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ANNUAL REPORT
2006 - 07

अखिल भारतीय समन्वित मसाला अनुसंधान परियोजना ए आई सी आर पी एस
All India Coordinated Research Project on Spices
AICRPS

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

ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

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परियोजना समन्वयक की रिपोर्ट

अखिल भारतीय समन्वित मसाला अनुसंधान परियोजना (ए आई सी आर पी एस) अपना मुख्यालय भारतीय मसाला फसल अनुसंधान संस्थान, कालिकट में 12 मसले फसलों में अनुसंधान का आयोजन और समन्वय करने के लिए निहित होता है! ए आई सी आर पी एस का अब 19 केन्द्र, जो 14 राज्यों में व्याप्त 15 राज्य कृषि विश्व विद्यालय में स्थित है! इसके अलावा 4 आश्रित केन्द्र है, जिसमें भारतीय इलायची अनुसंधान संस्थान (स्पाइसस बोर्ड) भी शामिल होता है, इस परियोजना के साथ सहयोगी कार्य किये जा रहे हैं। ए आई सी आर पी एस की दसवीं योजना की बजट 700 लाख रूपए है जिसमें वर्ष 2006- 07 का 115 459 लाख रूपए (आई सी ए आर का हिस्सा) भी शामिल होता है! अधिदेश मसाले फसलो का लगभग 100 शोध कार्यक्रम विभिन्न केन्द्रों मे आयोजित किये जा रहे है!

काली मिर्च

ए आई सी आर पी एस के विभिन्न केन्द्रो में काली मिर्च का लगभग 691 जर्मप्लासम बनाये रखे हैं। दापोली और पुंडिबारी केन्द्रों ने दो संचित किये और इसके साथ सात नये जर्मप्लासम को क्रमश: रत्नगिरी और उप हिमालयन क्षेत्रों से संचित किया है! पन्नियूर में किये लक्षण वर्णन के फलस्वरूप करिमुंडा III (4 57 कि.ग्राम), टीएमबी IV(4.09 कि. ग्राम) और करिमुंडा II (3.75 कि.ग्राम/वाइन) जैसे अधिक उपजवाली अक्सशनों की पहचान की गयी। येरकाड में पन्नियूर-3 अधिकतम उपज 2.6 कि ग्राम/वाइन अंकित की। पन्नियूर और सिरसी में किये परीक्षण के फलस्वरूप संस्तुत मात्रा में एनपीके लगाने के साथ जैवउर्वरक (अजोस्पिरिल्लम@ 50 ग्राम/फोस्फोबैक्टीरिया @ 50 ग्राम)+ एफवाईएम 10 कि.ग्राम लगाने पर प्रत्येक वाइन से अधिकतम उपज प्राप्त हुए। अजोस्पिरिल्लम और फोस्फोबैक्टीरिया वीएएम के साथ मिलाकर लगाने पर ओरगानिक फार्मिग के अन्तर्गत उपजता बढते देख ली। पन्नियूर, सिरसी, मुडिगरे और पाम्पाडुमपारा में काली मिर्च के फाइटोफथोरा खुर गलन रोग प्रबन्धन के लिए किये परीक्षण से प्रकट होता है कि पोटाशियम फोस्फोनट (0.3%) ट्राइकाडरमा हरजियानम (50ग्राम/वाइन) की दर में लगाने पर रोग नियन्त्रण प्रभावी होने के साथ अधिकतम उपजता भी प्राप्त हुई!

इलायची

दो केन्द्रों (पाम्पाडुमपारा और मुड़िगरे) में तीन सौ पांच जर्मप्लासम को बनाये रख गये! पाम्पाडुमपारा में किये सीवीटी परीक्षण में प्रति पौधे की अधिकतम उपज एस1 (510.15 ग्राम) मे अंकित किया जिसके पीछे पीएस 44(417.43 ग्राम) आता है! उपजता के लिए प्रारंभिक खेत मूल्यांकन परीक्षण के आधार पर मुड़िगरे, पाम्पाडुमपारा और सकलेशपुर से दो प्रविष्टियों को नये सीवीटी के लिए प्रस्तावित किया! इलायची के लिए आयोजित जैव उर्वरक परीक्षण से स्पष्ट होता है कि उपजता के लिए, अजैव नाइट्रोजन (100%)+ अजोस्पिरिल्लम (50 ग्राम) + 5 कि. ग्राम एफ वाई एम का उपचार करने पर उत्तम दक्षता होती है। नीम केक 0.5 या 1.0 कि.ग्राम /पौधे की दर में लगाने पर प्ररोह एवं केप्स्यूल बेधक से होनेवाली हानी अपेक्षतया कम होती है और उपजता में वृद्धि भी अकित की। पाम्पाडुमपारा और मुडिगरे मे किये प्रारंभिक परीक्षण से स्पष्ट होता है कि एन्डोमोपाथोजनिक नेमटोड लगाने पर इलायची के

रूट ग्रब की सख्या प्रभावी रूप से कम हो गयी। एपी सेस फन्ड योजना के फलस्वरूप गोतिमाला और श्रीलंका की उपजों से तुलना करने पर 1, 8 सिनोल (27.59%) और ¬ टरपिनिल असिटेट (41.65%) की अधिक उपजता युक्त इंडियन कारडमम की श्रेष्ठता प्रकट हुई!

अदरक

ए आई सी आर पी एस के विभिन्न केन्द्रों के अन्तर्गत 660 अक्सशनों का अदरक जर्मप्लासम बनाये रख दिया गया! पोटांगी में किये सीवीटी परीक्षण से अक्सशन 117 (12.95 टन/हेक्टर) की जांच पर गोरूबतन से तुलना करने पर अधिकतम उपजता 20.34 टन/हेक्टयर प्रकट हुई! एसजी 707, एसजी 827, एसजी 716, एस जी 682 और 51/04 जैसे जीन प्रकार उपजता के साथ अच्छे गुणवत्ता प्रस्तुत किये! विभिन्न केन्द्रों में किये परीक्षणों के फलस्वरूप Zn, bo और Fe को मृदा एवं पत्तों पर लगाने पर उपजता और गुणवत्ता पेरामीटर्स में बहुत वृद्धि अंकित की! पुंडिबारी में 10 कि. ग्राम बोराक्स, 25 कि. ग्राम जिंक सल्फेट और 10 कि. ग्राम फेरस सल्फेट प्रति हेक्टयर की दर में मृदा में लगाकर संयुक्त उपचार करने पर स्वच्छ राइजोम 35.17 टन/ हेक्टयर, 1.33% एसनशियल ऑयल और 6.52% ओलिओरसिन की अधिकतम उपजता अंकित की! अदरक के राइजोम गलन पर किये अध्ययन से अधिकतम स्वच्छ राइजोम उपजता (17.96 टन/हेक्टयर) के लिए बीज उपचार (मानकोजेब 3 ग्राम/लिटर + कारबन्डाज़िम 1ग्राम/लिटर+क्लोराफिरिफोस 2 मि लिटर/लिटर 30 मिनुट के लिए) और मृदा में 10 ग्राम तिमट (1कि ग्राम ai/हेक्टयर) लगाने पर उत्तम प्रभाव प्रकट होता है!

हल्दी

ए आई सी आर पी एस के आठ केन्द्रो के अन्तर्गत एक हजार दो सौ आठ जर्मप्लाजम अक्सशनों को बनाये रख दिया गया। तमिलनाडु के सेलम जिला से कोयंबतोर द्वारा तीन जर्मप्लासम संचित किया और सी. लोंगा की दो अक्सशनें पोटांगी द्वारा संचित की और दोनों को जर्मप्लासम में जोड़ दिया! इन्हीं जर्मप्लासम का लक्षण वर्णन धोली (आर एच 80, आर एच 16, आर एच 407 और आर एच 9/90) और कुमारगंज (एन डी एच 79, एनडीएच 18 और एनडीएच 9) जैसे आशाजनक अक्सशनों की पहचान की ओर ले जाती है। टीसीपी 2(25.01टन/हेक्टयर), आरएच 5 (22.48 टन/हेक्टयर) और टीसीपी1 (22.40 टन/हेक्टयर) आदि पुंडिबारी में किये सीवीटी में पहचान किये आशाजनक प्रविष्टियां है। पोटांगी में, उच्चतम स्वच्छ राइजोम उपजता पीटीएस 39 (23.73 टन/हेक्टयर) अंकित की जिसके बाद आता है पीटीएस 47(23.21 टन/हेक्टयर)। कोयंबतोर में किये जैवउर्वरक परीक्षण से प्रकट होता है कि अजैव नाइट्रोजन (50%) + अजोस्पिरिल्लम (5 कि.ग्राम/हेक्टयर)+ 5 टन एफवाइएम लगाने पर अधिकतम उपजता अंकित की। कुमारगंज मे, अजैव उर्वरक की 50% संस्तुत मात्रा (60:40:40 कि ग्राम/हेक्टयर एनपीक)+ 50% एफवाइएम (10 टन/हेक्टयर) + 5 कि. ग्राम/हेक्टयर अजोस्पिरिल्लम लगाने के साथ बीज उपचार और प्स्यूडोमोनस फलूरोसन्स+ ट्राइकोडरमा 50 ग्राम/मीटर ^{2} की दर में मृदा में लगाने पर अधिकतम स्वच्छ राइज़ोम उपजता (34.01 टन/हेक्टयर) अंकित की! एनपीके + एफवाइएम संस्तुत मात्रा में बीज उपचार करने के साथ ट्राइकोडरमा विरिडे और प्स्यूडोमोनस फलूरोसन्स 4ग्राम/ कि.ग्राम और 12.5 कि.ग्राम / हेक्टयर की दर में कनसोरटिया के मृदा में लगाने पर और 25 कि.ग्राम/हेक्टयर तट और उपर लगाने पर हल्दी के राइजोम गलन के नियन्त्रण के लिए मूल्य : लाभ का अनुपात 1: 2.8 अनुपात में क्रमश: प्रभावी हो गया!

वृक्ष प्रजातियां

ए आई सी आर पी एस के अन्तर्गत लौंग की 37, जायफल की 119, दालचीनी की 39 और कैसिया की 6 जर्मप्लासम बनाये रख दिये गये! पीचिपराई में किये दालचीनी जर्मपलासम के लक्षण वर्णन दो

उच्च उपजवाले अक्सशनो जैसे सेलक्शन 65 और 400 और 440 ग्राम छाल उपजतायुक्त एक स्थानीय संग्रह और पर्ण उपजता क्रमश: 6.0और 6.1 कि. ग्राम/पौधे की पहचान की ओर ले जाती है।

धनिया

विभिन्न केन्द्रों द्वारा धनिया के एक हजार आठ सौ पचानबे जर्मप्लासम बनाये रख दिये गये! जोबनर में किये सीवीटी परीक्षणो मे उच्च उपजवाले लाइन युडी 480 (1342 .82 कि ग्राम/हेक्टयर) की पहचान गयी और उसके बाद आता है युडी 118(1167.28 कि.ग्राम/हेक्टयर)! कोयंबतोर में पर्ण उपजता पर किये अन्य परीक्षण में, अधिकतम पर्ण उपजता डीएच232(2.6कि.ग्राम/20मीटर^2) में अंकित किया! गुणवत्ता के लिए मूल्यांकित अक्सशनों में युडी 728 वोलाटाइल तेल उपजता (5.35लिटर/हेक्टयर) की शर्तों में अग्रणी आता है! आई सीएस2(4.91 लिटर/हेक्टयर), के सेलक्शन (4 72 लिटर/हेक्टयर) आरडी 366(4.54 लिटर/हेक्टयर) और जे. कोरियान्डर 375 (4.53 लिटर/हेक्टयर) आदि उसके बाद आता है! गुंटूर में विभिन्न संरचनाओं में पर्ण उपजता देखने पर अधिकतम पर्ण उपजता (75%) (8988 कि.ग्राम/हेक्टयर) छायेदार नेट के अन्तर्गत प्राप्त हुई और पालमिरा पर्ण से छप्पर बनाये घर (8145 कि.ग्राम/हेक्टयर) और पौधो की छाया (7541 कि.ग्राम/हेक्टयर) उसके बाद आता है। अजैव नाइट्रोजन (100%) + अजोस्पिरिल्लम + 5 टन एफवाइएम/हेक्टयर की दर में लगाने पर हिसार में किये अध्ययन से अधिकतम उपज (1795 कि ग्राम/हेक्टयर) प्राप्त होते देख लिया। कुमारगंज में बोने के 30, 40 और 60 दिन के बाद ट्रयाकनटानोल 1लिटर/लिटर पानी में जोडकर लगाने से अधिकतम उपज 2.11 टन/हेक्टयर प्राप्त हुई। प्स्यूडोमोनस फ्लूरोसन्स आई आई एस आर 6 को 10ग्राम/कि.ग्राम बीज की दर में बीज उपचार करने के बाद पत्तों पर 10^8सीएफयु की दर में 60 दिनों तक छिडकने पर बुआई पाउडरी मिल्डयू रोग (18पीडीआई) होने के लिए प्रभावी देख लिया जाता है और अधिकतम मूल्य लाभ का अनुपात 1 2.1 अकित किया।

जीरा

जोबनर और जगुदान केन्द्र ने जीरा के 623 जर्मप्लासम बनाये रख दिये। म्लानी रोगबाधित प्लॉटों में किये छानबीन से जीसी - 4 (39. 30%) जगुदान में संयत प्रतिरोधक प्रकट हुआ! सीवीटी के अधीन आये प्रविष्टियों में, युसी 345, अधिकतम बीज प्राप्ति (607 64 कि.ग्राम/हेक्टयर) अंकित की आरइज़ड 209, चेक (557.29 कि.ग्राम/हेक्टयर), जे सी 95-30 (523 96 कि ग्राम/हेक्टयर), आर इजड 19 चेक (512.15 कि.ग्राम/हेक्टयर), यु सी 347 (510.76 कि ग्राम/हेक्टयर) और जी सी 3 चेक (450.00 कि. ग्राम/हेक्टयर) आदि इसके बाद आते हैं।! अधिकतम वोलाटइल तेल 5.30% यू सी 347 में देख लिया और आर इज़ड 209 में 5.25% , जी सी 3 में 5.03% , जे सी 95 -30 में 4.85% और यु सी 345 में 4.78% और स्थानीय चैक में 4 20 आदि इसके बाद आते हैं। सोयल सोलाराइसेशन+ ट्राइकोडरमा एफवाईएम (5 टन/हेक्टयर) मानकोजेब 0 25% मिट्टी में लगाने पर अधिकतम बीज उपलब्धि 485 कि.ग्राम/हेक्टयर के साथ न्यूनतम म्लानी आपतन (5%) और ब्लाइट (3 33%) अंकित किया!

सौंफ

ए आई सी आर पी एस द्वारा कुल 617 सौंफ जर्मप्लासम बनाये रख दिये गये। जोबनर की सी वी टी प्रविष्टियों में, अधिकतम उपज यु एफ 205 (1255.00 कि ग्राम/हेक्टयर) अंकित किया जिसके बाद आता है यु एफ 207(1153.89 कि ग्राम/हेक्टयर) जो, जी एफ - 2 चेक (1034.45 कि ग्राम/हेक्टयर) की तुलना में है! कुमारगंज में किये प्रारंभिक परीक्षण में एनडीएफ 5 को अधिकतम बीज उपलब्धि 1.26 टन/हेक्टयर पहचान गये और जिसके बाद आता है, 1.12 टन/हेक्टयर उपजवाले एन डीएफ 12। जोबनर में किये गुणवत्ता मूल्यांकन में अधिकतम मध्यम वोलाटाइल तेल की मात्रा 2.72% यु एफ 205 में अंकित किया जिसके बाद आता है में 2.55% वाले एन डी एफ12, 2.45% वालेयु एफ 206 और आर एफ 101 (चेक) और 2.42 % के स्थानीय

चेक। कुमारगज मे एफवाइएम को 10टन/हेक्टयर की दर मे 1 5 कि ग्राम/हेक्टयर अजोस्पिरिल्लम के साथ बीज उपचार करने पर अधिकतम बीज (0 91 टन/हेक्टयर) उत्पादित किया।

मेथी

ए आई सी आर पी एस केन्द्रो ने मेथी के 967 जर्मप्लासम अक्सशनो को बनाये रखते है। सी वी टी प्रविष्टियो मे जेएफजी 244 चेक की अपेक्षा उत्तम उपज (2001 कि ग्राम/हेक्टयर) अकित की, जो क्रमश: जी एम 1 और हिसार सोनाली से 11 29 और 12 16 प्रतिशत अधिक होते है । अधिकतम बीज उपलब्धता (1925 कि ग्राम/हेक्टयर) एच एम 232 मे अकित की और उसके पीछे आता है हिसार मे उगाये आर एम 18 (1860 कि ग्राम/हेक्टयर) और जेएफजी 273 (1855कि ग्राम/हेक्टयर)। कोयबतोर मे अधिक बीज उपलब्ध करने के लिए काम मे लाये विभिन्न उपचारो मे एफवाईएम (5 टन/हेक्टयर) के साथ अजैव नाइट्रोजन (100%) और अजोस्पिरिल्लम (1 5 कि ग्राम/हेक्टयर) लगाना अधिक उचित होता है। जोबनर मे एनएए 50 पीपीएम लगाने पर , मेथी का अधिक बीज उपजता प्राप्त होती है मगर यह ट्रयाकोन्टानोल 1 0 मि लिटर/लिटर से काफी दूर होते है। सरसो का केक 5ग्राम प्रति कि ग्राम की दर मे मिट्टी मे लगाने पर मेथी और ध निया मे एम इनकोग्निटा के प्रबन्धन के लिए बहुत प्रभावी देखा गया।

विभिन्न परियोजनाओ के अधीन प्रस्तुत अवधि की रिपोर्ट के अन्तर्गत देखी गयी मुख्य बाते नीचे प्रस्तुत की जाती है।

Project Coordinator's Report

The All India Coordinated Research Project on Spices (AICRPS) is vested with the mandate to conduct and coordinate research in 12 spice crops with its headquarter at Indian Institute of Spices Research, Calicut. AICRPS has at present 19 centres spread over 14 states based in 15 State Agricultural Universities (SAUs). In addition, 4 Voluntary Centres including Indian Cardamom Research Institute (Spices Board) are collaborating with this project. The X Plan budget of AICRPS was Rs. 700 lakhs with Rs. 115.459 lakhs (ICAR share) during 2006-2007. About 100 Research Programmes covering the mandate spice crops are being conducted at various centres.

Black pepper

A total of 691 black pepper germplasm have been maintained under different AICRPS centres. Dapoli and Pundibari centres have collected two and seven new germplasm from Ratnagiri and Sub-Himalayan region, respectively. The characterization resulted in identification of high yielding accessions *viz.*, Karimunda III (4.57 kg), TMB IV (4.09 kg) and Karimunda II (3.75 kg/ vine) by Panniyur. At Yercaud, Panniyur -3 recorded maximum yield of 2.6 kg/vine. Trials at Panniyur and Sirsi revealed maximum yield per vine with the application of biofertilizers (*Azospirillum* @ 50g/ *Phosphobacteria* @ 50g) + FYM 10 kg along with recommended dose of NPK. A combined application of *Azospirillum* and *Phosphobacteria* along with VAM found to enhance yield under organic farming. Trials on management of *Phytophthora* foot rot of black pepper at Panniyur, Sirsi. Mudigere and Pampadumpara revealed that application of potassium phosphonate (0.3%) with *Trichoderma harzianum* (50 g/vine) was effective in disease control and for maximum yield.

Cardamom

Three hundred and five germplasm accession have been maintained by two (Pampadumpara and Mudigere) centers. Under CVT trial at Pampadumpara, maximum yield per plant was recorded in S1 (510.15 g), followed by PS 44 (417.43 g). Based on the initial yield evaluation trials two entries each from Mudigere, Pampadumpara and Sakleshpur are proposed for new CVT. Biofertilizer trial conducted in cardamom. revealed superior performance of the treatment, inorganic N (100%) + *Azospirillum* (50 g) + 5 kg FYM, for yield. Application of neem cake @ 0.5 or 1.0 kg/plant has significantly reduced the shoot and capsule borer damage and significant increase in yield. Initial studies at Pampadumpara and Mudigere showed application of entomopathogenic nematode as effective in reducing the population of cardamom root grub. The results of AP cess fund scheme revealed that superiority of Indian cardamom with high 1, 8-cineole (27.59%) and α -terpinyl acetate (41.65%) compared to Guatemalan and Sri Lankan produces.

Ginger

Ginger germplasm of 660 accessions have been maintained under AICRPS centers. The CVT trial at Pottangi showed maximum yield of 20.34 t/ ha in Gorubathan compared to check, Acc 117 (12.95 t/ha). The genotypes *viz.* SG 707, SG 827, SG 716, SG 682 and 51/04 exhibited better quality attributes along with yield. The experimental results at various centers revealed that soil and foliar application of Zn, Bo and Fe recorded significant increase in yield and quality parameters. At Pundibari, the treatment combination of soil application of 10 kg borax, 25 kg zinc sulphate and 10 kg Ferrous sulphate per hectare recorded highest fresh rhizome yield of 35.17 t/ha, 1.33% essential oil and 6.52% oleoresin. Study on rhizome rot of ginger revealed the effectiveness of seed treatment (mancozeb 3 g/l + carbendazim 1g/l + chloropyriphos 2 ml/l for 30 min) and soil application of thimet 10G (1 kg ai/ha) for highest fresh rhizome yield (17 96 t/ha).

Turmeric

One thousand two hundred and eighty germplasm accessions have been maintained by eight centers under AICRPS. Three germplasm were collected from Salem district of Tamil Nadu by Coimbatore and two accessions of *C longa* were collected by Pottangi and included in the germplasm. Characterization of germplasm led to the identification of promising accessions at Dholi (RH-80, RH-16 RH-407 and RH9/90) and Kumarganj (NDH-79, NDH-18 and NDH-9). The promising entries identified in the CVT at Pundibari are TCP-2 (25.01 t/ha), RH5 (22.48 t/ha) and TCP1 (22 40 t/ha). At Pottangi, highest fresh rhizome yield was recorded in PTS-39 (23.73 t/ha) followed by PTS 47 (23.21 t/ha). The biofertilizer experiment at Coimbatore revealed that inorganic N (50%) + *Azospirillum* (5 kg/ha) + 5 t FYM recorded the highest yield. At Kumarganj, application of 50% recommended dose of inorganic fertilizer (60 40:40 kg/ha NPK) + 50% FYM (10t/ha) + 5 kg/ha *Azospirillum* + seed treatment and soil application of *Pseudomonas fluorescens* + *Trichoderma* @ 50 g/m^2 recorded maximum fresh rhizome yield (34.01 t/ha). Recommended dose of NPK + FYM + seed and soil application of consortia of *Trichoderma viride* and *Pseudomonas fluorescens* @ 4 g/kg and 12.5 kg/ha and 25 kg/ha as basal and top dressing respectively was found to be effective for control of rhizome rot of turmeric with cost benefit ratio of 1:2.8.

