.30	3	28.39	19.16	86.65	73.42
November	14.50	2	29.05	16.91	83.53	75.00
December	0	0	29.24	12.69	80.39	61.00

Coimbatore

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	10.0	1	30.7	19.0	86	41
February	-	-	32.4	18.3	80	31
March	0.5	-	35.8	20.8	80	25
April	107.2	8	35.7	24.1	87	44
May	167.6	11	30.9	22.9	89	64
June	51.8	7	30.6	22.5	83	57
July	46.4	3	31.2	22.6	84	58
August	27.0	3	31.5	22.1	85	53
September	96.9	7	31.6	22.3	88	58
October	288.8	15	29.9	21.7	91	63
November	155.8	9	28.3	20.8	91	65
December	0.4	-	29.5	18.3	89	45

Chintapalle

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	3.8	1	26.1	9.3	84.7	54.9
February	9.4	2	28.2	11.8	84.8	44.2
March	7.0	2	33.5	13.6	76.2	34.9
April	174.2	9	32.7	18.8	71.8	54.4
May	46.2	4	31.4	18.2	74.2	58.4
June	241.6	8	30.2	20.4	75.4	62.6
July	153	15	28	20.7	91.3	74.3
August	124.6	13	27.1	20.9	84.4	76.2
September	183.6	10	29.1	19.1	88.8	75.5
October	81.2	6	28.6	17.3	88.6	69
November	31.8	1	28.9	10.8	82	45.2
December	-	-	28.2	6.3	82.7	42.8

Jagtial

Month	Rainfall (mm)	Temperature (°C)		Relative humidity (%)	
		Max.	Min.	Max.	Min.
January	1.6	29.2	15.4	80.5	49.7
February	0.2	31.5	16.6	73.0	35.6
March	0.0	37.9	20.2	66.5	34.5
April	18.8	40.4	24.4	58.8	32.8
May	8.4	40.0	27.2	62.9	39.4
June	48.6	37.6	26.8	65.3	45.8
July	265.2	32.1	24.4	81.8	66.2
August	66.0	30.8	24.1	80.8	70.5
September	104.2	33.1	24.1	82.1	61.7
October	35.8	33.0	20.7	74.5	45.3
November	7.2	32.2	17.7	70.8	35.5
December	0.0	31.0	12.7	64.9	30.8

Guntur

Month	Rain fall	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
			Max.	Min.	Max.	Min.
January	0	0	29.38	17.20	91.74	56.00
February	0	0	32.25	18.64	82.75	44.68
March	3.20	1	35.83	22.19	83.06	42.03
April	0	0	37.84	27.04	74.80	45.33
May	139.30	7	37.50	26.65	70.58	47.00
June	135.10	8	36.63	26.71	74.06	46.00
July	155.20	12	32.57	24.88	86.80	64.51
August	92.00	6	34.17	25.58	73.51	53.45
September	226.50	11	32.43	24.43	86.80	68.26
October	69.70	6	31.06	23.47	81.83	74.93
November	7.00	1	30.65	20.36	86.13	60.63
December	0	0	30.25	16.64	86.87	56.03

Solan

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	-	-	19.2	0.7	85	36
February	41.4	2	15.1	2.2	94	64
March	-	-	26.5	7.5	67	33
April	3.4	-	31.1	13.5	67	33
May	-	-	34.4	15.7	52	24
June	30.6	3	30.1	16.6	70	55
July	30.4	4	31.5	20.9	84	64
August	36.03	3	27.9	20.0	98	82
September	-	-	31.5	17.1	81	48
October	84.0		24.7	10.9	80	64
November	-	-	24.2	5.8	83	46
December	-	-	24.8	4.8	76	32

Pottangi

Month	Rain fall	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	Nil	Nil	32	11	70.5	58
February	42.5	1	30	17	90	60
March	52.5	2	33	22	85	58
April	18.05	8	36	20	98	40
May	82.5	2	37	23	95	40
June	449.5	7	32	22	100	60
July	492.5	14	27	22	100	80
August	242.5	15	31	21	100	65
September	201.0	9	30	22	98	60
October	295.5	9	30	20	100	70
November	77.5	2	26	14	100	60
December	—	—	26	13	90	50

Jobner

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	0	0	22.04	4.90	90.80	45.40
February	0	0	28.27	6.97	78.00	29.00
March	0	0	36.27	13.35	60.25	22.75
April	3.1	1	38.60	21.58	47.80	22.00
May	4.6	1	41.15	27.20	45.00	19.75
June	8.2	1	37.37	27.10	54.50	31.00
July	192.5	7	36.76	26.08	66.60	42.00
August	231.5	14	31.50	24.13	90.50	71.50
September	4.8	1	35.70	22.67	72.00	39.50
October	21.8	2	31.74	15.90	78.60	41.80
November	0	0	30.20	9.17	72.75	23.75
December	0	0	24.85	6.47	80.25	30.25