Tree spices

A total of 37 clove, 119 nutmeg, 39 cinnamon and 6 cassia germplasm have been maintained under AICRPS. Characterization of cinnamon germplasm at Peechiparai led to the identification of two high yielding accessions *viz.* Sel. 65 and a local collection with bark yield of 400 and 440 g and leaf yield of 6.0 and 6.1 kg/tree, respectively.

Coriander

One thousand and eight hundred and ninety five germplasm of coriander have been maintained by different centres. The CVT trials at Jobner identified a high yielding line UD 480 (1342.82 kg/ha) followed by UD 118 (1167.28 kg/ha) In another trial on leafy coriander at Coimbatore, the highest leaf yield was recorded in DH 232 (2 6 kg/20 m^2). Among accessions evaluated for quality. UD-728 ranked first in terms of volatile oil yield (5.35 l/ha) followed by ICS-2 (4.91 l/ha), K Selection (4.72 l/ha), RD-366 (4.54 l/ha) and J. Cori-375 (4.53 l/ha). The results on different growth structures for leaf production at Guntur indicated that maximum leaf yield was obtained under shade net (75%) (8988 kg/ha) followed by palmyra leaf thatched housing (8145 kg/ha) and tree shade (7541 kg/ha). The study at Hisar indicated maximum seed yield (1795 kg/ha) with Inorganic N (100%) + *Azospirillum* + 5 t FYM/ha. Maximum seed yield of 2.11 t/ha was obtained with spraying *Tricantanol* 1 ml/l of water after 30, 40 and 60 days of sowing at Kumarganj. Seed treatment with *Pseudomonas fluorescens* IISR 6 @ 10 g / kg of seed followed by foliar spraying @ 10^8 CFU on 60 days after sowing was found to be effective to contain the powdery mildew disease (18 PDI) and recorded the maximum cost benefit ratio of 1:2.5.

Cumin

Jobner and Jagudan centres maintain 623 germplasm of cumin. Screening under sick plot for wilt revealed GC-4 (39.30 %) as moderately resistant at Jagudan. Among the entries under CVT, UC-345 recorded maximum seed yield (607.64 kg/ha) followed by RZ-209 check (557.29 kg/ha), JC-95-30 (523.96 kg/ha), RZ-19 check (512.15 kg/ha), UC-347 (510.76 kg/ha) and GC-3 check (450.00 kg/ha) The maximum volatile oil of 5.30% was observed in UC-347 followed by 5.25% in RZ-209, 5.03% in GC-3, 4.85% in JC-95-30 and 4.78% in UC-345 and minimum of 4.20 in local check. Minimum wilt incidence (5 %) and blight (3.33 %) was recorded in the treatment, soil solarization + soil application of *Trichoderma* + FYM (5 t/ha) + Mancozeb 0.25% spray with maximum seed yield (485 kg/ha).

Fennel

A total of 617 fennel germplasm have been maintained under AICRPS. Among the CVT entries at Jobner, maximum yield was recorded in UF-205 (1255.00 kg/ha) followed by UF-207 (1153.89 kg/ha) compared to GF-2 check (1034.45 kg/ha). The initial evaluation trial at Kumarganj identified NDF -5 with maximum seed yield of 1.26 t/ha followed by 1 12 t/ha in NDF-12 In the quality evaluation at Jobner, highest mean volatile oil content of 2.72% was recorded in UF-205 followed by 2.55% in NDF-12, 2.45% in UF-206 and RF-101 (check) and 2 42% in local check Application of FYM @

10 t/ha + 1.5 kg/ha of *Azospirillum* as seed treatment produced maximum seed yield (0.91 t/ha) at Kumarganj.

Fenugreek

AICRPS centres maintain 967 germplasm accessions of fenugreek. Among CVT entries, JFg-244 recorded significantly superior yield (2001 kg/ha) than checks, it was 11.29 and 12.16 per cent higher than GM-1 and Hisar Sonali, respectively. Maximum seed yield (1925 kg/ha) was recorded in HM-232 followed by RM-18 (1860 kg/ha) and JFg 273 (1855 kg/ha) under Hisar conditions. Application of FYM (5 t/ha) + inorganic nitrogen (100 %) and *Azospirillum* (1.5 kg/ha) was highly effective among the different treatments imposed for getting a higher seed yield at Coimbatore. At Jobner, application of NAA 50 ppm resulted in significantly higher seed yield of fenugreek but it was at par with Triacontanol 1.0 ml/l. Application of mustard cake @ 5 g/kg soil has been found very effective for the management of *M.incognita* in fenugreek and coriander.

The salient findings during the period under report, under different projects are presented hereunder.

Progress of work and achievements

1. BLACK PEPPER

1.1 Genetic Resources and Crop Improvement

1.1.1 Germplasm collection, characterization, evaluation and conservation

(Chintapalle, Dapoli, Panniyur, Pundibari, Sirsi and *Yercaud)*

Among 22 collections maintained at Chintapalle centre, Narayakkodi recorded the highest dry yield of 2.1 kg per vine. The black pepper germplasm maintained at different AICRP centres are given in Table 1.

The black pepper germplasm consisting of 75 accessions have been maintained at Dapoli and are being evaluated. Two black pepper germplasm accessions (No. KKVPNOR5 and KKVPNOR6) were collected from Ratngiri district.

Presently, 227 cultivated and 72 wild types of black pepper have been maintained at Panniyur centre. During the year 2006-07, the germplasm accessions that recorded more than 2.3 kg spike yield /vine were Karimunda III, TMB IV, Karimunda II, Ottamundi, Angamali and Moozhiyai. The genotype, Karimunda III recorded the maximum spike yield of 4.57 kg/vine followed by TMB IV (4.09 kg/vine) and Karimunda II (3.75 kg/vine) The number of spikes were maximum for Karimunda II (1507) followed by Karimunda III (1470) The spike length was maximum for TMB IV and Moozhiyar (10.9 cm) The number of developed berries per spike was maximum in TMB IV (30.7). The 100 seed weight was maximum in Moozhiyar (15 g) followed by TMB IV (14 g) The per cent dry recovery was more for TMB IV (37) followed by Karimunda III (37).

A total of 121 germplasm collections have been maintained at Sirsi. Among six promising accessions studied under Arecanut mixed cropping system, Selection-1, recorded the maximum dry berry yield (3.15 kg/vine) followed by Kudragutta (2.38 kg/vine). The three years pooled data showed maximum yield in Selection-1 (3 17kg/vine) followed by Ademane pepper (2.79 kg/vine).

At Pundibari, ten improved varieties of black pepper (Panniyur 1, 2, 3, 4 and 5, Sreekara, Subhakara, Pournami, Panchami and Kottanadan) were collected from IISR, Calicut and CPCRI, Mohitnagar respectively Seven new genotypes were collected from Sub-Himalayan region adjoining Bhutan boarder (including Totopara).

Among 135 pepper germplasm lines evaluated at Yercaud, berry set was observed in forty one accessions, of which PN 57 recorded the highest value of 9.8 kg and 3.2 kg, for green and dry berry yield The accession PN33 recorded the highest value for spike length 12.5 and number of berries 68.0.

Table 1. Black peper germplasm collections under AICRP centres

Center	Indigenous		Exotic	Total
	Cultivated	Wild and related sp.		
Panniyur	214	72	3	289
Sirsi	96	20	1	117
Chintapalle	58	-	-	58
Pundibari	16	1	-	17
Dapoli	70	5	-	75
Yercaud	125	10	-	135
Total	579	108	4	691

1.2 Hybridization Trial

1.2.1 Intervarietal hybridization to evolve high yielding varieties

(Panniyur)

Intervarietal hybridization is being carried out every year and the hybrids obtained are being planted and evaluated. Among the intervarietal hybrids P6

x P5 is found to be promising with spike yield of 2.456 kg/vine followed by Cul 54 x P1 (1.55 kg/vine). The hybrid P6 x P5 recorded maximum number of spikes per vine and number of developed berries per spike.

1.2 Coordinated Varietal Trial (CVT)

1.2.1 CVT. 1991 Series IV

(Ambalavayal and *Yercaud)*

Among 14 accessions evaluated at Yercaud, Panniyur-3 performed well with maximum mean yield of 8.8 kg of green berry and 2.6 kg dry berry per plant and 100 berry weight of 12.2 grams respectively. The increased yield in Panniyur-3 is due to long spikes and spike intensity.

Among the different cultivars at Ambalavayal, Panchami (ACC 856) showed the highest plant height (2.30 m) followed by Panniyur 3 (2.11 m). The lowest plant height was recorded in Culture 239 (1.33m).

1.2.2 CVT 2000 Series V

(Pampadumpara, Panniyur, Chintapalle, Ambalavayal and *Sirsi)*

The trial was laidout during 2002 at Panniyur with 12 entries (HP-34, HP-105, HP-813, Coll.1041 OPKM, PRS-17, HP-1411, PRS-21, PRS-22, Cul. 5308, Cul. 5489 and Panniyur-1) to evaluate the performance of released varieties as well as promising selections of black pepper. The mean spike yield per vine was maximum for the genotype HP 813 (737 g/vine) followed by Cul 5489 (614 g/vine). The genotypes HP 813, Cul 5489, Karimunda OP, Coll 1041, Karimunda and Panniyur 1 were statistically on par (Table 2). The number of spikes per vine was also maximum in HP 813. There was no significant difference between entries for number of spikes. The maximum spike length was recorded in Cul 5489 (13.5 cm) and this was significantly superior to all other genotypes.

Table 2. Performance of CVT 2000 black pepper genotypes at Panniyur

Genotypes	Spike yield (g/vine)	Spikes /vine	Spike length (cm)	100 berry weight (g)	Dry recovery (%)
Kalluvally IV	282	153	8.3	15	27
Karimunda II	140	82	6.0	11	26
Karimunda III	233	124	5.7	12	26
Cul 5308	450	155	8.4	18	29
Cul 5489	614	147	13.5	12	33
HP 34	323	141	7.5	12	35
HP 105	273	156	6 3	11	34
HP 813	737	260	8 2	11	31
HP 1411	430	158	8 4	12	32
Karimunda OP	573	188	10 1	17	36
Coll 1041	512	233	6.1	14	32
Karimunda	579	245	5.7	10	35
Panniyur 1	539	166	9 3	15	38
CD (P–0 05)	236	NS	1.2		
CV (%)	32	41	9		
SE	81	40	0 4		

Among the twelve accessions evaluated at Pampadumpara, significant differences existed in all the traits. In general, the yield performance was very low and Cul 5308 registered the highest yield (527 g/plant). All the accessions except Cul 5308 recorded less than 100g of dry berry yield per plant. Maximum spike length was observed in Panniyur 1 (14.2 cm) followed by OPKM (14 cm). Number of berries per spike ranged from 2.1 in OPKM to 56.6 in Cul 5308. Least 100 berry volume and weight was recorded in Cul 5308 (7.0cc and 3.1g) followed by PRS 17 (7.0cc and 3.9g) whereas maximum was recorded in OPKM (13.1cc and 6.5g). Cul 5308 and Col 1041 registered highest yield mainly due to maximum spike length and more number of berries per spike although its 100 berry volume as well as weight was very low (Table 3). Number of spikes as well as berry setting percentage of OPKM and HP 813 was found to be very low resulting in low yield, despite registering higher 100 berry weight and volume. Black pepper accessions such as HP 1411, HP 105, PRS 21 and PRS 22 were found to be tolerant to *pollu* disease and Panniyur 1 was highly susceptible.

Fourteen entries along with two local cultivars were planted during 2003 on Arecanut standards at Sirsi. The plant height was maximum in PRS-22 (3.87 m) followed by Col 1041 (3.39 m). Entries *viz.* HP-34, HP-105, HP-813, Col 1041, P-24, PRS- 17, PRS-21, Cul 5308 and Paniyur -1 have initiated flowering and the yield was meagre.

At Chintapalle, out of 12 entries, Cul-5489 recorded the highest plant height of 1.41 m followed by PRS-21 (1.36 m) which was on par, where as Panniyur 1 recorded the lowest plant height of 0.31m.

Among the 13 cultivars studied at Ambalavayal, highest numbers of lateral branches (5.93) were recorded in Cul. 5308 followed by HP

Table 3. Performance of CVT 2000 black pepper entries at Pampadumpara

Accessions	Spike yield (g/vine)	Green berry weigth (g/vine)	Dry berry weight (g/vine)	Spike length (cm)	Berries per spike	100 berry vol (cc)	100 berry weight (g)	*Pollu* infection (%)
HP 34	24.71	20 83	7 21	8 5	12 5	7.2	3 6	15 6
HP 1411	157 21	135	51 12	9 8	14 7	8.1	4 3	0.7
HP 105	22 78	21 38	7 50	9 9	13 3	9.0	4.4	1.3
HP 813	3 33	3 05	1.38	10.5	5 0	-	-	13.3
OPKM	2 00	1 55	0.55	14 0	2 1	-	-	19 8
PRS 17	58 33	54 16	19 45	7 5	20 0	7 0	3 9	6 0
PRS 21	48 88	37.22	14 45	9.5	12 0	9 1	5 2	1.4
PRS 22	194 45	166 67	61 67	10 8	25 0	9 1	5 1	1.6
Cul 5489	85 00	42 78	13 62	14.2	4.3	9.0	5 8	6 2
Cul 5308	1361.12	1277 78	527.78	13.5	56 6	7 1	3 1	8 6
Col 1044	250	188 88	66 66	13.3	38 0	8 0	4.2	18.8
Pan 1	46 12	35 55	11 95	14.2	22.3	9 1	4 4	33 7
Mean	187.83	165.4	65.28	11.3	20.4	9 0	4.7	10.5
CD (P=0 05)	284.27	419 77	141 94	0 98	4 06	0 27	0 18	11.5

1411 (5.57). Lowest number of branches was recorded in PRS-22 (2.22).

1.2.3 CVT 2006

(Chintapalle, Dapoli, Panniyur, Pampadumpara, Pundibari, Sirsi and *Yercaud)*

Nucleus planting materials of all the entries have been supplied to respective centres for multiplication and planting during 2008.

1.3 Nutrient Management Trial

1.3.1 Effect of biofertilizer, *Azospirillum* on black pepper production (final report)

(Panniyur, Sirsi and Yercaud)

The experiment was carried out in farmer's field with existing black pepper vines at Korlakatta village. Sirsi during 2000-01 to 2004-05. The objective was to derive the information on the role of *Azospirillum* on the yield of black pepper and to develop an appropriate package of nutritional requirement to improve the productivity in mixed cropping. Results from five years data (2000-01 to 2004-05) revealed that the application of *Azospirillum* @ 50 g along with recommended 100% inorganic N, P and K with 10 kg FYM per vine recorded higher fresh berry yield (6.83 kg) compared to recommended dose of fertilizers (RDF) (6.12 kg). This was followed by the vines supplied with *Azospirillum* @ 50 g along with recommended 75% Nitrogen and 10 kg FYM per vine (6 57 kg). It has also resulted in obtaining maximum cost benefit ratio of 1.3.29 (Table 4).

Among the different treatments at Panniyur, T1 (inorganic N 100 % + *Azospirillum* 50 g + 10 kg FYM) recorded the maximum spike yield of 3.77 kg/vine followed by T6 (normal package of practice) with 3.21 kg/vine. The pooled analysis of three years data revealed the significance of treatment T1 and T6 over other treatments. The treatment T1 recorded the maximum yield (5.03 kg/vine), followed by T6 (4.26 kg/ha). The treatment T1 was significantly superior to all other treatments except T6 and were statistically at par. From this experiment, it is evident that applying 50 g of *Azospirillum* per vine is highly effective in increasing the spike yield of black pepper.

At Yercaud, the height of the vine was maximum (178.5 cm) in T2 (Inorganic N (75%) + *Azospirillum* (50 g) + 10 kg FYM) and the number of leaves and leaf area were more (58.0 - 65.00 cm^2) in the T3 (Inorganic N (50%) + *Azospirillum* (50 g) + 10 kg FYM). Trial conducted in the existing field. the highest yield was recorded in T2 (Inorganic N 75% + *Azospirillum* (50) + 10 kg FYM) 8.4 kg and 2.6 kg of green and dry berries followed by T3 (Inorganic N 50% + *Azospirillum* (50 g) + 10 kg FYM) with 8.0 and 2.6 kg by green and dry berries respectively.

1.3.1 Effect of biofertilizer, P- solubilizers (*Phosphobacteria*) on black pepper (final report)

(*Panniyur*, *Yercaud* and *Sirsi*)

The study on the effect of *Phosphobacteria* on the yield of black pepper was carried out during 2000-01 to 2005-06 with different treatments and control.

Table 4. Effect of *Azospirillum* on of black pepper yield at Sirsi

	Treatments	Mean fresh berry yield (kg/ vine)					Mean yield (kg/vine)		C : B ratio
		00-01	01-02	02-03	03-04	04-05	Fresh	Dry	
T1	100% Inorg N - 50 g *Azospirillum* + 10 Kg FYM	6.49	6 20	6 25	7 98	7.23	6.83	2 01	1 3 29
T2	75% Inorg. N + 50 g *Azospirillum* + 10 Kg FYM	6 23	6 35	6.52	7.34	6.40	6.57	1.93	1 3.15
T3	50% Inorg. N + 50 g *Azospirillum* + 10 Kg FYM	6.49	6.32	5 99	6 66	6.20	6 33	1 86	1·2 58
T4	50 g *Azospirillum* + 10 Kg FYM	6.40	6.08	5.57	7.01	6.18	6.25	1 84	1: 3.01
T5	10 Kg FYM	6.83	5.67	5 27	5 76	4.83	5 67	1.67	1: 2.81
T6	Recommended dose of fertilizers (RDF)	5 91	6 19	4 38	7.34	6 78	6.12	1.80	1: 3 03
SEm (±0.46)		0.27	0 23	0 07	0 31	0.24			
CD (P=0.05)		NS	NS	0.70	0 19	0 93	0.72		

Experiment was carried out in farmer's field at Korlakatta village, Sirsi during 2000-01 to 2004-05. The objective was to derive the information on the role of *Phosphobacteria* on black pepper yield and to develop an appropriate package of nutritional requirement to improve the productivity in mixed cropping. It was revealed from the five years data that the application of *Phosphobacteria* @ 50 g along with recommended 100% inorganic P and 10 kg FYM / vine recorded maximum fresh berry yield (6.81 kg) compared to other treatments (Table 5). This was followed by the vines supplied with P solubilizer @ 50 g along with recommended 75% inorganic P and 10 kg FYM / vine (6.43 kg). It also resulted in obtaining maximum C:B ratio of 1:3.3.

At Panniyur, the three years yield data (2003 to 2006) were subjected to pooled analysis and found that T1 was maximum yielder (5.59 kg/vine), followed by T6 (4.93 kg/vine). The treatments T6 and T2 were statistically on par with T1. The treatment T1 was significantly superior to all other treatments except T6 and T2.

At Yercaud, the vine height was maximum (169.5 cm) in T4 (FYM 10 kg + phosphobacteria @ 50 g), the number of leaves per vine was higher (48.0) in the treatment T2 (Inorganic P (75%) + phosphobacteria (50 g) + 10 kg FYM) and the leaf area was more (72.6 cm^2) in the treatment T1 (Inorganic P (100%) + phosphobacteria (50 g) + 10 kg FYM). Trial conducted in the existing field, highest yield was recorded in T2 (Inorganic N 75% + phosphobacteria 50 g + 10 kg FYM) with 9.2 kg and 3.0 kg of green and dry berry yield followed by T3 (Inorganic N 50% + phosphobacteria 50 g + 10 kg FYM)) with 8.6 and 2.6 kg green and dry berry weight respectively.

Table 5. Effect of P solubilizer on black pepper yield under arecanut mixed cropping system at Sirsi

	Treatments	Mean fresh berry yield (kg/ vine)					Mean yield (kg/vine)		C : B ratio
		00-01	01-02	02-03	03-04	04-05	Fresh	Dry	
T1	100% Inorg P + 50 g P solubilizer + 10 Kg FYM	6.68	6.27	6 63	7.28	7.17	6.81	1 94	1:3 30
T2	75% Inorg P + 50 g P solubilizer + 10 Kg FYM	5.74	6 20	6 53	6 96	6 71	6 43	1.83	1 3 14
T3	50% Inorg P + 50 g P solubilizer + 10 Kg FYM	6 31	6 00	6 57	6 60	6 33	6 36	1.81	1·2.97
T4	50 g P solubilizer - 10 Kg FYM	6 00	6 31	6.13	6 03	5.99	6.00	1 73	1·2 66
T5	10 Kg FYM	5.74	6 71	4.77	6 19	5 80	5.84	1 66	1.2.72
T6	RDF	6 28	6 06	4 82	7 12	6 98	6 25	1 78	1:3 17
Sem (±0 37)		0 35	0 29	0 20	0.20	0 22			
CD (P=0 05)		NS	NS	0 86	0.54	0 62	0 66		

Table 6. Performance of black pepper under organic farming at Sirsi

	Treatments	Mean fresh berry yield (kg/ vine)					Mean yield (kg/vine)		C : B ratio
		00-01	01-02	02-03	03-04	04-05	Fresh	Dry	
T1	FYM 10 kg /vine	5 36	5.84	5 13	4.98	5 73	5.41	1 54	1 : 3 85
T2	Vermicompost (2kg) + Wood ash (1kg/vine)	5 06	5 40	5 02	4.19	4.20	4 77	1 36	1 : 3.77
T3	FYM 10 kg + Burnt earth 10 kg/vine	6.74	6 52	5 94	6 20	6 75	6 43	1 84	1 4.17
T4	FYM 10 kg + *Azospirillum* 50g/vine	5.05	5062	4 72	4 70	4 75	4 97	1.42	1 . 3.87
T5	FYM 10 kg + Leaf manure 10 kg/vine	5.61	5 82	4 09	3 62	4 15	4.66	1 33	1 : 3.33
Sem (±0 27)		0 16	0.18	0 06	0.28	0.19			
CD (P=0 05)		0 85	0.49	0 55	0.17	0.88	0.56		

1.3.3 Organic farming in black pepper (final report)

(*Panniyur, Yercaud* and *Sirsi*)

The experiment was carried out in farmer's field at Shigehally village, Sirsi during 2000-01 to 2005. The objective was to to develop an appropriate organic package for cultivation of black pepper in arecanut mixed cropping system for maximum returns. It was revealed from the five years data that the highest mean fresh berry yield was recorded in the vines supplied with FYM 10 kg + Burnt earth 10 kg (6.43 kg/vine) with significant difference and maximum C.B ratio (1 : 4.17) (Table 6). This was followed by the vines supplied with FYM 10 Kg/vine (5.41 kg/vine).

The experiment to study the effect of different organic manures on black pepper was carried out in a standing crop of pepper (Panniyur1) at Panniyur during 2002-2006 with 7 treatments. Pooled analysis of data over three years indicated that T4 (FYM 10 kg + *Azospirillum* 50 g + wood ash 2 kg) recorded maximum spike yield of 6.489 kg/vine, followed by T6 (recommended package of practices) with an yield of 5.434 kg/vine. The treatments T4, T1 and T2 were statistically at par with the package of practice recommendation. The lowest yield was obtained in the zero tillage treatment which was almost half of the yield in the best treatment (T6).

At Yercaud, maximum yield of 6.0 kg and 1.8 kg of green and dry berry was recorded in T5 (FYM 10 kg + 50 g *Azospirillum* + 50 g *Phosphobacteria* + 200 g of VAM). The spike length and number of berries was also highest in T5 (11 8 cm and 68 respectively).

1.3.4 Development of organic package for spice based cropping systems

(*Chintapalle, Dapoli, Sirsi, Panniyur*)

The observational trial was started during 2006 at Panniyur. Treatments included were organic package of practices and recommended package of practices. Non significant difference in spike yield was recorded between the two treatments.

The first year observations at Sirsi revealed, the vines supplied with recommended package of practices recorded dry berry yield of 0.90 kg/vine and it was 0.78 kg/vine in those supplied with only organic treatments.

A trial on development of organic package was planted during 2004-05 at Dapoli. The growth of vines under organic and inorganic packages was satisfactory during the first year. The organic package recorded higher mean vine length of 1.44 m over inorganic package (1.35 m).

1.3.5. Organic farming in black pepper -2006

(*Dapoli, Sirsi, Panniyur, Yercaud, Peechiparai*)

The trial was started during 2006 at Panniyur and among the treatments. fully organic farming recorded the maximum spike yield of 3.138 kg/ vine followed by inorganic (2.339 kg/vine) and integrated treatment (1.671 kg/vine). There was no significant difference between the treatments.

Treatments were imposed in an established pepper vines at Peechiparai centre. The experiment was conducted in three blocks *viz* . 1) organic 2) integrated 3) inorganic. The highest yield of 3.36 kg/vine was recorded in the inorganic and it was on par with integrated treatment which recorded an yield of 3.05 kg/vine.

1.4 Disease Management Trial

1.4.1 Adaptive trial on management of *Phytophthora* foot rot of black pepper in farmer's field

(*Panniyur, Sirsi, Pampadumpara* and *Mudigere*)

The trial was started during 2006 in farmers field at Panniyur. There was no significant difference between the treatments for disease incidence and plant growth characters. The treatment T2 recorded the maximum yield of 3.65 kg/vine followed by T1 (Table 7). T2 was significantly superior to T3 and on par with T1. The death of vines and defoliation was maximum in T3 (farmers practice).

The experiment was initiated during 2006-2007 at Pampadumpara. The current foot rot management technologies available in the packages of practices of Kerala Agricultural University and All India Coordinated Research Projects on Spices (AICRPS) were compared with the local practices followed by farmer. All the treatments were found to be significant in reducing the foot rot incidence. The disease index ranged from 2.9 in Potassium phosphonate (0.3%) + *Trichoderma harzianum* (50 g/vine) treated vines to 8.61 on vines adopted by local practice of farmer (Table 8). The plots treated with Potassium phosphonate @ 0.3% and *Trichoderma harzianum* @ 50 g/vine was found to be effective in managing foot rot incidence in black pepper followed by Bordeaux mixture 1% spray and COC 0.2 % drenched plots.

The results of adaptive trial at Sirsi revealed, disease incidence of *Phytophthora* foot rot of black pepper with respect to less leaf infection (5.60 per cent), less foliar yellowing (10.00 PDI), less defoliation (13.33 PDI), no collar infection and highest green berry yield of 1.80 kg per vine when vines were treated during onset of monsoon (June) and again during third week of August with Potassium phosphonate (@ 0.3 %) as spraying (@ 2 l/vine) and drenching (@ 3 l/vine) and soil application of *Trichoderma harzianum* @ 50 g per vine with one kg of neem cake to the root zone (Table 9). This was closely followed by chemical check with application of (1 %) Bordeaux mixture as spraying (@ 2 l/vine) and Copper oxychloride (@ 0.1 % a.i.) as drenching (@ 3 l/vine) where in less leaf infection (6.80 per cent), less collar infection (4.0 %), less foliar yellowing (16.66 PDI), low defoliation (19.98 PDI) and more green berry yield of 1.74 kg per vine were recorded. Black pepper vines were severely affected by the disease with leaf infection (20.00 %), collar infection (12.00 %), foliar yellowing (60.00 PDI) and high defoliation (56.66 PDI) with green berry yield of 1.45 kg per vine in farmers' practice of application of fungicide (1% Bordeaux mixture as spray) after appearance of the disease.

Under Mudigere condition, the minimum of 0.9 per cent foliage infection was recorded in T_2 as compared to control (2.1 %). Both T1 and T2 were effective in reducing the foliage yellowing and defoliation (Table 10) as compared to farmers practice (T_3).

Table 8. Management of *Phytophthora* foot rot of black pepper in farmer's field at Pampadumpara

Treatments	Disease Index
Potassium phosphonate (0 3%) + *Trichoderma harzianum* (50 g/vine)	2.9
Bordeaux mixture 1% spray + COC 0 2 % drench	5.7
Farmers practice (Bordeaux mixture 1% spraying and drenching)	8 61
CD (P=0 05)	0 53

Table 7. Influence of different treatments on management of *Phytophthora* foot rot of black pepper at Panniyur

Treatments	Per ent Disease Incidence			Yield (kg/vine)	Canopy size (m)	Laterals per vine
	Yellowing	Defoliation	Death			
T1 - Potassium phos phonate + *Trichoderma*	4 43	3 76	12.24	2 84	2 38	4.40
T2 - BM spray + COC drenching	3 92	4 73	12 24	3 65	2 80	4 12
13 - Farmers practice	4 11	6 77	20.40	2 05	2 48	4 14
CD (P=0.05)	NS	NS	NS	0 86	NS	NS

Table 9. Management of *Phytophthora* foot rot disease in black pepper (adaptive trial) at Sirsi

Treatments	Leaf Infection (%)	Collar infection (%)	Foliar Yellowing (PDI)	Defoliation (PDI)	Green berry yield (kg/vine)
T1. Potassium phosphonate (0 3 %) + *Trichoderma harzianum*	5 60	0.00	10 00	13.33	1 80
T2. Bordeaux mixture (1 %) spraying + Copper oxychloride (0.1 % a i.) drenching	6 80	4.00	16.66	19 98	1 74
T3 Farmers, practice Bordeaux mixture as spraying once after the disease appearance and only to affected vines	20 00	12.00	60.00	56 66	1.45
SEm ±	3 77	2 30	2.32	1 96	0.06
CD (P=0 05)	11 63	7.07	7.14	6 05	0.18

Table 10. Management of *Phytophthora* foot rot of black pepper in farmer's field at Mudigere

Treatments	Yellowing (%)	Foliage infection (%)	Defoliation (%) (0-3 scale)*
T_1 Potassium phosphonate (0 3%) +*Trichoderma harzianum*	1.03	1.76	1
T_2 Bordeaux mixture spray (1.0%) + COC (0.3 %) drench	1.16	0.90	1
T_3 Farmer's practice	1 8	2 1	2

*(0 = nil, 1 = up to 25%, 2 = up to 50%, 3 = > 50% defoliation)

Table 11. Management of *Phytophthora* foot rot of black pepper in existing plantation at Pampadumpara

Treatments	Disease Index
Potassium phosphonate (0.3%) + *Trichoderma harzianum* (50 g/vine)	4.27
Bordeaux mixture 1% spray + COC 0.2 % drench	6.96
Consortium of bactena(50 g/vine)	5 71
Trichoderma harzianum + Consortium of bacteria(50 g/vine)	2 88
Control	10.76
CD (P=0 05)	0 88

1.4.2 Trial on management of *Phytophthora* foot rot of black pepper in existing plantation

(*Panniyur, Sirsi, Pampadumpara* and *Mudigere*)

This experiment was initiated at Pampadumpara during 2006 and the treatments were imposed during pre and post monsoon periods. The efficacy of biocontrol agents and fungicides were compared on the management of foot rot disease of black pepper. Minimum disease incidence was recorded in the plots treated with *Trichoderma harzianum* and consortium of bacteria @ 50 g/vine followed by application of Potassium phosphonate @ 0.3% and *Trichoderma harzianum* @ 50 g/vine. The disease index ranged from 2.88 to 10.76 (Table 11). Combined application of *T harzianum* and consortium of bacteria was found to be synergistic than application of consortium of bacteria alone in suppressing the *Phytophthora* foot rot disease of black pepper.

The trial was started during 2006 at Panniyur. There was no significant difference between treatments. However yellowing and death of vine were more in control.

Under Mudigere conditions, black pepper vines treated with fungicides Potassium phosphonate (0.3 per cent) as spray (2 l/vine) and drench (3 l/vine) along with *Trichoderma harzianum* 50 g with one kg of neem cake as soil application during first week of June and third week of August showed less incidence of yellowing (8.33 PDI) and less defoliation (5.83 PDI), no death of vines and highest green berry yield (1.44 kg per vine). Similar results were recorded with chemical check i.e., Bordeaux mixture (@ 1 %) as spray (2 l/vine) and drench (3 l/vine) where in less yellowing (7.50 PDI) and low defoliation (5.00 PDI), no death of vine with higher green berry yield (1.22 kg/vine). However, biocontrol agents *viz* , either

Table 12. Management of *Phytophthora* foot rot disease in black pepper in existing plantations at Mudigere

Treatments	Yellowing (PDI)	Defoliation (PDI)	Death of vines (%)	Green berry yield (kg/vine)
T1 Potassium phosphonate (0.3 %) + *Trichoderma harzianum*	8.33	5 83	0 00	1 44
T2 Bordeaux mixture (1%) + Copper oxychloride (0 1 % a i)	7 50	5 00	0.00	1.22
T3. Consortium of bacteria	11.67	7 50	7 50	1.16
T4. *T harzianum* + Consortium of bacteria	10 00	6 66	5.00	1.27
T5. Control	21.67	22 50	25 00	1 06
SEm ±	1.49	1.85	1 94	0 05
CD (P=0.05)	4 59	5.69	5 97	0 15

with consortium of bacteria (for growth, nematode and *Phytophthora* suppression) alone as spray and drench or in combination of consortium of bacteria as spray and drench along with *Trichoderma harzianum* application to root zone also reduced the yellowing (11.67 and 10.00 PDI), defoliation (7.50 and 6.66 PDI), death of vines (7.5 and 5 00 per cent) and more green berry yield (1.16 and 1.27 kg per vine). Among the bioagent treatments combination of consortium of bacteria and *T harzianum* was found to be efficient in reduction of the disease. Black pepper vines without any protection exhibited severe incidence of yellowing (21.67 PDI), high defoliation (22.50 PDI), more death of vines (25.00 per cent) and least green berry yield (1.06 kg per vine) (Table 12).

1.4.3 Trial on management of *Phytophthora* foot rot of black pepper in new plantation

(*Panniyur, Sirsi, Pampadumpara* and *Mudigere*)

The trial was initiated at Panniyur, Pampadumpara, Sirsi and Mudigere during 2006 with split plot design. Three varieties of black pepper namely IISR Sakthi, IISR Thevam and Panniyur 1 were planted for evolving a management strategy for foot rot disease The treatments were imposed during pre and post monsoon periods. At Pampadumpara, the establishment in Panniyur –1 was found to be 85 percent whereas it was 75% and 60% in IISR Thevam and IISR Sakthi, respectively. Mild infection of foot rot disease was noticed in all these varieties.

1.5 Pest Management Trail

1.5.1 Management of scale insects in black pepper with organic products

(*Mudigere* and *Pampadumpara*)

The experiment was conducted in a farmer's field at Kattapana. Idukki during 2007. There were six treatments including control, three belonging to the group of biorationals and two insecticides. Observation on mussel scale population was recorded after second and fourth spray on vines treated with biorationals and that after first and second spray on insecticide-treated vines. Numbers of live scale insects were recorded in 1 cm^2 leaf area and 2.5 cm twig and are presented in Table 13.

The population of mussel scale, *Lepidosaphes piperis* on black pepper was found to be 36.7 per cm^2 on leaf and 50.1 per 2.5 cm twig, respectively as a pre-treatment count. All treatments belonging to insecticide group as well as biorationals reduced the scale population on both leaves as well as twigs, significantly. The scale population reduced from 33.3 to 9.0 on dimethoate-treated plants after the first spray on leaves Scale population on vines treated with fish oil (21.0) and neem oil (21 3) were found at par. After the second/ fourth spray, population of scale insects was reduced to 1.0 on dimethoate-treated vines followed by vines treated with thiamethoxam (6.0). Among the biorationals evaluated, neem gold (0.5%) was found to be more effective than neem oil and fish oil in reducing scale population on leaves.

A similar trend was also observed in mussel scale population on twig that was reduced from 48.5 to 9.8 in dimethoate-treated vines after the first spray. Scale population on neem oil (28.0) and fish oil-treated vines (28.3) were found to be non-significant and inferior compared to that of vines treated with thiamethoxam (16.0) and neem gold (20.8). After second / fourth spray, vines treated with dimethoate resulted in least population of scale insects (2.3) followed by thiamethoxam-treated vines (7.3). Among the biorationals evaluated, neem

gold (0.5%) was found to be effective in the suppression of scale population and the least scale population was recorded on vines treated with dimethoate (0.05%).

The efficacy of three organic insecticides *viz* . neem oil, econeem and fish oil rosin were compared with monocrotophos and an untreated control during 2006 at Mudigere. The pre-treatment mussel scale population ranged from 6.85 to 8.22 on leaves and from 41.75 to 51.50 on twigs. The mussel scale population was found lowest after 30, 60, 90 days after treatment compared to pre-treatment observations both on twigs and leaves. Among the treatments eco-neem plus treated vines recorded maximum population compared to other treatments and minimum population compared to un treated control. The mussel scale population was lowest with fish oil treatment followed by neem oil and monocrotophos (Table 14).

Table 13. Effect of organic products on scale insects of black pepper at Pampadumpara

Treatments	Scale population					
	Leaf			Twig		
	Initial count per cm²	I* /II# spray	II* / IV# spray	Initial count per 2.5 cm	I* /II# spray	II* / IV# spray
Neem Oil (0 5%)#	37 0(6 08)	21 0(4 58)	11 0(3 32)	50 0(7.07)	28 0(5 29)	17.3(4 15)
Neem Gold (0.5%)#	37 5(6.12)	15.8(3.97)	8 0(2.83)	50 3(7 07)	20 8(4 55)	10 0(3.16)
Fosco (3%)#	36 3(6 02)	21 3(4 61)	11.5(3.39)	49.5(7 04)	28 3(5 32)	17 5(4.18)
Thiamethoxam (0 013%)*	36 3(6 02)	13 0(3 61)	6 0(2 45)	50 5(7.11)	16 0(4 00)	7 3(2 70)
Dimethoate (0 05%)*	35.3(5.92)	9 0(3 00)	1 0(1.29)	49 8(7 05)	9 8(3.12)	2 3(1 47)
Control	37 5(6 12)	33 3(5 77)	31 3(5.59)	50 3(7 09)	48 5(6 97)	46 5(5 43)
CD (P=0 05)	NS	0.178	0.316	NS	0.149	0.261

(Values in parentheses are square root transformed)

Table 14. Management of scale insects of black pepper with organic products at Mudigere

Treatments	Dose	Pretreatment		30 DAFT		60 DAFT		90 DAFT		Mean	
		L	T	L	T	L	T	L	T	L	T
Neem Oil	0 5%	6 85	41 75	5 075	8 60	2.048	3.98	2 28	7.32	3 13	6 63
Econeem	0 5%	7 15	45 25	10 20	37 53	6 01	12 28	7.25	16 00	7 82	21 93
Fish oil	0 3%	7 65	46.25	3 82	5 85	1 185	2 33	2.14	2.51	2 38	3.56
Monocrotophos	0.05%	8 10	51.50	7 13	9 75	1 50	3 57	4 10	5.68	4 24	6 33
Control		8 22	47 25	10 37	60 51	14 140	101 3	17.97	90.05	14 16	83.97
CD (P=0 05)		1.613	12.91	0 905	18 76	2.58	1.90	2 434	11 76		
SEm (±)		15.42	20.19	8 76	6 32	37 69	5 64	26.17	35 79		

(DAFT – days after treatment: L – leaf: T - twig)

2. CARDAMOM

2.1. Genetic Resources

2.1.1 Germplasm collection, characterization, evaluation and conservation

(*Mudigere* and *Pampadumpara*)

The Mudigere centre maintains 152 cardamom germplasm collections. Among 152 germplasm evaluated during 2006-07, P-3 was the tallest (224 cm), P-3 and CL-730 were found to be superior for number of bearing suckers (12.5), P-3 for panicle length (48.3 cm), capsule number (47) and CL-730 for green capsule yield (400 g/ plant).

At Pampadumpara, IC numbers (547920 to 547992) were obtained for 73 cardamom accessions (CRSP 1-73) from National Bureau of Plant Genetic Resources, New Delhi. The data pertaining to yield (fresh and dry) of top ten germplasm accessions were recorded during 2006-07. The highest fresh yield of capsules (7600 g/ plant) and dry yield (1393 g/plant) of capsules was recorded in S 1 followed by CR 9 with 7040 g/ plant and 1320 g/plant of fresh and dry yield, respectively. CR 9 recorded maximum 100 capsule volume (238 3 cc) and weight (105 6 g) followed by PS 44 (223 3 cc and 103.0 g) suggesting higher boldness and liter weight of capsules. These two attributes determines the market price of cardamom. Five accessions namely PS 1 (23.3), PS 44 (21.0), PS 7 (20.7), SAM 10 and NS 50 (20) registered more than 20 seeds per capsule. CR 9 registered very minimum number of seeds per capsule (16.7). Driage percentage of PS 44 was found to be highest (22.5%) confirming its superiority in recovery percentage than all other accessions under study. PS 44 was also found to be tolerant to *azhukal* disease (1.66%). Thrips infestation was low in NS 50 (2.33%) and high in S1 (7.33%). CR 9 was found to be highly susceptible to *azhukal* disease (21 0%) whereas least capsule borer damage was recorded in the same accession. The cardamom germplasm at different AICRP centres are given in Table 15.

Table 15. Cardamom germplasm collections of AICRP centres

Centre	Indigenous		Total
	Cultivated	Wild and related sp.	
Pampadumpara	152	1	153
Mudigere	152	-	152
Total	304	1	305

2.2 Hybridization and Selection

2.2.1 Evaluation of OP progenies under intensive management

(*Mudigere*)

Eight promising cardamom clones which were identified as better general combiners were planted during 1995-96 at Mudigere with a closer spacing (6' x 3') and allowed for open pollination for collection of seeds. The 30 open pollinated progenies, planted in 2002-03, were evaluated. The progeny $22C_8$ yielded highest (252 kg/ha) followed by $23C_8$ (251.4 kg/ha) and $21C_8$ (232.8). M-2 was tallest (314 cm), 22 C_8 and 23 C_8 had maximum number of bearing suckers (12.67), 6 C_8 had longest panicle (73.00 cm) and maximum number of capsules per plant (60.67).

2.2.2 CVT 2000-Series IV

(*Pampadumpara, Mudigere* and *Sakleshpur*)

Yield attributing characters and incidence of pests were evaluated in 12 promising cardamom accessions at Pampadumpara and are presented in Table 16. Significant variations existed in all accessions for the eleven characters studied. Plant height was found to be highest in PS 44 (283 cm) and lowest in NKE 19 (200 cm). Both the Appangala accessions namely NKE 19 and RR 1 (203.6 cm)

Table 16. Yield, pest and disease incidence of CVT cardamom accessions at Pampadumpara

Accessions	Fresh weight (g/plant)	Dry weight (g/plant)	Thrips (%)	Capsule borer (%)	Azhukal (%)
S 1	2781 00	510 15	5 33	0 33	2 33
MCC 347	1842 08	347 98	3 33	1 00	2.33
MCC 200	2075 58	394 52	4 66	0 33	1 66
PS 44	1935.00	417.43	4.66	1 00	3 33
SKP 165	655 49	142 68	5 66	1.00	5.67
SKP 170	1678 00	330 82	2 00	1.66	5.00
Greengold	1843 33	357 27	5.00	1 66	5.00
CL 692	1755.45	344.12	1 67	1 00	6.66
MHC 18	1770.48	340.05	2 00	0 33	2 00
MHC 13	998.54	204 49	4 33	2.00	4.00
RR 1	1571 57	295 94	1 33	1 33	2 66
NKE 19	1166 30	237.13	2.33	0 66	2 33
Mean	1672.73	326 88	3 52	1.02	3.58
CD (P=0 05)	135 00	40.74	0 58	NS	NS

were found shorter and inferior in growth Four accessions *viz.*, S 1 (58), PS 44 (52). *Greengold* (51) and RR 1(51) registered more than 50 number of tillers per clump. Highest number of panicles per clump was recorded in PS 44 (51) and NKE 19 registered the least (30). The panicle length ranged from 55 cm in SKP 170 to 95 cm in PS 44. Maximum 100 capsule volume was registered in RR 1 (148.3cc) followed by *Greengold* (151.66cc), whereas maximum 100 capsule weight was recorded in PS44 (93.33g) and minimum in CL 692 (58.33g). Two accessions namely CL 692 (6.66%) and SKP 165 (5.67%) recorded higher capsule rot infection than the check whereas MCC 200 (1.66) registered the least. Infestation by thrips was found to be low in RR 1 (1.33%) and CL 692 (1.67%). Highest fresh (2781.00 g/plant) and dry yield (510.15 g/plant) was observed in S 1 which was found to be significantly superior than other accessions. Three accessions namely S 1, MCC 200 and PS 44 recorded more dry yield than the check *Greengold*, whereas the least dry yield was observed in SKP 165 (142.68 g/plant). Dry yield (339.4 g/plant) of PS 44 was found to be higher than *Greengold* even though the fresh yield was low indicating higher recovery percentage (22 7%) than any of the accessions under the CVT evaluation.

At Mudigere. two clones were found superior for dry capsule yield and significantly superior over check (M-2) MHC-10 yielded highest (292 kg/ha) followed by CL- 692 (262 kg/ha). Number of bearing suckers was maximum in MHC 18 (19.11), panicle number was maximum in MHC 10 (40.2) and APG 293 had longest panicle (52.9 cm) and maximum number of capsules (49.8).

Morphological observations have been recorded, compiled and analysed for the year 2006-07 at Sakleshpur. Plant height was significantly more in PS 44 (268 cm). Tillers, bearing tillers, panicles and racemes did not show any significant difference between the treatments. Yield was significantly high in SKP 165 (310 kg/ha), MHC 10 (304 kg/ha). S 1 (304 kg/ha), MHC 18 (303 kg/ha) and in ICRI 3 (301 kg/ha). Maximum percentage of bold capsules (capsules retained in 8 mm sieve) were found in PS 44 (60.4%) followed by SKP 165 (57.7 %).

2.2.3 CVT – 2005 - Series V

(*Mudigere* and *Pampadumpara*)

A total of seven accessions namely MCC 73, MCC 309, MCC 246, MHC 26 (ICRI, Myladumpara), CL 722 (RARS, Mudigere), PS 27 (CRS, Pampadumpara) and Green Gold (check) have been raised during 2005.