Jagudan

Month	Rain fall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)
			Max.	Min.	
January	-	-	24.6	13.1	43.7
February	-	-	23.7	10.4	46.6
March	-	-	34.4	14.5	41.3
April	-	-	37.3	21.9	40.4
May	421	2	43.4	26.2	46.3
June	32	3	43.0	26.6	54.1
July	-	-	37.3	27.9	75.0
August	96	6	31.7	24.6	89.6
September	-	-	35.3	25.4	86.3
October	5	1	33.6	24.6	80.7
November	-	-	34.1	19.2	61.3
December	-	-	32.5	14.8	52.1

Hisar

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
					January	22.23
18.3	4.0	93	54			
February	56.5	6	20.5	7.4	93	58
March	57.2	6	27.8	13.1	94	51
April	21.0	1	38.3	19.6	59	25
May	55.1	2	38.8	23.3	61	31
June	61.7	3	37.6	24.6	70	43
July	0.0	0	39.2	27.4	69	41
August	86.6	12	33.9	25.0	88	65
September	41.0	2	35.4	22.5	79	44
October	36.4	2	31.1	16.4	88	43
November	0.0	0	28.8	9.3	90	35
December	2.0	1	22.4	6.2	94	49

Dholi

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	40.0	2	18.5	9.5	89	68
February	3.0	1	25.2	11.2	84	46
March	0	0	32.3	17.4	83	44
April	60.0	4	33.1	22.0	79	54
May	133.0	7	35.3	24.2	80	49
June	185.0	11	33.5	26.1	84	64
July	520.0	16	31.7	26.7	88	74
August	110.5	11	32.8	27.7	85	72
September	115	2	33.3	26.9	88	68
October	0	0	31.1	21.4	88	54
November	0	0	28.3	14.5	88	45
December	0	0	23.8	11.6	90	56

Kumarganj

Month	Rain (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	23.0	8.00	22.4	7.5	88.0	57.2
February	8.6	3.00	24.5	10.5	90.0	51.6
March	11.2	2.00	33.0	16.0	91.8	35.7
April	0.00	0.00	38.9	17.9	92.2	23.2
May	18.4	3.00	39.7	23.0	81.6	25.7
July	235.8	14.00	23.4	26.1	89.4	72.5
August	152.6	12.00	33.5	26.2	91.3	75.1
September	109.9	9.00	33.9	25.1	91.0	71.0
October	40.4	2.00	31.7	18.6	89.5	28.4
November	0.00	0.00	28.2	11.1	85.2	42.3
December	0.00	0.00	22.4	8.0	85.2	56.2

Pundibari

Month	Rainfall (mm)	Temperature (°C)		Relative humidity (%)	
		Max.	Min.	Max.	Min.
January	-	23.2	9.5	85	62
February	-	25.6	10.1	90	57
March	16.0	30.8	17.1	91	60
April	216.0	32.0	18.7	90	65
May	315.0	33.6	19.8	94	70
June	425.0	36.6	22.1	94	74
July	813.4	32.9	22.0	95	75
August	245.0	33.6	23.4	96	72
September	656.4	32.6	22.7	94	81
October	-	30.3	18.4	95	80
November	-	29.5	13.2	91	76
December	-	27.9	9.8	89	58

Dapoli

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative humidity (%)	
			Max.	Min.	Max.	Min.
January	0.0	0	31.1	14	95	60
February	3.0	1	32.8	14	93	49
March	0.0	0	33.8	16.4	89	49
April	00	00	33.2	19.5	93	75
May	88.3	7	33.4	24.1	92	69
June	1097.6	21	29.9	23.3	94	87
July	1093.0	29	28.1	23.1	97	92
August	915.3	26	27.0	23.0	97	94
September	322.0	18	29.0	22.0	98	89
October	20.8	1	32	19.5	93	71
November	17.4	2	32.8	17.4	94	61
December	00	00	81.0	15.0	95	43

Raigarh

Month	Rainfall (mm)	Temperature (°C)		Relative humidity (%)	
		Max.	Min.	Max.	Min.
January	-	21.77	11.93	73.22	46.06
February	-	28.50	16.96	68.79	44.71
March	-	35.70	21.06	71.22	28.22
April	-	41.73	23.16	68.53	26.80
May	-	41.70	29.19	69.38	31.51
June	15.68	42.86	16.13	84.03	55.03
July	33.60	34.45	25.45	91.58	74.77
August	47.30	29.61	25.61	89.83	71.87
September	0.63	33.26	28.96	81.39	67.96
October	4.50	28.93	23.64	83.09	67.19
November	-	28.10	15.26	79.36	53.10
December	4.32	25.35	11.38	74.25	50.96

Pechiparai

Month	Rainfall (mm)	No. of rainy days	Temperature (⁰ C)		Relative humidity (%)
			Max.	Min.	
January	25.2	2	30.3	20.5	75.2
February	54.3	9	32.4	21.3	77.7
March	68.9	7	34.8	26.4	73.2
April	241.4	10	34.0	22.4	87.9
May	367.4	16	31.0	23.6	89.1
June	257.5	16	30.7	23.3	87.7
July	161.5	11	30.1	23.4	89.5
August	66.4	6	31.5	23.3	84.7
September	233.2	10	30.9	22.5	88.8
October	175.9	17	30.5	22.9	89.7
November	86.1	9	30.7	22.4	88.0
December	54.4	4	34.0	21.0	87.9

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