Among the seven accessions evaluated at Pampadumpara. PS 27 (201.67cm) registered maximum plant height followed by MCC 73 (196.67cm). PS 27 (201 67cm) and MCC 73 (196.67 cm) were found to be taller than the check Greengold (193.33cm). Number of tillers ranged from 19.56 (MCC 309) to 27.56 (MHC 26). Three accessions namely PS 27 (25.33), MCC 73 (25.11) and MHC 26 (27.56) were found to have more

Table 17. Performance of IET II entries at Mudigere

Clones	Plant height (cm)	Suckers/ plant	Bearing suckers/ plant	Panicles/ plant	Panicle length (cm)	Capsules/ panicle	Inter-nodes/ panicle	Dry capsule yield (kg/ha)
MCC-34	234.33	15 00	8.00	17.00	43 22	30.89	16 56	136 8
CCS-800	243 67	17 00	11.33	24 67	47 78	45 22	17 00	234 0
SKP-14	239 67	16 33	10.67	21 67	38 44	42 33	14 78	189 6
SEL-800	257.33	27.00	16.33	36 67	62 78	50 33	21 22	403 2
CL-668	275 67	27 00	16 00	30 00	57 33	38.78	16 11	222.0
CL-726	301.67	26 33	18 00	43 00	55 56	31 67	16.22	494.4
HS-1	265 33	28 67	16.00	48 67	41 33	35 44	13 11	358 8
CL-691	309 00	31 67	18 67	40 33	48 00	47.89	17 67	283 2
CL-692	284 00	28 67	16 67	42 00	47 00	45.56	16 22	316.8
SEL-98	249.00	23.00	8 67	20 33	42.89	41 22	18 00	276.0
M-1	265 00	32 67	18 67	43 67	60 89	50.33	19.44	235 2
M-2	294 67	22 00	13.33	24 67	38 89	33 33	16 33	244.8
CL-722	299 67	31.33	14 33	36 00	57 89	38 78	15.56	374.4
Mean	270 69	25.12	14 40	33 0	49.4	40 9	16 8	289 9

number of tillers than the check Greengold (23.67) The Mudigere results revealed, MCC 246 was tallest (198 11 cm) and M-2 had maximum number of suckers (12.22).

2.3 Varietal Evaluation Trial (VET)

2.3.1 Initial evaluation trial (IET-I)

(*Mudigere*)

Evaluation of fifteen open pollinated progenies was initiated in 1999. None of the entries performed better over check M-2. M-2 was tallest (288.67 cm), 24-17-D10 was superior for number of bearing suckers (16.00), 12-7-D11 for number of panicles per plant (42.0) and 2-4-D4 for panicle length (69.44 cm) and capsules per panicle (87.89).

2.4 Initial evaluation trial (IET-II)

(*Mudigere*)

Initial evaluation trial consisting of 13 entries was started in 1999-00. Cl-726 yielded highest (494 kg/ha) followed by Sel- 800 (403 kg/ha) and Cl-722 (374 kg/ha) (Table 17). Cl-691 was tallest (309 cm) while M-1 had maximum number of suckers (32.7) and bearing suckers (18.7), HS-1 was found superior for panicle number (48.7), Sel-800 for panicle length (62.8 cm) and M-1 for number of capsules (50.33).

2.5 Nutrient Management Trial

2.5.1 Integrated nutrient management (INM) in cardamom

(*Mudigere*)

Results (Table 18) indicated that the application of inorganic fertilizers performed

Table 18. Effect of INM on growth and yield of cardamom

Treatments	Bearing suckers	Panicle length (cm)	Capsules/ Panicle	Nodes/ panicle	Dry weight (kg/ha)
100 % Organic (OM)	17 60	52 60	16 34	12 54	106 00
75% OM + 25% INF	17.85	53 65	17 81	12 81	122 22
50% OM + 50% INF	19 90	58 12	19 69	12 63	141 92
25% OM + 75% INF	22 38	61.68	21 79	12 88	165 37
100 Inorganic Fert	25 20	65 28	22 95	13 76	224 15
Control	15.15	35 02	12 20	8 73	70 45
S Em + / -	0 26	1 26	0 31	0 15	3 01
CD (P=0 05)	0 82	3 99	0 98	0 48	9 54
CV (%)	2 68	4 65	3 36	2 41	4 35

(OM - 12 t/ha IOF - 75 N 75 P_2O_5 150 K_2O kg /ha)

Table 19. Effect of *Azospirillum* on cardamom yield at Pampadumpara

Treatments	Tillers per plant	Plant height (cm)	Yield (kg / ha)	
			Wet weight	Dry weight
Inorganic N 100%+*Azospirillum* 50 g +5 kg FYM	46 75	260 50	2820	550
Inorganic N 75%+*Azospirillum* 50 g +5 kg FYM	43.56	235.00	2622	478
Inorganic N 50%+*Azospirillum* 50 g +5 kg FYM	40.75	224 00	2537	378
Azospirillum 50 g +5 kg FYM	34.50	219 50	2342	337
FYM 5kg alone	29.75	210.70	1950	420
Azospirillum 50g FYM 10 kg	39 00	220 50	2418	377
FYM 10 kg alone	32 75	216 50	2157	370
Control	24 75	199 50	1319	270
CD (P-0 05)	1 72	2 20	107 86	26 63

significantly superior over other treatments. Application of 25% FYM – 75% inorganic fertilizer was second best. Organic manure alone did not support for higher yield. The supporting yield parameters also had similar tendency as that of yield obtained.

2.3.2 Effect of biofertilizer, *Azospirillum* on cardamom

(*Mudigere, Pampadumpara* and *Myladumpara*)

The experiment was started during 2001 and the results are presented in the Table 19. Maximum fresh weight of capsules (2820 kg/ha) and dry weight (550 kg/ha) was recorded in plots treated with inorganic nitrogen 100% + *Azospirillum* 50 g + 5 kg FYM and minimum in control plots (1319.75 kg/ha, 270 kg/ha). Maximum number of tillers (46.75) and plant height (260.5cm) was also recorded in the same treatment.

The results obtained at Mudigere indicate that the application of inorganic N alone or with *Azospirillum* performed significantly superior over other treatments (Table 20). Application of FYM alone with or without bio-organism yielded less. The supporting yield parameters also had similar tendency as that of yield obtained.

At Myladumpara, among the *Azospirillum* treatments significantly higher yield was recorded in plots which received 75.75:150 kg NPK/ha + *Azospirillum* 50 g/plant + 5kg FYM/plant (624 kg/ha) followed by 10 kg FYM + *Azospirillum* 50 g/plant (593 kg/ha) and both treatments were on par to each other (Table 21). Lowest yield was recorded in plots where FYM 5 kg/plant was applied (393 kg/ha) Five kg/ha FYM along with *Azospirillum* has significantly increased the yield

Table 20. Effect of *Azospirillum* on gowth and yield of cardamom at Mudigere

Treatments	Bearing suckers/plant	Panicle length(cm)	Capsule / panicle	Nodes/ panicle	Dry weight (kg/ha)
Inorganic N (100%) + *Azospirillum* (50g) + 5kg FYM	23 87	65 71	23 60	16.64	220 76
Inorganic N (75%) – *Azospirillum* sp (50g) + 5 kg FYM	20 80	65 87	22 75	15 72	208 58
Inorganic N (50%) – *Azospirillum* sp (50g) + 5kg	19 33	64.20	21 49	14 45	169 16
FYM T-4 FYM (5 kg) + *Azospirillum* sp	16 93	62 87	16 79	13 45	150 16
FYM (5 kg)	19.67	63 29	17 79	14 01	152 36
FYM (10 kg) + *Azospirillum* sp (50g)	18 33	64 62	17 64	13 15	153 59
FYM (10 kg)	17 60	63 87	17 32	15 08	145 29
Inorganic N (100%)	23 73	67 71	23 21	16 64	210 79
Inorganic N (75%)	20 00	66 20	22 89	16 11	194 37
S Em (+ / -)	0 58	1 14	0 46	0 41	4 98
CD (P-0 05)	1 74	NS	1 38	1 23	14 93
CV (%)	5 06	3 05	3 91	4.69	4 83

(P and K were given as per recommended package - 75 150 kg/ha in two splits)

Table 21. Effect of *Azospirillum* on yield and yield attributes of cardamom at Myladumpara

Treatments	Total tillers/ clump	Bearing tillers/ Clump	Panicles/ clump	Yield (kg/ha)
Inorganic N/P (100%) + *Azospirillum* 50 g +5 kg FYM	41.15	19 00	30 25	449
Inorganic N/P (75%) + *Azospirillum* 50 g +5 kg FYM	38 81	16 50	25.15	339
Inorganic N/P (50%) + *Azospirillum* 50 g +5 kg FYM	32.54	21 20	34 25	384
Azospirillum 50 g +5 kg FYM/plant	34 14	20 40	36.00	393
5 kg FYM/plant	39 00	18 60	30 15	485
Azospirillum 50 g +10 kg FYM/plant	50 48	21 11	40.00	624
10 kg FYM/plant	40.00	16 50	31 00	593
CD(P=0 05)	2 15	5 14	5 88	49.20

(619 kg/ha) over 5 kg/ha FYM alone whereas it was on par with 50 % N and 100 % PK + 5 kg FYM/ha (589 kg/ha). These results indicate that 50 % of inorganic nitrogen application can be saved by using nitrogen fixing bio fertilizer. Analytical data of soil and leaf NPK content did not show any variation among the treatments.

2.5.3 Effect of biofertilizer P-solubilizers on cardamom

(*Mudigere, Pampadumpara* and *Myladumpara*)

The experiment was started during 2003 at Pampadumpara and the results on biometrical parameters are presented in the Table 22. Number of tillers was found maximum (41.5) in plots treated with inorganic P 100% + *Phosphobacteria* 50g + 5kg FYM and minimum in control plots (19.7). Highest plant height (263 cm) was recorded in plots treated with inorganic P 100% + *Phosphobacteria* 50g + 5 kg FYM and lowest in control plots (207.25 cm). Maximum fresh (2775 g/plant) and dry (555 g/plant) weight was observed in inorganic P 100% + *Phosphobacteria* 50 g + 5 kg FYM treated plots.

The results obtained at Mudigere indicate that the application of inorganic P alone or with P-solubilizer performed significantly superior over other treatments. Application of FYM alone with or without bio-organism yielded less. The supporting yield parameters also had similar tendency as that of yield obtained.

Under Myladumpara conditions, use of *Phosphobacteria* showed significant impact on yield recording highest yield in plots receiving 75:75:150 kg/ha NPK + *Phosphobacteria* 50 g/pl + 5 kg/ha FYM (423 kg/ha) followed by 10kg FYM/ha + *Phosphobacteria* 50 g/pl (408 kg/ha). Both treatments were found on par to each other. Lowest yield (218 kg/ha) was recorded where 5 kg/ha FYM alone was applied whereas with addition of 50 g/pl *phosphobacteria* recorded significantly higher yield (423 kg/ha). Total number of bearing tillers/clump and number of panicles per clump were found significantly different among treatments. Available P and K content in soil were significantly different among treatments and were found highest in T1 treatment which received 100 % NPK + 50 g/plant bio-fertilizers + 5 kg/ha FYM. Nutrient content in leaf did not show any significant variation among the

Table 22. Effect of *Phosphobacteria* on yield of cardamom at Pampadumpara

Treatments	Tillers per plant	Plant height (cm)	Yield (kg / ha)	
			Wet	Dry
Inorganic N 100%+*Phosphobacteria* 50 g +5 kg FYM	41 50	263.00	2775	555
Inorganic N 75%+ *Phosphobacteria* 50 g +5 kg FYM	35 70	258 25	2660	531
Inorganic N 50%+ *Phosphobacteria* 50 g +5 kg FYM	32 00	248 50	2575	516
Phosphobacteria 50 g +5 kg FYM	27 75	230 75	2403	480
FYM 5kg alone	24 00	217 00	2014	403
FYM 10 kg + *Phosphobacteria*	30 50	242 00	2487	498
FYM10 kg alone	25 25	225 50	2225	445
Control	19 75	207 25	1500	300
CD (P=0 05)	1 43	3 18	88 18	16 91

Table 23. Effect of *Phosphobacteria* on nutrient content in soil and plant at Myladumpara

Treatments	Soil nutrient content				Leaf nutrient content (%)		
	OC (%)	Av.P (mg/100g)	Av.K	pH	N	P	K
Inorganic N/P (100%) + Biofertilizer 50 g +5 kg FYM	1 66	3 78	45 8	5.07	2 39	0 15	2 89
Inorganic N/P (75%) + Biofertilizer 50 g +5 kg FYM	2.04	4.78	56 1	5 03	2.20	0.16	2 65
Inorganic N/P (50%) + Biofertilizer 50 g +5 kg FYM	1 86	4.01	56.5	4 82	2.32	0.13	1.94
Biofertilizer 50 g +5 kg FYM/plant	1 77	1.59	36.9	5.15	2 35	0 14	1 74
5 kg FYM/plant	1 81	2.54	30.5	4 97	2 26	0.15	1.69
Biofertilizer 50 g +10 kg FYM/plant	1.96	3 01	34 0	5.07	2 32	0 16	2.05
10 kg FYM/plant	1 78	3.78	30 9	5 06	2.19	0 14	2 31

treatments except potassium content (Table 23).

2.5.4 Effect of neemcake on the productivity, pest and disease incidence in cardamom

(*Mudigere* and *Pampadumpara*)

The experiment on the influence of neem cake on biometrical characters of cardamom and reaction to insect-pest started during 2003 at Pampadumpara. Application of neem cake two times irrespective of the doses could significantly increase the number of tillers, plant height as well as yield of cardamom. Among the neem cake treatments, application of neem cake twice @ 0.5 kg and 1.0 kg resulted in significantly more number of tillers, higher plant height and yield. Minimum number of tillers (32.8, 33.3), lowest plant height (209.5, 206.8 cm) and lowest yield (247.7, 275.0 g/plant) were recorded in plants treated with 0.5 kg and 1.0 kg neem cake applied once, respectively. It was clearly evident from the table that maximum number of tillers (47.5), tallest tillers (262.8 cm) and highest yield (373.8 g/plant) were observed in plants treated with recommended schedule of fertilizers. Borer infested tillers were found to be lowest (7.3%) in plants treated with 1 0 kg neem cake once a year. However, highest and significant damage (11.8%) caused by shoot and capsule borer was recorded in plants treated with recommended schedule of fertilizers indicating the susceptibility of the crop due to application of fertilizers. Application of neem cake has significantly reduced the damage caused by shoot and capsule borer on cardamom tillers. Occurrence of root grub was found at par for all the treatments ranging from 2.0 to 2.5 in $30cm^3$ soil. Damage caused by thrips, borer and *azhukal* (capsule rot) on cardamom capsules was found to be non-significant.

Table 24. Parasitization of cardamom shoot and capsule borer

Month	Parasitization (%)	Parasitization by	
		Ichneumonid (%)	Others (Dipteran) (%)
May' 06	84 2	62 5	37 5
Jun' 06	86 7	61.5	38 5
Aug' 06	76 9	70 0	30 0
Oct' 06	76 5	76 9	23 1
Nov' 06	73 3	72 7	27 3
Dec' 06	16 7	100 0	0 0
Feb' 07	66 7	70 0	30 0
Mar' 07	68 4	61 5	38 5
Apr' 07	64 3	77 8	22.2

The results obtained under Mudigere conditions indicate that application of neem cake @ 0.5 or 1.0 kg/plant had yielded better than the control.

2.6 Pest Management Trial

2.6.1 Bioecology of natural enemies of major pests of cardamom

(*Mudigere* and *Pampadumpara*)

Observations recorded at fortnightly intervals on natural enemies of the major pests of cardamom with special reference to cardamom thrips and capsule borer at Mudigere indicated general predators like spiders in the cardamom ecosystem. larvae of *Chrysoperla* sp. were found to be the predators of thrips. more often weather factors (rainfall) playing a vital role in minimizing thrips population. The observation on larvae of

Table 25. Probit analysis of dosage mortality relationship of *B. fulvicorne* to *H. indica* (CRS isolate)

Time	Heterogeneity		Regression equation (y)	LC_{50}	LC_{90}	Fiducial limit	
	x^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 26. Quantitative parameters of healthy and thrips infested capsules

Treatments	Fresh 100 capsule weight (g)	Seeds / capsule	Dried 100 capsule weight (g)	Capsules in 100 cc	Driage (%)	5 capsule husk weight (g)
Category 0(Healthy)	108 8	20.3	24 0	160 3	19.7	0 4696
Category 1(10% scab)	95.0	19.0	21 8	184 8	19 8	0.4384
Category 2(11-33% scab)	86.3	18 5	18 0	196 5	19 8	0.3622
Category 3(>33% scab)	76.3	18 3	15.1	221.0	19.7	0 3415
CD (P=0 05)	**12.23**	**ns**	**1.15**	**2.29**	**ns**	**0.059**

Conogethes punctiferalis found being parasitized by *Xanthopimpla* sp., *Ropalidia* sp. and unidentified species of *Ichneumonid*. No microbial infected pests found during the study period.

At Pampadumpara, natural parasitization of cardamom shoot and capsule borer larvae by ichnuemonids *viz.*, *Agrypon* sp. and *Temeluchus* sp. ranged from 16.7% to 86.7%. Cardamom root grub, *Basilpeta fulvicorne* was found to be naturally infected by *Metarhizium* sp. to a maximum of 12.9% under field conditions. Probit analysis of dosage mortality relationship against *B. fulvicorne* revealed that *Heterorhabditis indica* (CRS, isolate) was more virulent than *H. indica* (Hi 6.71). Cardamom whitefly was infected by three species of entomopathogenic fungi *viz.*, *Aschersonia placenta*, *Verticillium* sp. and *Acremonium* sp.

Parasitization percentage of cardamom shoot and capsule borer on different months of 2006-2007 is presented in Table 24. Shoot borer larvae could not be collected during the months of July, September and January. Highest parasitization was observed in June (86.7%) and lowest in December (16.7%). Extent of parasitism was found to be lowest during winter period and caterpillars could not be collected during peak monsoon phases. Except during December, parasitization of shoot and capsule borer larvae was recorded in all months to more than 60%. Parasitization of cardamom shoot borer larvae by ichnuemonids ranged from 61.5% to 100% and occurred during all months under investigation. Highest parasitization was recorded during December (100%). Parasitization by other dipteran parasitoids was registered in all months except December. Occurrence of dipteran parasitoid was always found to be less than 40%. Results revealed that 68.2% of shoot and capsule borer was parasitized by ichnuemonids as well as dipteran parasitoids. Parasitization was predominantly performed by ichneumonids.

Comparison of virulence between *H. indica* (Hi 6.71) and *H. indica* (CRS isolate) against *B. fulvicorne*

Probit analysis of dosage mortality relationship of *B. fulvicorne* between *H. indica* (Hi 6.71) and *H. indica* (CRS. isolate) revealed that *H. indica* (CRS isolate) was more virulent than *H. indica* (Hi 6.71) against *B. fulvicorne* (Table 25). The LC_{50} value of *H. indica* (Hi 6.71) was 1.7 times higher than LC_{50} value of *H indica* (CRS, isolate) at 72 h after treatment. The trend was, however, identical at 96h and got reduced to 1.2 times at 120h.

Table 27. Activity profile of trypsin-like protease in healthy and thrips infested cardamom seed extract

Stage of seed	Activity (nmole p-nitroaniline/ min/g seed Mean ± SD		Protein (mg/g) Mean ± SD		Specific activity (nmole/min/mg protein)	
	Healthy	Scab	Healthy	Scab	Healthy	Scab
Fresh white seed	55 37 ±1 32	53 90 ±2 21	16 85 ±0 50	13 48 ±0 47	3 29	3 99
Fresh black seed	32 11 ±0 97	35 57 ±0 88	10 50 ±1 65	11 15 ±0 39	3.06	3 19
Dried black seed	14 10 ±1 03	22 31 ±1 13	12 15 ±0 33	9.66 ±1 50	1 16	2 31

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

(*Mudigere* and *Pampadumpara*)

Variation in quantitative parameters of healthy and thrips infested capsules is summarized in Table 26. 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 108.8 g in category 0 (healthy) to 76 3 in category 3 (>33% scab). A similar trend was also recorded in dry weight of 100 capsules ranging from 24.0 in category 0 (healthy) to 15 1 in category 3 (>33% scab). Puncturing and desaping by thrips reduced the fresh and dry weight of the capsules significantly and the scab formation is mainly attributed to host induced reaction. The number of dried capsules in 100 cc progressively increased with increase in thrips damage. It was found that 160.3 healthy capsules occupied in 100 cc which further increased to 221.0 for thrips-infested capsules (category 3). This indicated that the size of the capsules were shriveled and became smaller due to feeding by thrips. However, there was no significant difference in the number of seeds per capsule as well as driage percentage in healthy and thrips infested capsules. Husk weight of five capsules indicated a progressive decline with increase in thrips infestation. Husk weight was found to be highest (0.470 g) for healthy capsules (category 0) and lowest (0.342 g) for capsules with highest thrips infestation (category3).

It was also found that the husk:seed ratio was found highest in healthy capsules (38:62) and got reduced after thrips infestation (33:67). The volatile oil content did not differ significantly between healthy and thrips infested capsules. Peptidase activity of healthy cardamom capsules declined progressively as the maturity advanced (Table 27). Highest trypsin-like activity in healthy capsules was observed in fresh white seed (55.37 nmoles *p*NA / min/g) and lowest in dried black seed (14.10 nmoles *p*NA / min/g). A similar trend was also observed in thrips infested capsules. Cardamom capsules are normally exposed to >60°C during curing which inactivated the enzyme in dried black seed. However, peptidase activity in dried black seed was found to be significantly higher (22.31 nmoles *p*NA / min/g) in thrips infested capsules than healthier ones (14.10 nmoles *p*NA / min/g). Variation also existed in protein content for healthy and thrips infested capsules in all three categories of seeds studied. Specific activity of scab capsules was found to be higher than healthy capsules and the highest specific activity was recorded in fresh white seeds for both categories. A two-fold increase in specific activity was recorded between the dried black seeds of healthy and thrips infested capsules. It is therefore suggested that the thrips infested capsules are qualitatively more superior than healthy capsules with respect to specific activity of peptidase enzyme.

The thrips damage was assessed based on the per cent scabbed surface areas of the capsules at Mudgere centre. Capsules harvested and dried were graded in to four groups as 0= no damage, 1= upto 10% scabbed area, 2= 11% to 33% scabbed area and 3= >33% scabbed area. Observations recorded showed significant reductions in the number of seeds with the increase in scabbed area by thrips. Reduction in capsule weight, husk weight, number of healthy seeds were recorded under thrips infestation.

2.6.3 Management of shoot fly in cardamom

(*Mudigere* and *Pampadumpara*)

The efficacy of three insecticides *viz* , phorate, fipronil and actara and three organic insecticides *viz.*, neem cake, fish oil rosin and neem seed kernel extract (NSKE) were compared for effectiveness management of shoot fly in newly planted cardamom plantations during 2006-07 at Mudigere. The population of shootfly was significantly low in all the treatments compared to NSKE and untreated control (Table 28). Among the treatments phorate (6.16%) actara (6.33%) and neem cake (8.17%) were found superior compared to other treatments. However, neem cake recorded significantly superior over other treatments with mean number of tillers (18.91).

2.6.4 Management of cardamom root grub through entomopathogenic nematodes

(*Mudigere* and *Pampadumpara*)

A field experiment was conducted at CRS, Pampadumpara to evaluate the efficacy of two

Table 28. Management of cardamom shoot fly *Formosina flavipes* at Mudigere

Treatments	Dosage	Pre-treatment	30 DAT	60 DAT	Mean	Mean number of tillers
Phorate	10 gm	15 00	5 00	7 33	6 16	11.21
Neem cake	½ kg	11 00	7.67	8 67	8 17	18 91
Fipronil	1.5 ml	9 67	8 00	8 33	8.16	9 62
Fish oil rosin	4 gm	13 67	11 33	13.00	12.17	10 51
NSKE	4%	9 00	19 33	15 00	17.17	8 65
Actara	1 gm	6 00	5.33	7 33	6 33	9.65
Control		11 00	14 67	14 33	14 5	6 13
CD (P=0 05)		4.600	2 174	1.812		
SEm		36.70	18.32	14 72		

(DAT - days after treateemnt)

isolates of *Heterorhabditis* sp. at two different concentrations against cardamom root grub. Combination of entomopathogenic nematodes (EPN) with imidacloprid (0.01%) was also attempted in the study. Treatments were superimposed during evening hours of April 2007 and the field was adequately moistened before release of EPN. Initial population of the root grub was assessed as 26.6 in 30cm^3 of soil before the application of treatments Application of EPN was found to be effective in reducing the population of cardamom root grub. Application of EPN @ 100 IJ/grub or 200 IJ/grub was found to be at par in reducing the root grub population. However, the local isolate *H. indica* was found to be more effective than *H bacteriophora* in suppressing the population of cardamom root grub (61.4%). The cardamom root grub population ranged from 4.1 to 15.8 in 30 cm^3 of soil after the application of EPN Significant reduction of cardamom root grub was observed in plots treated with combined application of imidacloprid (0.006%) and *H. indica* (100 IJ/grub). Application of two different concentrations of *H. indica* (100 IJ/grub or 200 IJ/grub) and imidacloprid (0 01%) alone was found to be at par in the suppression of cardamom root grub (Table 29).

The root grub mortality increased significantly when the nematode was applied alone or in combination with imidacloprid. In addition to increase in root grub mortality, combined application of nematode-imidacloprid increased the speed of kill compared to nematode or imidacloprid used separately. Imidacloprid is therefore compatible with entomopathogenic nematodes and the sluggishness brought about on cardamom root grub made easy entry of EPN in to the host resulting in accelerated speed of kill. A combined application of nematode and neonicotinoid is therefore suggested as a curative method in the management of cardamom root grub. Care should be taken to ensure adequate moisture content while applying EPN and application of EPN should be restricted to evening hours for better results.

Table 29. Effect of entomopathogenic nematodes and imidacloprid on cardamom root grub

Treatments	Initial grub* pop. (No.)	Grub pop. after treatment (No.)*	% reduction after drenching**
T1 *Heterorhabditis indica* (CRS isolate) 100IJ/grub	25 6 (5 06)	10 0 (3 16)	60 9 (51 9)
T2 *H indica* (CRS isolate) 100IJ/grub	26 8 (5 17)	10 3 (3 21)	61 4 (52.1)
T3 *H bacteriophora* 100IJ/grub	27 4 (5 23)	15 1 (3 88)	44 8 (42 6)
T4 *H bacteriophora* 200IJ/grub	26 1 (5 11)	15 8 (3 97)	39.2 (39 3)
T5 Imidacloprid 0 01% (0 7 ml/litre)	27 5 (5 25)	9 6 (3 09)	65 2 (54 5)
T6 *H indica* (CRS isolate) 100IJ/grub plus Imidacloprid 0 006% (0 5ml/litre)	26 1 (5 11)	4 1 (2 02)	84 2 (67 4)
T7 Control	26 7 (5 00)	24 2 (4 92)	3 8 (11 2)
CD (P-0 05)	n s	0 11	6 10

* Values in parentheses are square-root transformed ($\sqrt{x}$)

** Values in parentheses are arc-sine transformed (Sin$^{-1}\sqrt{x}$)

2.6.5 Management of panicle rot and clump rot diseases of cardamom in existing plantation

(*Mudigere* and *Pampadumpara*)

This experiment was laid out in Pampadumpara during 2006 and the treatments were imposed. Biocontrol agents and fungicides were evaluated against capsule rot and clump rot diseases of cardamom. Least disease incidence on tillers, panicles and capsules was recorded in the plots treated with *Trichoderma harzianum* and consortium of bacteria @ 50 g/vine followed by consortium of bacteria @ 50 g/vine. Tiller infection due to clump rot disease ranged from 2.67 % to 15.04 % for all the treatments. Minimum panicle infection (3.1%) and capsule infection (3.4%) due to capsule rot was recorded in the plots treated with *Trichoderma harzianum* and consortium of bacteria @ 50 g/vine and maximum infection on panicles (15.02%) and capsules (15.52 %) was observed in control plots.

2.6.6 Management of panicle rot and clump rot diseases of cardamom in new plantation

(*Mudigere* and *Pampadumpara*)

Trial was initiated at Pampadumpara during 2006 and pre and post monsoon treatments were imposed. Three varieties of cardamom namely Greengold, PV-2 and IISR-Avinash were planted for evolving a management strategy for capsule rot and clump rot diseases of cardamom. The clumps of PV-2 and Greengold have established well whereas the growth and establishment of IISR-Avinash was poor compared to other varieties. Capsule and clump rot disease incidence was not noticed in all the varieties.

3. GINGER

3.1 Genetic Resources

3.1.1 Germplasm collection, characterization, evaluation and conservation

(*Dholi, Chintapalli , Raigarh, Solan, Kumaraganj, Pottangi* and *Pundibari*)

Based on yield performance 47 germplasm accessions of ginger were collected from different parts of Bihar. Among 47 germplasm lines evaluated at Dholi, seven germplasm accessions *viz* , RG-21, RG-39, RG-15, RG-23, RG-16, RG-31 and RG-5 recorded high yield ranging from 10.00 to 14 kg/ 7 m^2. The maximum yield was obtained in RG-21 (14.0 kg/7m^2) followed by RG-39 (12.0 kg/7m^2). The ginger germplasm at different AICRP centres are given in Table 30.

Germplasm collections were made from high altitudes and tribal zones of Chintapalli and among 6 collections evaluated Vamugedda recorded the highest fresh rhizome yield of 12.3 t/ha followed by Chinarajupakalu (11.6 t/ha).

Thirty three germplasm accessions were evaluated at Raigarh. Maximum yield was obtained in IG-5-30 (5.93 t/ha) followed by IG-5-41 (4.52 t/ha) and IG-5-12 (3.72 t/ha). The local check IG-1 recorded yield of 9.35 t/ha which was significantly higher as compared to other entries.

Two hundred and eighty six collections were evaluated under field conditions for different horticultural characters at Solan. The yield per plot (3 m^2) of ten promising lines varied from 7.25 to 11.5 kg whereas the yield range of germplasm varied from 1.50 to11.5 kg. The accessions SG 1119 and SG 29/04 gave maximum yield and less disease incidence (1.0%).

Twenty nine germplasm entries of ginger were evaluated at Pundibari. GCP-21 recorded maximum plant height (67.50 cm) followed by GCP-12 (65.0 cm), whereas GCP-16 recorded the lowest plant height (45.27 cm) Maximum number of tillers was recorded in GCP-31 (9.33) followed by GCP-27 (8.50) and GCP-8 (8.10). GCP-5 and GCP-28 recorded maximum number of leaves (18.67), whereas GCP-13 (11.0) recorded lowest leaf number per plant. GCP-12 recorded the highest mean values for stem girth (4.07 cm) while GCP-7 recorded the lowest values for the same trait (1.85 cm). For leaf length, GCP-32 recorded maximum mean values (22.63 cm) followed by GCP-17 (21.87 cm) and GCP-21 (21.83cm), whereas GCP-7 recorded the lowest value (13.90 cm). GCP-20 recorded the broadest leaf (4.17 cm) followed by GCP-21 (2.97 cm) while GCP-7 and GCP-25 recorded the narrowest leaf (1.57 cm each). Maximum PDI was recorded in the germplasm GCP-12 (75.30 %) followed by GCP-13 (75.10 %) and GCP-3 (75.0 %). Lowest PDI was recorded in GCP-30 (25.0 %). Highest rhizome yield/plant was recorded in GCP-31 (268.25 g) followed by GCP-32 (258.33 g), GCP-21 (254.67 g) and GCP-16 (252.33 g). Lowest rhizome yield per plant was recorded in GCP-25 (133.33 g) followed by GCP-22 (146.0 g).

At Pottangi, 145 accessions (out of 177 germplasm) were evaluated and results revealed 28 promising accessions with high yield (>8 kg/ 3 m^2), the range of yield being 2.80 kg to 12.4 kg/3 m^2. The highest fresh rhizome yield was recorded in

Table 30. Ginger germplasm collection of AICRP centres

Center	Indigenous	Exotic	Total
Pottangi	174	3	177
Solan	286	-	286
Dholi	47	-	47
Chintapalle	06	-	06
Kumarganj	58	-	58
Pundibari	42	-	42
Raigarh	44	-	44
Total	657	3	660

Table 31. Growth and yield parameters of CVT 2000 ginger at Pundibari

Entries	Estimated yield (t/ha)						
	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	Mean
Gorubathan	38 65	21.75	15 690	14 830	14 86	16 28	20 34
SG-682	17 20	14 79	9 590	10 988	11 17	11 33	12 51
SG-692	17 26	15 98	9.130	14 119	14 05	13.83	14 06
V_1S_1-2	15 91	14 58	9.725	10 172	10 16	10 89	11 91
V_1S_1-8	15 30	12 76	9 353	13 218	13 16	13 79	12 93
ACC-35	16 39	14 00	14 897	10 101	10 12	10 59	12.68
ACC-117 (check)	15 74	16 25	13 720	10.585	10 60	10.82	12.95
SEm (±)		1 98	1 98	1.03	0.15	0 27	
CD (P=0 05)		2 82	2 82	2 245	0 32	0 59	

V_1E_5-4 (12.4 kg/3m²), PGS-12 (12.0 kg/3m²) followed by KG-42 (11.5) and PGS-8 (11.0).

Out of 54 germplasm lines evaluated at Kumarganj centre, NDG-27 produced the maximum fresh rhizome yield of 12.52 t/ha followed by NDG-29 (12.32 t/ha). a local germplasm.

3.2 Coordinated Varietal Trial (CVT)

3.2.1 CVT 2000 Series V

(*Raigarh, Pottangi* and *Pundibari*)

The trial was initiated in Raigarh during 2001-02 and is in the fifth year of progress. Seven entries were evaluated during 2006-07. The highest yield was obtained in IG-1 (7.03 t/ha) followed by IG-5 (3.82 t/ha) and IG-4 (2.95 t/ha).

The CVT with 7 entries started during 2001-02 at Pundibari and analysis of pooled mean values over six years (2001-2007) showed that the genotypes exhibited significant genetic variability for the different traits under study. The genotype Gorubathan recorded maximum values for several traits *viz* plant height (65.13 cm), number of tillers (9.29), number of leaves per plant (18.14), leaf length (20 91 cm), leaf breadth (2.24 cm). pseudo stem girth (2.71 cm). rhizome yield per plot (8.07 kg/3m²) and projected yield (20.34 t/ha). The genotype SG-692 with a projected yield of 14.06 t/ha (Table 31), in addition to Gorubathan, out yielded the check, ACC-117 (12.95 t/ha). However, lowest pooled mean values for PDI was recorded by V_1S_1-8 (27.80).

Table 32. Mean performance of ginger entries for yield and disease incidence

Entries	Yield/plot (kg)	Yield/ha (t)	Disease incidence (%)
SG50/04	8 5	17 10	3 4
SG27/04	7 5	15 07	4 0
SG17/04	4 5	9 04	10 0
SG827	6 2	12.10	5 5
SG983	5.3	10 65	6 5
Himgiri	7.2	14 47	4 5
Mean	7 8	15 67	5 6
SE ±	1 50		
CD (P=0 05)	3 15		

At Pottnagi, there was significant difference among the entries for fresh rhizome yield. Highest fresh rhizome yield over two years was recorded by V_1S_1 -2 (25.10 t/ha) followed by ZO-2 (22.99 t/ha).

3.2.2 CVT 2005 (*Solan*)

Significant differences amongst entries were observed for yield per plot. SG 50/04. though gave maximum yield per plot (8.5kg) but was at par with check Himgiri. Minimum yield of 5.3 kg/plot was recorded in SG 983 (Table 32). The disease incidence was minimum (3.4%) in SG 50/04 while maximum (10.0%) in SG 17/04.

3.3 Initial evaluation trial (IET)

(*Solan, Raigarh and Pottangi*)

Sixteen accessions including check were evaluated in IET during 2006 at Solan. Significant differences were observed for yield per plot and quality attributes. The entries, SG 810 and SG 1046 were at par with Himgiri and recorded with 17.30 and 12.90 % disease incidence. respectively. None of other genotypes recorded with disease incidence less than 10%.

A new IET with 10 entries was evaluated during 2006-07 at Raigarh. The entry IG-5-22

Table 33. Performance of IET 2006 ginger genotypes in Raigarh

Entries	Yield/plot (kg/3m² bed)	Yield (t/ha)
IG-5-1	3 37	6 77
IG-5-2	1 33	2.68
IG-5-14	3 17	6 37
IG-5-22	5 9	11 86
IG-5-24	3 17	6 37
IG-5-25	4 17	8 38
IG-5-26	3 60	7 24
IG-5-27	2 63	5 29
IG-5-28	3 0	6 03
IG-5-32	3 10	6 23
Local check (IG-1)	4.07	8 17
Mean	3 41	6 85
CD (P=0 05)	-	1 74

(11.86 t/ha) was significantly superior than the check IG-1 (8.17 t/ha) (Table 33).

Significant difference was recorded among the entries tested at Pottangi for fresh rhizome yield. Highest fresh rhizome yield was recorded by V_1E_5-4 (26.71 t/ha) followed by PGS-9 (26.29 t/ha).

3.4 Quality Evaluation Trial

3.4.1 Evaluation of ginger germplasm for quality

(*Solan*)

The samples were analyzed during 2006 for different quality attributes *viz* , dry matter, essential oil, oleoresin and fiber content. Out of 110 collections, 55 were found to be superior for quality attributes as they had high essential oil (> 1.5 %) and oleoresin (> 4.5 %). Whereas, fiber content in these collections were recorded to be less than 6.0 per cent Dry matter content ranged between 11.15 and 21.40 per cent in all the collections under study. Essential oil and oleoresin contents varied from 0.5 to 2.0 and 2.5 to 6.5 per cent, respectively. Among the collections SG 707. SG 827 followed by SG 682, SG 1071. 50/04, SG 1030, 17/04, 19/04, 24/04, SG 114, SG 911, 14/04 and SG 84 were found significantly superior for dry matter content in comparison to check Himgiri. The oleoresin and essential oil contents in SG707. SG 716, SG1102 and SG995 were found to be significantly higher than Himgiri. However. significantly less fibre content was recorded in SG 827. SG716. SG707 and 12/04 in comparison to check Himgiri. Overall, collections like SG 707. SG 827, SG 716. SG682 and 51/04 exhibited better quality attributes along with yield (> 5 kg /plot). However, other collections *viz.*, SG 1030, SG 603 and SG 49/04 also exhibited superior quality attributes but recorded lesser yield. Ninety genotypes were evaluated for various quality attributes *viz* dry matter, oleoresin and essential oil content The dry matter varied from 13.65 to 29.80%. The oleoresin and essential oil ranged form 3.40 to 6.86% and 1.0 to 2.50%, respectively.

3.5 Nutrient Management Trial

3.5.1 Effect of micronutrients on ginger

(*Dholi, Pottangi, Raigarh, Pundibari* and *Kumaraganj*)

In Dholi, soil application and foliar application of zinc sulphate, borax and ferrous sulphate had non significant effect on plant height and number of leaves per tillers. Soil application of zinc sulphate @ 25 kg/ha, borax @ 10.0 kg/ha and foliar application of ferrous sulphate @ 1.0 percent at 60 and 90 days after sowing were significantly increased the number of tillers per plant (25.99) and yield (29.35 t/ha) in comparison to other combinations of zinc sulphate, borax and ferrous sulphate and control. The cost benefit ratio indicated the maximum return of Rs. 5.21 per unit cost (1.5.21) under the treatment soil application of zinc sulphate, borax and foliar application of ferrous sulphate.

At Pottangi, the results revealed that there was significant difference among different treatments. Highest fresh rhizome yield was obtained in T14 (zinc sulphate 25 kg/ha – borax 25 kg/ha + iron sulphate 25 kg/ha as soil dressing) (18.27 t/ha) followed by T15 (zinc sulphate 25 kg/ha – borax 25kg/ha as soil dressing + iron sulphate 0 5% as foliar Sprays at 45 and 60 DAP) with yield of 17.01 t/ha.

The experimental results of Raigarh centre revealed that application of zinc sulphate resulted in appreciable improvement in fresh rhizome yield of ginger significantly Maximum yield of 21.43 t/ha was recorded with application of 0.5% foliar spray at 60 and 90 days after planting (DAP). The minimum yield of 18.10 t/ha was recorded in the treatment without zinc sulphate. Increasing levels of boron also increases the ginger yield significantly.

Application of 0.2% borax as foliar spray (60 and 90 DAP) recorded maximum rhizome yield of 21.47 t/ha. Application of ferrous did not increase the yield of ginger significantly and it was at par with control. Maximum yield of 20.18 t/ha was recorded in application of 1.0% ferrous sulphate (60 and 90 DAP) as foliar sprays. The interaction effect between Zn, Bo and Fe was not significant but the yield was appreciably higher at higher level of Zn, Bo and Fe. The maximum yield 24.05 t/ha was recorded with foliar sprays of 0.05% zinc sulphate 0.2% of borax and 1.0% of ferrous sulphate at 60 and 90 DAP.

At Kumarganj, foliar spray of zinc @ 0.5 %, borax @ 0.2 % and ferrous sulphate @1.0 % produced maximum fresh rhizome yield of 1.60 t/ha after 60 and 90 DAP, followed by foliar spray of borax yielding 1.0 t/ha of fresh rhizome yield. Three years pooled data also showed maximum fresh rhizome yield in foliar spray of zinc @ 0.5 %, borax @ 0.2 % and ferrous sulphate @1.0 % followed by foliar spray of borax @ 0.2 %.

The experimental results at Pundibari revealed that soil and foliar application of zinc, boron and iron recorded significant increase in yield and quality parameters, separately over its control. There was also a significant interaction effect for zinc and boron towards increase in yield. Soil application of each micronutrient gave better results for yield and quality over its foliar spray. The treatment combination of soil application of 10 kg borax, 25 kg zinc sulphate and 10 kg ferrous sulphate per hectare (B_{10} Zn_{25} Fe_{10}) recorded highest yield of 35.17 t/ha fresh rhizome, 1.33% essential oil and 6.52% oleoresin.

3.5.2 Organic farming in ginger (new)

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

At Kumarganj maximum fresh rhizome yield of 0.47 t /ha was obtained in application of 50% inorganic fertilizer + 50% FYM along with 5 kg/ha of *Azospirillum* and seed treatment as well as soil application *Pseudomonas fluorescens* + *Trichoderma* (50 g/3m^2). The experimental plots were severely affected by rhizome rot disease hence the yield was very poor.

At Pottangi, there was no significant difference among different treatments for fresh rhizome yield. Highest yield was recorded in T_3 (recommended inorganic inputs) (17.64 t/ha) followed by T_2 (semi organic with inorganic package of practices) (15.12 t/ha).

3.6 Disease Management Trial

3.6.1 Disease surveillance and etiology of rhizome rot in ginger

(*Pundibari* and *Solan*)

The disease surveillance with regard to rhizome rot of ginger was undertaken in districts Sirmour, Solan, Mandi, Bilaspur and Shimla by the Solan centre. The disease symptoms and pathogen associated are given in Table 34.

Table 34. Disease incidence in ginger

Disease	Pathogen	Location
Leaf blight	*Xanthomonas* sp	-
Rhizome rot	*Pythium & Fusarium*	Shillai,Nauni (Sirmour)
Leaf spot	*Phyllosticta zingiberi*	Solan, Sirmour
Soft rot	*Pythium ultimum* & *Ralstonia solanacearum*	Sundernagar (Mandi)
Leaf spot	*Bipolaris* sp	Nauni

3.6.2 Biocontrol studies on rhizome rot of ginger (final report)

(*Kumaraganj, Pottangi* and *Raigarh*)

During 2006-07 at Kumarganj, minimum rhizome rot incidence of 46.00 % was observed with seed treatment of rhizome (hot water at 51°C for 30 minutes) and *Trichoderma harzianum* for 30 minutes mixed with neem cake. Maximum yield of 1.406 t/ha was also observed in this treatment. In three years pooled data, similar observations were made with the same treatment recording minimum rhizome rot disease incidence and maximum yield showing 123.70 % of increase in yield over control (Table 35).

There was significant difference for yield among different treatments at Pottangi. However highest fresh rhizome yield (17.96 t/ha) was obtained in T_5 (seed treatment with mancozeb 3 g/l + carbendazim 1g/l + chloropyriphos 2 ml/l for 30 min and soil application of thimet (10G) 1kg ai/ha) followed by T_6 (hot water seed treatment + T_1)

Table 35. Effect of bio-control agent, fungicide and hot water treatment on incidence of rhizome rot disease at Kumarganj

Treatments		Rhizome rot (%)				Yield (t/ha)			
		2004-05	2005-06	2006-07	Mean	2004-05	2005-06	2006-07	Mean
T_1	Seed sown directly (Control)	95 33	89 00	90 00	91 44	0 199	0 560	0 456	0 450
T_2	Seed treatment with hot water at 51°C for 30 minutes	76 00	62 00	64 66	67 53	0 499	0 690	0 926	0 705
T_3	Seed treatment with mancozeb (3g/l) for 30 minutes	78 00	67 00	70 00	71 66	0 333	0 890	0 893	0 705
T_4	Seed treatment with *Trichoderma harzianum* for 30 minutes	88 00	78 00	68 66	78 22	0 299	0 540	0 583	0 474
T_5	Seed treatment with *Trichoderma harzianum* for 30 minutes + mancozeb (3g/l) for 30 minutes	76.66	70.00	69 33	71 99	0 580	1 02	1 043	0 881
T_6	Seed treatment with hot water at 51°C for 30 minutes and seed treatment with *T harzianum* for 30 minutes with neem cake.	66.00	54 30	46 00	55 43	0 660	0 66	1 400	0.908
T_7	Soil application of neem cake at the time of sowing & planting	80.00	80 00	80 00	80 00	0 610	0 072	0 980	0 554
CD (P=0 05)		15 16	04 96	7 29	-	0 410	-	0 41	-
CV (%)		10 68	40.08	5 55	-	51 08	-	34 85	-

Table 36. Effect of bio-control agent, rhizome solarization and fungicides and hot water treatment, on integrated management of *Pythium, Fusarium* and *Ralstonia* in ginger at Kumarganj

Treatments		Sprouting (%)				Rhizome rot (%)				Yield (t/ha)			
		2004-05	2005-06	2006-07	Mean	2004-05	2005-06	2006-07	Mean	2004-05	2005-06	2006-07	Mean
T_1	Seed treatment with mancozeb (3g/l) for 30 minutes	79 00	78 50	78 5	78 66	54 00	44 00	45 5	47.83	1 37	2 13	2 16	1 88
T_2	Seed treatment with *T harzianum* @ 4 g/kg	75 00	56.50	59 0	63 50	57 00	51 00	55 0	54 33	1 28	1 49	1 72	1 49
T_3	Rhizome solarization in Polybags for 2 hrs before sowing	21 50	75 50	77 5	58 16	94 00	69 00	67 5	76.83	0 125	1 63	1 80	1 18
T_4	Ridomil mancozeb (100 ppm metalaxyl)	67 00	59.50	60 5	62 33	61 50	60 50	61 5	61 16	1.33	1 69	1 71	1 57
T_5	Seed treatment with hot water at 51°C for 30 minutes	73 50	73 50	81 5	76.16	63 50	64 50	67 5	65 16	1 31	1 77	1 86	1 64
T_6	Untreated control	65 50	67 00	73 0	68 50	71 00	76 00	79 00	75 33	0 91	1 50	1 48	1 29
SEm		-	21.49	8.42	-	-	10 83	-		-	18.15	-	
CD (P=0 05)		8 82	17 04	8 74	26 54	26 73	5 54	3 97	-	1 05	0 67	0 15	-
CV (%)		13 42	17.07	26 54	21 49	38 75	9 62	12 52	-	96 67			

Table 37. Effect of different treatments on diseases and yield of ginger at Solan

Treatments	Disease incidence (%)				Yield (kg/3m²)
	Soft rot	Yellows	Bacterial wilt	Total	
Mancozeb (0 3%)	4 37(2 091)	8 37 (2 894)	7 25(2 692)	19 99	5 49
Trichoderma harzianum (2 5%)	6 37(2 524)	6 31 (2 512)	6 68(2 586)	19 36	7 00
Rhizome solarization (45 min)	7 25(2 692)	5 31 (2 304)	2 37 (1 541)	14 93	7 38
HWT (45°C/30 min)	5 31 (2 304)	4 37 (2 091)	3 12 (1 767)	12 8	6 56
Copper oxychloride (0 3%)	7 18 (2 681)	8 37 (2 894)	4 37 (2 091)	19 92	6 56
Control	12 25(3 500)	10 43(3 231)	9 37(3 062)	32 05	
CD (P=0 05)	0 077	0 057	0 058		0 25

Table 38. Disease incidence of ginger in UP

District	Variety	Disease	Incidence (%)
Farmer's field			
Faizabad	Barua Sagar (Jhansi)	Rhizome rot	24-75 47
		Leaf spot (Nagpur)	24-92 80
Kushinagar	Local	Rhizome rot	5-60 00
		Leaf spot	20-37 5
Padrauna	Local	Rhizome rot	5-60 00
Kasya	Local	Rhizome rot	0-5 0
Storage – Trader Shop			
Samples	**Source of Ginger**	**Disease observed**	
Faizabad	Karnataka	Rhizome rot / Storage rot	
	Barua Sagar		
	Milkipur		
	Nepal Border		
	Bihar		
Lucknow	Karnataka	Rhizome rot	
	Barua Sagar		
Kushinagar	Local	Low incidence of rhizome rot	

3.6.3 Integrated management of *Pythium*, *Fusarium* and *Ralstonia* in ginger (final report)

(Kumaraganj, Solan, Pundibari, Raigarh and Pottangi)

During 2006-07, minimum rhizome rot disease incidence (45.50 %) and maximum fresh rhizome yield (2.16 t/ha) was recorded in seed treatment of rhizomes with mancozeb (3 g/l) for 30 minutes. Three year pooled data also showed minimum incidence of rhizome rot disease and maximum yield (an increase of 45.73 % over control) in seed treatment with mancozeb (3 g/l) for 30 minutes (Table 36)

At Raigarh, minimum disease incidence (7%) and maximum yield per plot (5.6 kg) was recorded in treatment Ridomil Mancozeb (100 ppm of Metalaxyl) Maximum disease intensity (21%) and minimum yield (2.1 kg/plot) were recorded in control.

The data (Table 37) revealed that minimum incidence was in hot water treatment (HWT) (45°C for 30 min) followed by rhizome solarization (45 min). The increased effect of rhizome solarization was noticed on yield (7.375 kg/3m²) followed by soil application of *Trichoderma harzianum* (7 kg/ 3m²) and HWT (6 562 kg/3m²). HWT was found to decrease the incidence of *Pythium* soft rot, *Fusarium* yellows and *Ralstonia* wilt of ginger at Solan.

At Pundibari, minimum disease incidence was recorded in seed treatment with Ridomil Mancozeb (T_5) followed by seed treatment with *Trichoderma harzianum* (T_2) and seed treatment with hot water treatment at 51°C for 30 minutes (T_4). The treatments T_2, T_4 and T_5 were statistically

at par. The highest yield was also obtained in T_5 (5.46 kg/plot) followed by T_2 (5.10 kg/plot) and T_4 (4.34 kg/lot).

3.6.4 Survey and monitoring of disease in ginger

(Raigarh, Kumarganj and Pundibari)

Surveys were conducted in 15 locations in Raigarh district during 2006-07 which revealed maximum disease incidence in Padigao village of Pusour developmental block and minimum disease incidence in Samabalpuri village of Raigarh developmental block.

Survey at different locations by Kumarganj centre showed incidences of rhizome rot (5.0 – 75.47 %) at farmers field and up to 75.47 % in experimental plots at Kumarganj. Incidence of leaf spot was observed at Padrauna and Nagipur (20 – 92.85%). Rhizome rot disease was observed as major disease in ginger. In some pockets, leaf spot was also observed in farmer's field during last three years (Table 38).

The survey was conducted in three major blocks of Darjeeling namely Kalimpong I, Kalimpong II and Kalimpong III (Gorubathan) of West Bengal by Pundibari centre. Among the varieties grown in this area, Gorubathan is most widely cultivated followed by Bhaisi and Nangrey. Disease incidences at different locations were determined during the month of July – September, 2006 In the survey it was found that Kalimpong III block was the hot spot for bacterial wilt disease of ginger (49.12%). This was followed by Kalimpong I (44.74%) and Kalimpong II (29.37%) block respectively. In the survey it was also found that *Phyllosticta* leaf spot disease of ginger was highest in Kalimpong II block (13.26%) followed by Kalimpong III (10.59%) and Kalimpong I block (3.84%).

3.6.5 Management of rhizome rot in ginger

(Mudigere, Pampadumpara, Chintapalle, Sirsi and Dapoli)

Rhizome rot was not noticed under Sirsi conditions in any of the treatments both in solarized and non solarized rhizomes. *Trichoderma harzianum* was effective in improving the germination of solarized rhizomes (76.02 %) where as combination of both *T. harzianum* and bacterial consortium (for growth, nematode and *Pythium* suppression) treated rhizomes showed higher per cent germination (76.60 %). Mancozeb (@ 0.25 per cent) treated rhizomes of both solarized (80.92 %) and non solarized (2.03 %) gave highest germination. Solarized (66.32 %) and non solarized rhizomes (67.60 %) without any protection with either bioagents or chemical showed minimum germination. Solarized rhizomes treated with *T. harzianum* showed highest tiller production (8.65) followed by solarized rhizomes treated with bacterial consortium (7.75). But the least tiller production (6.78) was recorded in non solarized and unprotected rhizomes.

Fresh rhizome yield was maximum (13.65 t/ha) in the solarized rhizomes treated with mancozeb (@ 0.25 %) as rhizome and bed treatment (Table 39). Solarized rhizomes when treated with combination of bioagents *viz.*, *T. harzianum* and bacterial consortium recorded yield of 11.56 t/ha. *T. harzianum* performed better in solarized rhizomes in increasing the yield (11.02 t/ha). Lowest yield was noticed in unprotected rhizomes (control) *viz.*, both in solarized (6.70 t/ha) and non solarized rhizomes (6.29 t/ha).

Table 39. Incidence of rhizome rot and yield levels of ginger under different treatments at Sirsi

Treatments	Rhizome rot incidence	Germination(%)			Projected fresh rhizome yield (t/ha)		
		Solarized rhizomes	Non solarized rhizomes	Mean	Solarized rhizomes	Non solarized rhizomes	Mean
T1 *T harzianum* + Bacterial cosortium	0	76 02	74.62	75.32	11 02	10.96	10 99T2.
	0	74 41	73 88	74 14	10.97	10.72	10 85
T3. *T harzianum* + Bacterial consortium	0	77.31	76 60	76.95	11.56	11 41	11.49
T4 Mancozeb (@0 25 %)	0	80.92	82.03	81 47	13 65	12 37	13 01
T5. Control	0	66.32	67 60	66 96	6 70	6 29	6.50
			Interaction			Interaction	
S Em ±		1 72	1 54	1.15	0 27	0 15	0.15
CD (0 05)		4 91	4 38	3.25	0 81	0.44	0 44

4. TURMERIC

4.1 Genetic Resources

4.1.1 Germplasm collection, characterization and conservation

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

Eighty nine germplasm accessions of turmeric have been collected and promising lines were evaluated at Dholi for yield Out of 89 germplasm, 18 germplasm accessions *viz* , RH-80, RH-16, RH-9/90, RH-407, RH-13/90, RH-50, RH-9/80, RH-24, RH-5, RH-406, RH-14, RH-7, RH-12, RH-17, RH-7/80, RH-403 and RH-411 recorded with maximum fresh rhizome yield of 40.50 to 30 kg/7.2 m^2. Among high yielding genotypes, maximum yield was recorded in RH-80 and RH-16 (40.50 kg/7.2m^2) followed by RH-9/90 and RH-407 (40.0 kg/7.2m^2)

At present, 273 germplasm collections are being maintained at Jagtial. Genotypes were grouped into long (8-9 months), medium (7-8 months), short duration (6-7 months) groups based on duration. High variability was observed for growth and yield characters. During 2006-07, among the germplasm lines tested, CLI-317 recorded highest rhizome yield (29.6 t/ha) followed by JTS-14 (23 6 t/ha) and was on par with JTS-14.

Out of 197 turmeric germplasm accessions at Pottangi, 179 (155 *Curcuma longa*, 20 *Curcuma aromatic* and 4 *Curcuma amada*) were evaluated. The fresh rhizome yield in *C. longa* varied from 5.2 to 15.2 (kg/3m^2) and more than 10.0 kg/3m^2 yield was recorded in 32 accessions. The maximum yield was recorded in PTS-47 (15.2 kg/3 m^2), PTS-4 (14.0 kg/3 m^2), PTS-62 (13.6 kg/3m^2) and PTS-27 (13.0 kg/3m^2). In *Curcuma aromatica* the fresh rhizome yield varied from 5.0 to 11 2 (kg/3m^2) and more than 7.0 kg/3m ^{2} yield was recorded in 7 accessions. The maximum yield was recorded in *Chaya Pasupu-II* (11.2 kg/3m^2) Out of four *C amada* types, yield was ranging from 8.82 to 13 6 (kg/3 m^2). Two new accession of *C longa* were collected and included to the germplasm totaling 157 *C longa*

To the existing germplasm of 255 genotypes of Coimbatore centre, three more collections from Eraiur, Nariapanur of Salem district and Suvarna were added during 2006-07 The yield level among the accessions varied from 8.0 to 20 kg/plot (3m^2). The accession CL 15 registered the highest yield of 20 kg/plot followed by CL 18 and CL 20 (19 kg/plot). Among 258 accessions, 14 accessions registered the fiesh rhizome yield more than 15 kg/plot.

Raigarh centre evaluated 42 genotypes along with check Prabha Highest yield was recorded in IT-6 (18.90 t/ha) which was significantly superior to the check (17.69 t/ha), followed by IT-7 (15.58 t/ha) and IT-1 (14.78 t/ha).

At Pundibari, TCP-22 was found to be the tallest culture (167.17 cm) followed by TCP-52 (164.97 cm) where as TCP-17 was the dwarf one (58.26 cm). TCP-04 recorded highest number of tillers. Similarly, highest number leaves were found

Table 40. Turmeric germplasm collections in AICRP centres

Centre	Indigenous		Total
	Cultivated	Wild and related sp.	
Pottangi	197	-	197
Jagtial	273	-	273
Dholi	87	2	89
Raigarh	42	-	42
Kumarganj	126	-	126
Pundibari	136	14	150
Solan	145	-	145
Coimbatore	258	-	258
Total	**1264**	**16**	**1280**

in TCP-111 (9 67) followed by TCP-153 (9 50). Maximum pseudo stem girth was recorded in TCP-145 (14 83 cm) followed by TCP-135 (11.73 cm) whereas lowest in TCP-56 (6 50 cm). Longest leave was found in genotype TCP-12 (72.17 cm), followed by TCP-19 (71 13 cm) and TCP-13 (70.50 cm), whereas shortest leaf was found in TCP-114 (32.50 cm). Broadest leaves were recorded in entry TCP-136 (16 80 cm) followed by TCP-97 (15.80 cm) and narrowest in TCP-73 (8.60 cm). Rhizome yield of individual plant (clump weight) was maximum in TCP-135 (480.30 g) followed by TCP-66 (403 40 g), TCP-42 (394 40 g), TCP-22 (380 40 g) and TCP-24 (375.40 g) Considering plot yield and projected yield, TCP-66 (55.64 tons/ha), TCP-146, TCP-47 (40 32 tons/ha each), TCP-49 (39 92 tons/ha) and TCP-107, TCP-67 (38.30 tons/ha each) recorded significantly higher rhizome yield. A total of 20 genotypes out yielded the local check TCP-2 (29.84 t/ha).

At Kumarganj, among early maturing germplasm maximum fresh rhizome of 33 12 t/ha was obtained in NDH-79 followed by NDH-68 (32.12 t/ha). NDH-18 produced maximum fresh rhizome yield of 38.4 t/ha followed by NDH-14 (36.30 t/ha), among medium maturing germplasm. NDH-9 was highest fresh rhizome yielder (38 2 t/ha) followed by NDH-8 (33 0 t/ha) in 36 genotypes of late maturing germplasm. The germplasm accessions maintained under different centres are summarized in Table 40.

4.2 Coordinated Varietal Trial (CVT)

4.2.1 CVT 2000-Series V

(Jagtial, Pottangi, Pundibari, Raigarh and *Coimbatore)*

Coimbatore centre evaluated nine accessions for growth and yield parameters. Regarding the growth characters, plant height varied from 22.6 cm to 38 1 cm and the maximum plant height (38.1 cm) and number of leaves were registered in CL 18. Regarding the number of tillers, it varied from 1 3 to 2.9 and the highest number of tiller was recorded in CL 34 The results revealed that the Acc 39 recorded maximum rhizome yield of 31.31 t/ha as against local check Roma (30 70 t/ha) Regarding the growth parameters during 2005-06, the plant height varied from 22 0 cm to 36 2 cm. The maximum plant height (32.5 cm) was registered in CL 39 and ND 19 Regarding the number of tillers it varied from 1.4 to 2.5. Maximum number of tillers was recorded in the accession CL 14. The results revealed that among the eight accessions evaluated in CVT 2001 series CL 34 registered the highest fresh rhizome yield of 46.2 t/ha Based on the two year data the accession CL 39 recorded the highest rhizome yield of 31.31 t/ha during 2004-05 and CL 34 registered the highest yield of 46 2 t/ha during the year 2005-06.

At Raigarh, the CVT 2000 is in the VIth year of progress TCP-2 (16.01 t/ha) and IT-2 (15.21 t/ha) were found to be significantly superior over the check RH-5 (13 33 t/ha)

During 2006-2007, out of 30 entries tested at Jagtial, PTS-59 recorded maximum fresh rhizome yield (29 9 t/ha) followed by NDH-9 (28.8 t/ha) in comparison to check Duggirala Red (29 t/ha).

At Pundibari, pooled analysis of mean data over the years (2001 – 2007), for the different growth and yield parameters revealed that that plant height, number of tillers, leaf length, clump weight, number of mother rhizome, number, weight and length of primary and secondary fingers contributed significantly to rhizome yield of turmeric The genotype ICP-2 showed the highest rhizome yield (25 01 t/ha), followed by RH-5 (22.48 t/ha), TCP-1 (22.40 t/ha) and TCP-11 (21.54 t/ha) (Table 41)

Table 41. Performance of CVT 2000 turmeric entries at Pundibari

Entries	Yield (t/ha)						Mean
	2001 -02	2002 -03	2003 -04	2004 -05	2005 -06	2006 -07	
PTS-11	22 16	15 75	8 29	13 926	13 98	3 29	12 90
PTS-15	21 82	15 08	7 34	12 634	13 06	8 13	13 01
PIS-52	23 11	15 37	7 57	17 614	18 59	3 89	14 36
PTS-55	27 18	17 47	9 11	16 789	17 40	4 16	15 35
PIS 59	31 17	14 00	7 57	12 533	12 63	7 93	14 31
ACC-126	29 24	14 25	6 19	12.015	12 17	8 20	13 68
ACC-584	24 15	11 96	6 70	12 477	12 36	17 80	14 24
ACC-585	20 25	11 25	4 91	10 251	11 42	7.25	10 89
TCP-1	29 03	24 00	11 31	25 154	23 65	21 23	22 40
TCP-2	33 14	28 38	14 88	23 507	25 74	24 39	25 01
TCP-11	-	26 56	15 68	22 908	22 50	20.06	21 54
TU-1	25 52	15 63	9 92	13 289	13 37	23 99	16 95
RH-5	25 20	22 25	14 54	23 789	22 44	26 68	22 48
Pratibha	23 06	16 29	7 65	15 523	17 00	11 29	15 14
Prabha	27 36	15 33	8 03	14 535	14 72	11 56	15 26
SEm	1 30	1 76	-	1 671	0 41	1 50	-
CD(P=005)	3 79	3 60	-	3 422	0 84	3 08	-

Table 42. Yield performance of CVT 2004 turmeric entries at Kumarganj

Entries	Yield (t/ha)			Mean (pooled) (t/ha)
	2004-05	2005-06	2006-07	
IT-1	20 55	16 10	19 96	18 87
IT-2	17 33	30 51	30 73	26.19
PTS-34	13 55	26.10	25.53	21.72
PTS-39	13 88	26 60	26 16	22.21
TCP-56	12.21	21.07	21 16	18 14
TCP-82	12.88	19.97	20 16	17 67
NDH-18	30.66	29.43	30.86	30 31
TCP-11	26.88	24 43	23 00	24.77
NDH-9	29 22	31 63	31 96	30 93
IT-3	27.88	21.63	21 83	23 78
CL-101	13 44	30.50	30 60	24.84
CL-147	12 77	15 81	16 06	14.88
NDH-14	26 66	26.08	25 76	26.16
RH-9/90	-	04.33	12.76	-
RH-13/90	-	08.87	14.10	-
Prabha (Check)	28.33	27.77	29.40	28.50
SEm ±	-	4.43	1 26	-
CD (P=0 05)	2.60	12 51	4 47	-
CV (%)	7.58	32.02	9 21	-

Significant difference for fresh rhizomes yield among cultivars was recorded among the entries at Pottangi. Highest fresh rhizome yield was recorded in PTS-39 (25.03 t/ha) followed by PTS-11 (23.94 t/ha) and PTS-4 (23.94 t/ha).

4.2.2 CVT- 2004 – series VI

(Raigarh, Chintapalle, Coimbatore, Kumarganj, Pundibari and Pottangi)

At Raigarh, highest yield was recorded in TCP-11 (20.71 t/ha) followed by TCP-82 (18.56 t/ha) compared to check Prabha which yielded 17.22 t/ha.

At Kumarganj, fresh rhizome yield of 31.96 t/ha was recorded in NDH-9 followed by 30.86 t/ha in NDH-18. Yield of CL-101 was at par with the NDH-18. The three years data revealed maximum fresh rhizome yield of 30.93 t/ha in NDH-9 followed by NDH-18 (30.31 t/ha) and NDH-9 (Table 42).

The experiment conducted at Coimbatore revealed that among the twelve accessions evaluated, the yield ranged from 9.2 kg/plot to 27.4 kg/plot (3m^2). Highest yield of 27.4 kg/plot was registered in NDH 9 followed by CL 147 (26.8 kg/plot).

At Pundibari, TCP-56 recorded highest yield per plot (3 m^2) of fresh rhizomes (13.83 kg) followed by TCP-11 (13.23 kg) and IT-2 (12.96 kg). Lowest rhizome yields were recorded by PTS-34 (3.80 kg), PTS-39 (3.86 kg) and CL-147 (3.96kg). The four top yielders *viz.* TCP-56, TCP-11, IT-3 and IT-1 were also recorded highest clump weight, weight of mother rhizome, number of mother rhizome/clump, length of primary and secondary fingers, weight of primary and secondary fingers and number of secondary fingers which might have contributed towards higher rhizome yield.

At Pottangi, highest fresh rhizome yield was recorded in PTS-39 (23.73 t/ha) followed by PTS-47 (23.21 t/ha).

4.3 Varietal Evaluation Trial

4.3.1 Comparative yield trial-CYT 1999-2000

(Pundibari, Raigarh)

Analysis of the pooled data (2004-2007) at Pundibari revealed that numbers of tillers per plant and leaves per plant, pseudostem girth, leaf length and breadth, clump weight contributed significantly to the fresh rhizome yield. The genotypes exhibited significant genetic variability for the different growth and yield attributing traits. TCP-56 recorded the highest rhizome yield (25.50 t/ha), followed by TCP-57 (25.29 t/ha), TCP-119 (24.98 t/ha), TCP-70 (24 28 t/ha), TCP-82 (23.51 t/ha), TCP-54 (23.47 t/ha) and TCP-129 (23.44 t/ha) and TCP-104 (22.55 t/ha). The rest of the genotypes recorded lower rhizome yield compared to that of the check, TCP-2 (21.54 t/ha).

4.3.2 Comparative yield trial-CYT 2005-06

(Jagtial and Coimbatore)

At Jagtial, out of 10 promising turmeric entries tested JTS-401 recorded the highest fresh rhizome yield (33 t/ha) followed by JTS-406 (25.5 t/ha) and Duggirala Red (25.2 t/ha). The check PCT-13 recorded the fresh rhizome yield of 25 t/ha.

4.3.3 Initial evaluation trial

(Pottangi and Kumarganji)

Highest fresh rhizome yield of 23.88 t/ha was recorded in VK-9, followed by PTS-3 (23.88 t/ha)

in Pottangi. Out of 10 promising lines tested at Kumarganj, NDH-18 produced the maximum fresh rhizome yield (37.66 t/ha) followed by NDH-79 (34.55 t/ha).

4.4 Quality Evaluation Trial

4.4.1 Quality evaluation of germplasm

(Coimbatore)

Fifteen promising accessions were tested for quality parameter like curcumin content, oleoresin and essential oil. The curcumin content ranged from 4.0 to 6.2 % and the highest curcumin content of 6.2 % was recorded in CL 206 followed by CL 219 (6.0 %). Regarding oleoresin content, it varied from 8 to 12 %. Highest oleoresin content (12 %) was recorded in CL 18, CL 193 and 219. The essential oil content varied from 3.1 to 4.7 % and the highest essential oil content was recorded in CL 193.

4.4.2 Impact of environment on quality of turmeric

(Coimbatore)

Six varieties were evaluated to study the effect of environment on the quality characters, the yield ranged from 8.8 kg/plot ($3m^2$) to 15.4 kg /plot. The highest yield of 15.4 kg/plot was registered in CL 133 (Roma) followed by BSR 2 (12.2 kg/plot). The curcumin content ranged from 3.2% to 5.2%. The highest curcumin content of 5.2% was recorded in CL 131 (Suguna). Regarding the oleoresin content it ranged from 8.0% to 10.5%. The highest oleoresin content of 10.5 % was registered in CL 131 (Suguna). The essential oil content ranged from 3.0% to 3.4%. The highest essential oil content of 3.4% was registered in CL 151 (IISR Prabha).

4.5 Nutrient Management Trial

4.5.1 Effect of biofertilizer, *Azospirillum* on turmeric (final report)

(Coimbatore, Pundibari and Kumarganj)

The pooled analysis of the three year data (2003-06) is presented in the Table 43. The results revealed that T_3 (inorganic N (50%) + *Azospirillum* (5 kg/ha) as soil application + 5 t FYM) recorded the highest yield and hence the treatment T_3 can be considered as a best treatment for enhancing the yield of turmeric.

At Kumarganj, application of 100 % inorganic nitrogen, 5 kg/ha of *Azospirillum* as seed treatment and 5 t/ha of FYM (T_1) produced maximum rhizome yield of 39.97 t/ha, followed by yield of 33.65 t/ha by application of 10 t/ha of FYM and seed treatment of rhizome with 5 kg/ha with *Azospirillum*. The pooled data over two years

Table 43. Effect of *Azospirillium* and different levels of nitrogen on growth and yield of turmeric var. BSR 2 at Coimbatore

Treatments	Plant height (cm)	Tillers per plant	Weight (g)			Yield (t/ha)
			Mother rhizome	Primary rhizome	Secondary rhizome	
T_1 Inorganic N (100%) + *Azospirillum* (5 kg/ha) as soil application + 5 t FYM	35 00	3 54	130 95	207 07	113.03	35 95
T_2 Inorganic N (75%) + *Azospirillum* (5 kg/ha) as soil application + 5 t FYM	35.49	3.33	115.04	164.46	101.17	34.25
T_3 Inorganic N (50%) + *Azospirillum* (5 kg/ha) as soil application + 5 t FYM	37.12	3 64	129 47	174 94	107 99	41 66
T_4 FYM (5 t/ha) + *Azospirillum* (5 kg/ha) soil application	37 50	2 76	127 34	152 49	98.05	30.70
T_5 FYM (5 t/ha)	35 20	3 15	73.45	127 47	72 37	20.69
T_6 FYM (10 t/ha) + *Azospirillum* (5 kg/ha) soil Application	35 27	2 84	83 57	141 56	96 99	27 78
T_7 FYM (10 t/ha)	36 34	3 13	92 44	175 30	105 22	21 73
T_8 *Azospirillum* (5 kg/ha) soil application	33.95	2.68	84 10	167 57	96 73	24 11
T_9 Urea (100%)	35 13	2 39	70 21	155 13	98 67	24 98
T_0 Control	35 43	3 34	91 47	183 83	96 21	23.08
SED	2 36	0.21	5 49	12 39	6.14	1 72
CD (P=0 05)	4 97	0 43	11 55	26 02	12 89	3 61

Table 44. Effect of NPK, FYM and *Azospirillum* on yield of turmeric at Kumarganj

	Treatments	Yield (t/ha)			
		2004-05	2005-06	2006-07	Mean
T_1	Inorganic N 100% + *Azospirillum* 5 kg/ha + 5t/ha FYM	36.33	36 14	39 97	37 48
T_2	Inorganic N 75% + *Azospirillum* 5 kg/ha + 5 t/ha FYM	33.07	32.91	32.87	32 95
T_3	Inorganic N 50% + *Azospirillum* 5 kg/ha + 5 t/ha FYM	31.83	32.24	31.87	31.98
T_4	FYM 5 t/ha + *Azospirillum* 5 kg/ha	30 58	21.33	30 80	27.57
T_5	FYM 5 t/ha alone	33 16	33.24	33 37	33 25
T_6	FYM 10 t/ha + *Azospirillum* 5 kg/ha	34 41	34 57	33 65	34 21
T_7	FYM 10 t/ha alone	34 58	33 58	32 95	33.70
T_8	Nitrogen 100%	30.74	29.58	29.47	29 92
SEm ±		-	0 96	0.81	-
CD (P=0 05)		3 15	2 83	2 77	-
CV(%)		6 54	5.84	5 02	-

(2004-07) revealed maximum fresh rhizome yield of 37.48 t/ha was recorded in treatment T_1 (Table 44).

4.5.2 Organic farming in turmeric (new)

(Coimbatore, Jagtial, Kumarganj, Pundibari, Pottangi)

At Coimbatore, the fully inorganic treatment (Recommended N,P,K and drench/spray with Dithane M 45 for disease and Malathion (0.1%) at 21 days interval) recorded the highest yield (13.1 kg/3m²) followed by integrated treatment (20t FYM + ½ N,P, K + P solubilizing bacteria , *Pseudomonas fluorescens* – *Trichoderma viride* both as seed treatment and soil application (50 g/3m²), which recorded yield of 9.44 kg /3m²). The treatment fully organic (Neem cake @ 12.5 kg/150 m², rock phosphate @ 25 kg/150 m², wood ash @ 12.5 kg/ 150 m², FYM @ 500 kg /150 m² + *Azospirillum* @ 50 g/3m², *Phosphobacteria* @ 50 g/3m² + *Pseudomonas fluorescens* @ 50 g/3m², *Trichoderma viride* @ 50 g/3m² both as seed treatment and soil application) recorded a yield of 3.8 kg/3m².

At Kumarganj, application of 50% recommended dose of inorganic fertilizer (60:40:40 kg/ha NPK) + 50% FYM (10 t/ha) + 5 kg/ha of *Azospirillum* + seed treatment and soil application of *Pseudomonas fluorescens* + *Trichoderma* @ 50 g/3m² (T_3) produced maximum fresh rhizome yield (34.01 t/ha) followed by 33.77 t/ha in T_1 with application of recommended dose of fertilizer @ 120:80:80 kg/ha NPK (Table 45).

During 2006-07 at Jagtial, integrated treatment recorded highest rhizome yield (25.9 t/ ha) followed by inorganic package (23.8 t/ha) where as organic treatment recorded the lowest yield of 22 t/ha.

There was no significant difference among the different treatments at Pottangi. Highest fresh rhizome yield (24.36 t/ha) was obtained in T3 (recommended inorganic inputs) followed by T2

Table 45. Effect of biofertilizer and bio agents on turmeric at Kumarganj

	Treatments	Plant height (cm)	Weight of fresh rhizome/ clump (g)	Yield (t/ha)
T_1	100% recommended dose of fertilizer (120 80:80 kg/ha NPK)	101 95	513 07	33.77
T_2	100% FYM (20 t/ha) + seed treatment and soil application *Pseudomonas fluorescens*, + *Trichoderma* (50 g/3m²)	103 28	522 57	31 40
T_3	50% recommended dose of fertilizer (60·40 40) + 50% FYM (10 t/ha) – *Azospirillum* (5 kg/ha) + Seed treatment and soil application *Pseudomonas fluorescens*, + *Trichoderma* (50 g/3m²)	103 70	510 67	34.01
T_4	100% FYM (20 t/ha) + *Azospirillum* (5 kg/ha) + seed treatment and soil application *Pseudomonas fluorescens*, + *Trichoderma* (50 g/3m²)	100 61	504 74	32.82
	SEm ±	1 52	26.79	1 11
	CD (P=0 05)	4 53	79 62	3 30
	CV (%)	3 94	13 82	8 91

(semi organic with inorganic package of practices) (21.42 t/ha).

4.6 Disease Management Trial

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

(Coimbatore, Pundibari, Raigarh and *Kumarganj)*

Out of the 258 turmeric germplasm accessions screened for resistance to leaf spot and leaf blotch diseases at Coimbatore, the accessions CL 6, 148, 165, 179, 182 and 210 were highly resistant to leaf spot and the accessions CL 70, 121, 134, 140, 141, 159, 160, 161, 162 and 205 were highly resistant to leaf blotch.

In the survey and identification of disease conducted by Raigarh, maximum disease intensity of *Colletotrichum* leaf spot was recorded in Bhalumar (42.6%) in Gaighoda developmental block and *Taphrina* leaf blotch in Patelpali (35 2%) of Raigarh developmental block. Among entries screened, Pratibha, TCP-11. Sudarshana. Suroma, Rashmi and TCP-56 recorded resistant reaction against both the diseases.

Survey of different farmers field in 5 districts *viz.* Kushinagar, Faizabad by Kumarganj centre showed incidence of leaf spot (5.15 - 87 5%) and leaf blotch disease (5.25 – 87.5%). Rhizome rot was not observed in any of farmers' field. Leaf spot and leaf blotch was the most prominent disease observed in the area surveyed during 2004-07.

A survey conducted in Coochbehar district revealed presence of three major diseases namely, leaf blotch (*Taphrina* sp.). leaf spot (*Colletotrichum* sp.) and rhizome rot. Incidence of another leaf spot was also identified in the survey and the causal organism was identified as *Helminthosporium* sp. Most of the area is covered with local varieties which are highly susceptible to leaf blotch disease. In the survey it was found that severity of leaf blotch was high in Coochbehar II block (27.44%) than Coochbehar I block (25.22%). In Dinahata II block, leaf blotch disease severity was 24.17%. Regarding leaf spot it was found that disease severity is more or less same in Coochbehar I block (14.78%) and in Coochbehar II block (14.83%) whereas in Dinhata II block the average disease severity was 10.83%. Screening of germplasm against both leaf blotch and leaf spot revealed TCP 3, 5, 20, 28, 40, 53, 54, 73, 93, 110, 115, 118, 137, 170, 193, 198 and 208 as tolerant to leaf blotch. The germplasm found to be tolerant against leaf spot were 5, 12. 19, 20, 32, 33. 47, 53, 54, 73, 74, 93, 114, 115, 176, 198 and MG 01.

4.6.2 Investigation on the casual organism of rhizome rot of turmeric and screening of biocontrol agents for its management (final report)

(*Coimbatore, Kumarganj, Pottangi* and *Pundibari*)

A field trial was conducted to test the bio efficiency of biocontrol agents against rhizome rot of turmeric at Coimbatore. Recommended dose of

Table 46. Effect of bio-control agents on yield of turmeric at Kumarganj

	Treatments	Yield (t/ha) 2004-05	2005-06	2006-07	Mean	Increase in yield (%)
T_1	Recommended dose of NPK (Control)	22 22	34.96	19 99	25.72	-
T_2	T_1 + FYM	25 07	35 96	23 88	28 30	10 03
T_3	T_1 + seed treatment of *Trichoderma viride* + *Pseudomonas florescens* @ 4g/kg	26 66	36 46	26.44	29 85	16 56
T_4	T_1 + soil application of *T viride* + *Pseudomonas flourescens* @ 12.5 & 25 kg/ha as basal and top dressing	29 44	37 96	26 66	31.35	21 56
T_5	T_2 + T_3	31 66	37 97	27 66	32 43	26 08
T_6	T_2 + T_4	32 66	36 96	25 55	31 72	23.32
T_7	T_2 + T_3 + T_4	42 66	32 47	30 60	35 24	37 01
T_8	T_2 + *Bacillus subtilis* @ 1 ml/lit. water	36.00	35 47	22 77	31 41	22 12
	SEm ±	-	-	3 26	-	-
	CD (P=0 05)	07 02	05 39	7 67	-	-
	CV (%)	14 38	08 88	102 00	-	-

NPK + FYM + seed and soil application of consortia of *Trichoderma viride* and *Pseudomonas fluorescens* @ 4 g/kg and 12.5 kg/ha and 25 kg/ha as basal and top dressing respectively was found to be effective for control of rhizome rot with the maximum yield of 54.80 t/ha. The same treatment also recorded the maximum C: B ratio of 1.2.8.

Rhizome rot disease was not observed during 2004-07 by survey conducted at Kumarganj. Maximum fresh rhizome yield of 30.60 t/ha was observed with recommended dose of NPK (120 80.80) + 10 t/ha of FYM + seed treatment of *Trichoderma viride* and *Pseudomonas florescens* @ 4 g/kg and soil treatment of *Trichoderma viride* and *Pseudomonas florescens* @ 12 5 and 25 kg/ha as basal and top dressing (T_7) which showed increase in 53.07 % of fresh rhizome yield over control. Similar trend was observed in three years pooled data with an increase in 37.01 % fresh rhizome yield over control (Table 46).

5. TREE SPICES

5.1 Genetic Resources

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

(Dapoli and Pechiparai, Yercaud)

Clove: The trial was initiated during 1992 with an objective to collect, maintain, characterize and catalogue the germplasm of clove at Pechiparai. Morphological, yield and yield attributing traits are being evaluated to identify promising accessions. Among the 22 accessions, the tree height ranged between 2.13 m (SA. 22) to 7 35 m (SA. 7). The stem girth ranged between 1.60 cm to 32 8 cm. The accession SA.13 registered the highest yield of 6 72 kg/tree At Dapoli, the clove germplasm consisting of 2 accessions *viz* IISR Calicut type and Kallar type planted in 1996-97 and are being evaluated for growth and yield performance IISR Calicut type recorded vigorous growth with maximum plant height (4 70 m), girth (20 15 cm) and spread (2.92 m). The yield of dry buds per plant was 165.00 g and 100 00 g in IISR Calicut and Kallar type respectively.

Nutmeg: At Pechiparai, this trial was initiated during 1992 with an objective to collect, maintain, characterize and catalogue the germplasm of nutmeg Morphological, yield attributing traits and yield are being evaluated to identify promising accessions Among 22 accessions, the height of the trees ranged between 0.50 m (Sel.22) and 6.35 m (Sel 2). The highest yield of 525.50 fruits/tree was recorded in Sel 2. The germplasm of nutmeg at Dapoli, 97 accessions have been maintained and are being evaluated for growth and yield characters Tree No. 9, 38, 4 and 56 of A- 4/22 accession and tree No. 15, 43, 65 of A-4/22, A-9/4 and A- 9/79 accessions were observed to be promising in respect of early bearing, nut size and yield characters. Acc. A-9/4, A-9/79 produced large sized fruits

Cinnamon: Among the 12 accessions evaluated at Pechiparai, Sel 65 performed well and gave the bark yield of 400g of dried bark/tree and leaf yield of 6.1 kg/tree A local collection from Pechiparai (CV 12) had recorded the leaf yield of 6 0 kg/tree and bark yield of 440 g/tree (Table 47).

Table 47. Performance of cinnamon germplasm at Pechiparai

Accessions	Tree height (cm)	Rejuvenation growth (120 days)	Stem girth (cm)	Leaf yield (kg/plant)	Bark yield (g/plant)
Sel 5	2 35	0 94	12 5	3 6	210
Sel 44	2 37	0 99	14 5	3 2	320
Sel 53	2 38	0 96	11 0	3 7	80
Sel 63	2 35	1 09	13 4	4 4	226
Sel 65	3 20	1 25	25 5	6 1	400
Sel 139	2 30	1 12	15 4	4 5	370
Sel 203	2 61	1 09	17 2	4 7	140
Sel 310	2 65	1 10	15 1	4 2	313
Sel 312	2 60	1 15	15 2	4 5	302
Konka	2 64	1 14	13 8	4 1	214
Bhavani	2 28	1 14	14 8	4 0	240
CV 12	2 21	1 15	23 5	6 0	440
CV (%)	7 34	7 91	10 99	14 24	11 85
SED	0 18	0 09	1 76	0 63	32 15
CD (P=0 05)	0 40	0 19	3 87	1 38	70 76

The growth performance of 9 accessions was evaluated at Dapoli and there was no significant difference among the accessions The mean plant height (2.43 - 2.80 m), girth (14.47-17.17 cm), spread (2 18-2.67) and number of regenerated shoots per plant (2.51-3 88) were recorded among the accessions.

Table 48. Tree spices germplasm collections at AICRP centres

Crop/Center	Indigenous/cultivated
Clove	
Pechiparai	22
Dapoli	2
Yercaud	13
Total	**37**
Nutmeg	
Pechiparai	22
Dapoli	97
Total	**119**
Cinnamon	
Pechiparai	12
Dapoli	11
Yercaud	16
Cassia	
Dapoli	06
Total	**45**

5.2 Coordinated Varietal Trial (CVT)

5.2.1 CVT-1992 - clove

(Pechiparai/Yercaud)

Nine genotypes collected from IISR, Calicut were evaluated for growth and yield parameters. Among the genotypes Sel. 3 was found to be promising in terms of yield characters (4.98 kg/ tree).

5.2.2 CVT 2001- nutmeg

(Pechiparai and *Dapoli)*

Six accessions collected from IISR, Calicut were evaluated along with a local check. Among the accessions A9/150 has recorded the highest plant height of 67.25 cm.

The CVT 2001 on nutmeg was planted during 2003 and the morphological observations in respect of plant height, girth, number of branches plant and spread did not show significant differences. The plant height ranged from 0.56 to 0 79 m and the stem girth from 3.93 to 7.03 cm.

5.2.3 CVT 2001 - cassia

(Pechiparai and *Dapoli)*

At Pechiparai. among the four selections. D1 was found to be promising with the leaf yield of 241.50 g/tree (Table 49).

Table 49. Growth and yield performance of cassia at Pechiparai

Accessions	Plant height(m.)	Stem girth(cm)	Leaf yield (fresh) (g/tree)	Leaf yield (Dry) (g/tree)
C1	1 18	7.8	141 30	73.4
D1	1 24	6.96	241.50	142 6
D3	1.41	7.1	205 90	100.10
D5	0.94	5 26	95 30	48.60
CV (%)	28 36	16.18	9 27	18.88
SED	0.27	0 90	12.94	14.06
CD (P=0 05)	0 63	2.19	31.66	34 41

The growth performance of six accessions showed morphological variations, however they did not show any significant differences in growth parameters. Variability for mean plant height (1.32 - 2.27 m), girth (7.14 - 10.94 cm) and spread (0.76 - 1.26 m) were recorded among the different accessions.

5.3 Propagation/Multiplication Trial

5.3.1 Soft wood grafting in clove *(Dapoli)*

The trial on softwood grafting of clove conducted on different species of jamun root stock showed initial success of grafts of 20-50 per cent (one month after grafting), however survival of grafts recorded after three months was nil.

5.4 Disease Management Trail

5.4.1 Survey for disease incidence in tree spices

(Pechiparai and Dapoli)

Clove: Survey conducted by Pechiparai centre reported the maximum incidence of leaf spot caused by *Colletotrichum gloeosporoides* during the north east monsoon period. The Per cent Disease Incidence (PDI) was highest at Keeriparai area (20.1%). Seedling wilt caused by *Rhizoctonia* sp. was maximum (19.2%) at Maramalai followed by Keeriparai (9.5).

Five clove orchards (two each in Ratnagiri and Sindhudurg districts and one in Raigad district) were surveyed in the Konkan region by Dapoli centre. Leaf rot, leaf spot and sudden branch wilt were the major diseases observed in this region. Incidence of leaf rot disease was moderate (11 to 30%) in Ratnagiri and Sindhudurg districts whereas it was low (< 10%) in Raigad district. Low incidences of leaf spot and diebeck diseases was recorded in the Konkan region.

Nutmeg: Fruit rot incidence of nutmeg (3.2%) was noticed during 2006 at Pechiparai area. Survey was undertaken in twenty nine nutmeg orchards (fifteen in Ratnagiri district, seven in Sindhudurg district and seven in Raigad district) in Konkan region revealed the incidence of dieback, shot hole and fruit rot diseases. Low incidence of dieback (< 10%) was observed in the region. Low incidence of shot hole (< 10%) and fruit rot diseases was also recorded.

Cinnamon: Survey conducted by Dapoli centre in 7 orchards revealed the crop was disease-free in this region. Low incidence of leaf blight, leaf spot and pink diseases (< 10%) was observed in the Konkan region.

6. CORIANDER

6.1 Genetic Resources

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

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

A total of 274 accessions were evaluated for yield and incidence of powdery mildew at Coimbatore. Eight accessions (CS 2, 10, 13, 22, 31, 52, 87 and 55) recorded the high yield of 2 to 2.5 kg /20 m^2 with moderate resistance to powdery mildew (20 to 36 PDI). Nine accessions (CS 62, 70, 78, 106, 130, 163, 193, 211 and 235) registered a high yield of 2 to 2.5 kg/20 m^2 with susceptible reaction to powdery mildew (40 – 72 PDI). Two hundred and seventy four accessions were screened for their resistance against coriander powdery mildew disease using 0 - 5 scale. The results showed that none of the accessions were resistant to powdery mildew disease. The accessions CS 107, 108, 196, 213. 250. 251 and 252 recorded the lowest PDI (16) followed by CS 110, 208, 253 and 267 with 18 PDI. The other germplasm lines recorded the disease incidence of 20 PDI to 80 PDI.

During 2006-07, 94 entries were raised and evaluated with GCori-1 and GCori-2 as checks for different yield attributes at Jagudan. Among them 10 entries observed as dwarf types (< 60 cm plant height) and twelve entries had more branches (>12 branches per plant). More than 20 umbels per plant was recorded in 10 entries and fourteen entries recorded more than 6 umbellate per umbel. Ten entries were promising for more seeds per umbellate (≥ 11 seed per umbellate) and ten entries observed as early maturing (≤ 100 days). Nine entries had high volatile oil (≥ 4.3 %). Nine entries identified as high yielders with grain yield of more than 1800 kg/ha. The variability details for quantitative characters are presented in Table 50.

The germplasm at Jobner consists of 855 accessions (753 indigenous and 102 exotic) in coriander. The germplasm has been evaluated for yield, adaptability and the reaction to diseases and pests, maintained scientifically and updated with new accessions.

One hundred forty one accessions of coriander were evaluated at Hisar using Hisar Anand, Narnaul Selection and Pant Haritima as checks during 2005-2006. The seed yield of the germplasm ranged from 160 g (DH-345) to 540 g (DH-277 and DH-281). Forty-six lines recorded higher seed yield than Hisar Anand, 47 higher than Narnaul Selection and 90 out yielded Pant Haritima. The most promising lines for seed yield were DH-204, DH-210, DH-213, DH-222. DH-236. DH-276, DH-277, DH-278, DH-281. DH-282, DH-293, DH-297, DH-298 and DH-335.

During 2006-07, rabi season, one hundred and forty four coriander collections were evaluated at Guntur. Among the one hundred and twenty four entries evaluated, LCC-235 recorded highest yield (1492 kg/ha) followed by LCC-206 (1396 kg/ha), LCC-228 (1396 kg/ha), LCC-229 (1358 kg/ha). LCC-170 (1346 kg/ha) and LCC-240 (1346 kg/ha). The check Sadhana recorded an yield of 850 kg/ha.

Among the germplasm lines evaluated at Dholi, nine accessions *viz.*, RD-120, RD-154, RD-378, RD-366, RD-380, RD-373, RD-121, RD-377 and RD-379 recorded the yield of 1.30, 1.20, 1.10, 1.05, 1.0, 0.95 and 0.95 kg/4.5 m^2 respectively. The maximum yield was recorded in RD-120 (1.30 kg/4 5 m^2) followed by RD-154 and RD-378 (1.20 kg/4.5 m^2).

Table 50. Variability for coriander germplasm at Jagudan

Characters	Range	GCo-2 (Check)	Desirable Values	Number of Entries	Promising entries
Plant height (cm) (Dwarf)	53-91	70	≤ 60	10	Moroccan, EC-363972,EC-363966, JCr-380,403,Australian, JCr-383, 378,EC-363974 and JCr-334
Branches/ plant(more branches)	3 7-9 3	5 3	≥ 7.5	12	UD-79, JCr-360, 392, 397, 401, Russian, JCr-342, Lam-87, EC-232669, EC-363965, EC-363972 & Lam-45
Umbels/plant(more umbels)	7 0-28.3	12	≥ 20	10	JCr-378, 397, 375, Egyptian,Lam-5,EC-350691, JCr-389, Lam-87, Lam-45 & Lam-73
Umbellates/umbel (more umbellates)	3.3-7.3	5	> 6 0	14	UD-273, Dhana-157, UD-100, UD-90, JCr-360, 283, Lam-23, JCr-377, Egyptian, Bulgarian, JCr-380, 382, 379 & Lam-69
Seeds/umbellate(more seeds)	4 7-12 7	6.7	≥ 11	10	UD-105, JCr-333, 401, Lam-43, EC-357849, EC-363970, JCr-329, 399, 400 & JCr-398
Days to maturity(early)	98-125	107	≤ 100	10	Lam-6, UD-309, UD-217, JCr-327, 328, 334, 283, Lam-5, EC-363966 & Bulgarian
Volatile Oil %	0 05-0 60	0.35	≥ 0.45	6	EC-343365, Morroccan, JCr-383, 283, 393 & JCr-375
1000 Seed weight (g)	7.28-19.12	13 92	> 16	4	Bold Seeded - JCr-403, 402, 342 & 283
			< 9	8	Small Seeded - JCr-400, 395, 391, 389, 388, 390, 398 & 392
Grain yield (g/plant)	1.58-11.53	11 53	≤ 7	7	GCr-2, JCr-401, EC-232669, EC-243370, Lam-5, Lam-6 & FC-363974
Grain yield (kg/ha) (high yield)	706-1917	1298	≥ 1800	9	UD-290, Lam-5, JCr-372, Lam-23, JCr-375, Lam-16, Lam-6, UD-240 & JCr-327

Eighty eight lines were evaluated during 2005-06 at Kumarganj. Maximum seed yield was obtained in NDCor-2 (1.78 t/ha) followed by NDCor-30 (1.68 t/ha) against check Hisar Anand and K. Selection.

6.2 Coordinated Varietal Trial

6.2.1 CVT 2001 Series V (final report)

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

Table 51. Coriander germplasm collection at AICRP centres

Centre	Indigenous		Total
	Cultivated	Wild and related sp.	
Jobner	753	102	855
Jagudan	74	21	95
Coimbatore	274	-	274
Hisar	251	-	251
Guntur	248	-	248
Dholi	97	-	97
Kumarganj	75	-	75
Total	1772	123	1895

Nineteen accessions were evaluated for the growth and yield characters during 2005-2006 rabi season at Coimbatore. These accessions were obtained from Hisar (DH 206, DH 242, Hisar Anand), Kumarganj (K.sel., ND Cor - 2, ND Cor – 30), Jagudan (J.cori- 340, J. cori- 375), Jobner (Lcc, UD and RG series). The highest grain yield of 1050 kg/ha was recorded in LCC 170 followed by UD 728 (700 kg/ha). All the nineteen cultivars were screened for powdery mildew disease resistance using 0 – 5 scale. The results showed that none of the accessions found resistance to powdery mildew disease.

At Jagudan, the yield differences among the entries were significant. JCr-328 recorded significantly highest yield (1456 kg/ha) followed by JCori-360, GCo-2 and LCC-174. The genotype JCr-328 significantly out yielded the national check Hisar Anand (1235 kg/ha). However none of the test entries except JCori-328 and JCr-360 out yielded the local check variety GCo-2. The pooled data over four years showed that significant yield differences due to treatments. But none of the entry gave

Table 52. Yield performance of CVT 2001 entries at Jagudan

Entries	Yield (Kg/ha)					Increase over check (%)	
	2002-03	2003-04	2004-05	2005-06	Mean	GCo-2	His.And.
JCr-328	1573	1939	1729	1456	1674	7.51	35 88
JCr-360	1591	1835	1526	1399	1588	1.99	28 90
LCC-174	950	1250	1362	1261	1206	-	-
LCC-225	1005	1090	1400	1129	1156	-	-
UD-118	1223	1545	1214	1008	1248	-	1 30
UD-480	982	1337	1232	1109	1165	-	-
NDCo-2	1127	1219	1274	1008	1157	-	-
K.Selection	1181	1403	1185	1101	1218	-	-
DH-205	1256	1542	1480	1000	1320	-	7 14
DH-234	1401	1550	1496	1059	1377	-	11.77
GCo-2 ©	1558	1835	1533	1301	1557	-	16 38
Hisar Anand N©	-	-	1228	1235	1232	-	-
SEm ±	87	103	69	77	61		
CD (P=0.05)	251	298	200	220	177		
CV (%)	13.68	13.58	10.10	13 11	12.81		

significantly superior yield than check. However, highest yield was reorded in JCr-328 (1674 kg/ha) which was 7.51 per cent higher than check (Table 52).

At Jobner, the mean yield performance over three years (2002-05) revealed the superior performance of UD-480 with yield of 1324.82 kg/ha, followed by UD-118 (1167.28 kg/ha). The character wise pooled mean over three years (2002-03, 2003-04 and 2003-04) also indicated that the entries differed significantly for all the characters studied.

The CVT at Hisar with 12 entries was conducted during 2002-03 to 2004-05. Significant differences among entries were obtained for all the yield contributing characters. The maximum seed yield was recorded in DH –234, followed by DH-205. On the basis of three years average yield (2002-03 to 2004-05), the maximum seed yield was recorded in DH-234 (1839 kg/ha), followed by DH-205 and Kumarganj selection.

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

(*Coimbatore, Hisar* and *Guntur*)

The CVT trial was laid out with 12 leafy types of coriander during 2006-2007. Among the 12 accessions evaluated, the leaf yield per plot (20 m^2) varied from 0.98 kg to 2.6 kg (Table 53). The highest leaf yield was recorded in the accession DH 232 (2.6 kg/plot).

At Guntur sowing was taken up on 18th April with 18 entries and all the entries failed to germinate due to high temperatures prevailed during that time. Subsequently, eight production structures were tried to study its suitability for off-season coriander leaf production. The results indicated that maximum coriander leaf yield was obtained under shade net (75%) (8988 kg/ha) followed by palmyra leaf thatched housing (8145 kg/ha) and tree shade (7541 kg/ha).

Table 53. Growth and yield performance of leafy type coriander during off-season at Coimbatore

Entries	Days to 50% flowering	Plant height (cm)	Leaves/ plant	Yield / plot 20 m^2(kg)	Yield / ha (kg)
DH 202	41 3	31.37	11 35	1.7	850
DH 228	38.6	31.59	14.00	1.3	650
DH 232	43 6	37.55	17.20	2 6	1300
ACR 250	36.3	33.83	14 40	1.45	725
ACR 256	39.3	30.70	12.60	0.98	490
Jco 377	38.6	31.47	10 25	1.10	550
Lcc 234	35.3	31.80	17.00	1.44	720
Lcc 232	35.3	37.17	15.20	1.52	760
Jcor 384	34.6	32.47	15 60	1.12	560
P Har	36.6	40.23	21 00	1.84	920
CO 2	40.3	32.47	16 40	1 24	620
CO 4	33 3	30.90	14.00	1.36	680
SED	0 097	2.15	0.17	0 49	51.63
CD (P=0.05)	0 202	4.29	0.34	0.97	102.3

Table 54. Yield and ancillary characters of CVT 2005 at Jagudan

Entries	Plant height (cm)	Umb/ plant	Seeds/ umbel	Volatile oil (%)	Yield kg/ha	Increase over check (%) GCo-2	Hisar Anand
DH-206	73 6	12.9	7.4	0 40	1215	-	-
DH-242	77 2	13 3	6.6	0 35	1533	3.58	9 34
JCr-340	82 7	11 0	8 5	0.45	1595	7 77	13.77
JCr-375	76 1	15 6	10 0	0 50	1608	8 64	14 69
LCC-170	71 0	15 2	7 6	0.30	1403	-	0 07
LCC-212	71 1	16 5	7 3	0 40	1435	-	2 35
LCC-216	66 3	15 1	6.3	0 35	1239	-	-
NDCo-30	78 0	9 7	7 9	0.40	1078	-	-
RD-154	70 7	13 2	7.7	0 30	1309	-	-
RD-366	72 6	13 5	8 9	0.30	1452	-	3.57
UD-728	84.3	10 9	8 8	0.20	1246	-	-
UD-796	79 1	11 0	8 9	0.25	1092	-	-
UD-797	75 6	9.6	7.3	0 20	973	-	-
Hisar Anand N©	68 9	11.1	6.8	0 30	1402	-	-
GCr-2 ©	77 4	12.0	7.3	0 45	1480	-	5 56
SEm (±)	3 8	1.2	0.6	-	111		
C D (P=0 05)	NS	3.5	1.8	-	322		
C V. (%)	8.75	16.54	13.90	-	14 36		

6.2.3 CVT 2005

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

The trial was started at Jagudan during 2005-06 with thirteen entries and two checks, local check (GCı-2) and national check (Hısar Anand). The yield differences among the entries were significant. But none of the entry gave significantly superior yield than check. However, an entry JCr-375 recorded highest yield (1608 kgha ^{1}) which was 8.64 per cent higher than local check and 14.69 per cent than national check (Table 54).

Twenty one entries were evaluated at Jobner and significant differences were observed for all the characters including seed yield. Moderate to high variability was recorded for all the character *viz.*, mean days to flowering 61.00 (LCC-216) to 91.67 days (UD-797), plant height 50.33 (RCr-436 check) to 84.93 cm (UD-797), branches per plant 5.13 (LCC-216) to 8.53 (UD-728), umbels per plant 15.00 (DH-206) to 26.00 (UD-728), umbellets per umbel 3.80 (DH-242) to 5 53 (RCr-435 check), seeds per umbel 23.6 (LCC-212) to 50 (K. Selection) and test weight 8.69 (UD-797) to 19.00 g (LCC-216). The seed yield ranged 722.22 to 1337.96 kg/ha. The genotype UD-728 recorded the maximum seed yield of 1337.96 kg/ha followed by ICS-2 (1226.85 kg/ha), K. Selection (1180.56 kg\ha), RD-366 (1134.26 kg/ha), RD-154 (1069.44 kg/ha), J. Cori- 375 (1046.30 kg/ha), DH-206 (981.48 kg/ha) and RCr-435 Check (972.22 kg/ha). while lowest seed yield of 722.22 kg/ha was recorded in local check and LCC-212.

During 2006-07, seventeen entries from different coordinating centers were tested at Guntur centre. All CVT entries were inferior to check Sadhana (813 kg/ha).

Results at Dholi, revealed that among the seventeen entries COR-3 recorded significantly higher plant height (109.47 cm) over national check Jcr-340 and other entries. However, none of the entries were found to be significantly superior over local check Rajendra Swati regarding number of branches per plant, number of umbellets per umbel and yield per plot. Significantly more number of umbels per plant was recorded in COR-14, COR-16 and COR-15 (37.13, 33.67 and 33 33) than local check Rajendra Swati. However. COR -15, COR -14 and COR -13 were found significantly more number of grains per umbel (39 27, 35 13 and 31.93) over local check Rajendra Swati. COR -1. COR -2, COR -6 and COR -8 were found to be late maturing as compared to national check Jcr-340 and local check Rajendra Swati.

In two years of observations maximum mean seed yield was obtained in NDCor-30 (1.85 t/ha)

Table 55. Initial Evaluation Trial (IET) in coriander at Hisar

Accessions	Seed yield (kg /ha)			Increase over
	2004-2005	2005-2006	Mean	check (%)
DH-207	1933	1887	1910	15.27
DH-211	1790	1768	1779	07 36
DH-220	2156	2132	2144	29.39
DH-233	2198	2247	2223	34.16
DH-278	1883	1910	1897	14 48
DH-288	1805	1897	1851	11.71
DH-294	1793	1835	1814	09.47
DH-297	1883	1753	1818	09.72
DH-317	1971	1940	1956	18 04
Hisar Anand	1661	1653	1657	-
CD (P=0 05)	230	186	-	-

followed by NDCor-2 (1.75 t/ha), which was at par with NDCor-30 at Kumarganj.

At Raigarh highest yield of 1059.03 kg/ha was recorded in COR-15 followed by COR-5 (1048.62 kg/ha) and COR-7 (1034.73 kg/ha).

6.3 Coordinated Varietal Trial

6.3.1 Initial evaluation trial

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

The trial was conducted with ten accessions along with check Hisar Anand during 2004-2005 to 2005-2006 at Hisar. The results indicated that maximum yield in DH-220 and DH-233 over Hisar Anand showing 29.4 and 34.2 % increase in yield, respectively (Table 55).

During 2006-07, ten promising accessions were tested at Guntur and LCC-237 recorded the maximum yield of 1119 kg/ha followed by LCC-236 with 1090 kg/ha which were superior over checks Sadhana (848 kg/ha) and Swathi (868 kg/ha).

In Jobner, IET coriander consisting of ten entries, the analysis of variance revealed significant differences among the entries for all the traits including seed yield. The seed yield ranged from 444.44 to 1240.74 kg/ha. Of the ten entries evaluated, UD-475 recorded maximum seed yield of 1240.74 kg/ha followed by followed by UD-20-130-278 (1046.30 kg/ha), RCr-435 check (833 33 kg/ha), RCr-436 check (805.33 kg/ha), UD-600 (675.00 kg/ha) and Merigold-6 (657.41 kg/ha), while lowest yield of 444.44 kg/ha was recorded in Local check. Mean performance of the entries evaluated in IET over 2004-05 and 2005-06 revealed superior performance of UD-475 yielding 1480.57 kg/ha followed by UD-20-130-278 (1346.07 kg/ha). RCr-435 check (1138.89 kg/ha), Merigold-6 (1033.57 kg/ha) and UD-630 (1022.57 kg/ha), while lowest mean yield of 760.42 kg/ha was recorded in Local check.

The trial was started during 2005-06 at Jagudan with 10 entries and results revealed non significant yield differences among the entries. The entry JCr-383 recorded maximum yield (1400 kg/ha) and out yielded the check GCr-2 by 15.42 per cent, the yield increase was non significant.

6.4 Quality evaluation trial

6.4.1 Quality evaluation in coriander

(*Jobner*)

The volatile oil content among 21 CVT entries ranged from 0.30 to 0.47 %. The maximum volatile oil of 0.47 % was observed in UD-797 and N.D.Cori-2 followed by 0.43 % in J.Cori-378. RCr-435 check and UD-728 and minimum of 0.30

Table 56. Volatile oil content of coriander entries

Entries	Seed yield (kg/ha)	Volatile oil(%)	Volatile oil yield (l/ha)
UD-728	1337.96	0.40	5 35
UD-796	875.00	0 40	3 50
UD-797	861 11	0 47	4.03
J Cori-340	888 89	0.40	3.56
J Cori- 375	1046.30	0.43	4 53
DH-206	981.48	0.40	3 93
DH-242	907.41	0 30	2 72
K. Selection	1180 56	0 40	4.72
N.D Cori-2	842 59	0.47	3.96
N D.Cori-30	972.22	0.40	3 89
ICS-1	907.41	0 30	2.72
ICS-2	1226 85	0.40	4.91
LCC-170	782 41	0 33	2 62
LCC-212	722 22	0 40	2.89
LCC-216	828.70	0.40	3 31
RD-154	1069 44	0 40	4.28
RD-366	1134 26	0 40	4 54
Hisar Anand (NC)	851 85	0.40	3 41
RCr-435 C	972 22	0 43	4 22
RCr-436 C	888 89	0 40	3 56
Local C	722 22	0.40	2 89
CD (P=0 05)	101 88	0 05	0 60
CV (%)	6 37	6 81	9 49

Table 57. Effect of *Azospirillum* and different levels of nitrogen on growth and yield of coriander cv. CO 3 at Coimbatore

Treatments	Plant height (cm)	Primary branches	Secondary branches	Umbels per plant	Umbellets per umbel	Yield (kg/ha)
Inorganic N (100%) + *Azospirillum* (1 5 kg seed treatment) + 5 t/ha FYM	66 20	6.93	15 03	33 30	7.00	519 43
Inorganic N (75%) + *Azospirillum* (1 5 kg seed treatment) - 5 t/ha FYM	66.13	6.86	14 66	34 80	7 13	564 93
Inorganic N (50%) + *Azospirillum* (1 5 kg seed treatment) - 5 t/ha FYM	70 73	7 60	16.86	39.00	8 03	631.26
FYM (5 t/ha) + *Azospirillum* (1 5 kg seed treatment)	65.66	6.23	13 80	32 10	6 86	424 26
FYM (5 t/ha)	62 63	6.60	14 46	33.16	6 66	367.20
FYM (10 t/ha) + *Azospirillum* (1.5 kg seed treatment)	65.63	6 56	14 96	30 00	6 70	426 03
FYM (10 t/ha)	62 06	6 13	13.86	31 86	6 56	354 56
Azospirillum (1.5 kg seed treatment)	60.33	6.83	14 16	31 96	6 43	244.56
Urea (100%)	62 50	7.30	15 60	34.73	6 40	252 50
Control	64 00	6 96	15.16	32.33	6.96	507.70
SEd	4 83	4 83	0 80	2.23	0 37	29.60
CD (P=0 05)	10 15	10 1	1 69	4.70	0.78	62.19

% in DH-242 and ICS-1.The entry UD-728 ranked first in terms of volatile oil yield (5.35 l/ha) followed by ICS-2 (4.91 l/ha), K Selection (4.72 l/ha). RD-366 (4.54 l/ha) and J. Cori-375 (4.53 l/ha). While lowest volatile oil yield of 2.62 l/ha was recorded in LCC-170 (Table 56).

The volatile oil content of IET entries ranged from 0 33% to 0.47%. The maximum volatile oil of 0.47% was recorded in UD-475 followed by 0.43% in Merigold-6, UD-20-130-278 and RCr-435 and minimum of 0.33% in UD-707. Highest volatile oil yield was recorded in UD-475 (5.75 l/ha) followed by UD-20-130-278 (4.54 l/ha) and RCr-435 (3.60 l/ha) and minimum was recorded in local check (1.63 l/ha). On the basis of two years data (2004-05 and 2005-06), the highest mean volatile oil content of 0.47% was recorded in UD-475 and Merigold-6 followed by 0.43% in UD-20-130-278 and 0.40% in RCr-435. whereas minimum 0.31% was recorded in local check. The maximum mean volatile oil yield in terms of litre per ha was observed in UD-475 (6.34 l/ha) followed by UD-20-130-278 (5.79 l/ha) and Merigold-6 (4.65 l/ha) and minimum in local check (2.36 l/ha).

6.5 Nutrient Management Trial

6.5.1 Effect of biofertilizer, *Azospirillum* on coriander

(Coimbatore, *Kumarganj and Hisar*)

At Coimbatore the pooled analysis of the data over three years revealed that the seed yield was highest in the treatment FYM (5 t/ha) + inorganic N (50%) + *Azospirillum* 1.5 kg (seed treatment). The volatile oil content varied from 0.20

Table 58. Effect of inorganic N, FYM and biofertilizer on seed yield of coriander at Hisar

Treatments	Seed Yield (kg/ha)		
	2003-2004	2005-2006	Mean
Inorganic N (100%) + *Azospirillum* + 5 t FYM/ ha	1750	1840	1795
Inorganic N (75%) + *Azospirillum* + 5 t FYM/ ha	1730	1810	1770
Inorganic N (50%) + *Azospirillum* + 5 t FYM/ ha	1500	1620	1560
Azospirillum + 5 t FYM/ ha	1540	1600	1570
5 t FYM/ ha	1480	1540	1510
Azospirillum + 10 t FYM/ ha	1710	1780	1745
10 t FYM/ ha	1560	1630	1595
Inorganic N (100%)	1750	1810	1780
Azospirillum @1 5kg/ha	1520	1600	1560
Control	1470	1500	1485
CD (P=0 05)	120	140	-

Table 59. Effect of NPK, FYM and *Azospirillum* on yield of coriander at Kumarganj

Treatments		Yield (t/ha)			
		2004-05	2005-06	2006-07	Mean
T_1	Inorganic Nitrogen (100%) + *Azospirillum* 1 5 Kg/ha + 5 t/ha FYM	2 03	1 33	1 36	1 57
T_2	Inorganic Nitrogen (75%) + *Azospirillum* 1 5 Kg/ha + 5 t/ha FYM	2 23	1 28	1.50	1 67
T_3	Inorganic Nitrogen (50%) + *Azospirillum* 1 5 Kg/ha + 5 t/ha FYM	2 35	1.25	1 38	1.66
T_4	FYM 5t/ha + 1.5 Kg/ha *Azospirillum*	2 26	0.97	1 45	1.56
T_5	FYM 5 t/ha	2 35	0.98	1 52	1 61
T_6	FYM 10 t/ha + 1 5 Kg/ha *Azospirillum*	2.44	1 37	1 54	1 78
T_7	FYM 10 t/ha	2 26	1.18	1 28	1 57
T_8	100% Inorganic Nitrogen	2 02	1 23	1.22	1 49
T_9	*Azospirillum* 1 5 Kg/ha	2 23	1 14	1.38	1.58
T_0	Control	1 95	0.67	1.16	1 26
SEM +-		0 11	0.11	-	
CD (P=0 05)		0 26	0.32	0 41	-
CV (%)			7.79	16.86	14 85 -

to 0.25 % among different treatment (Table 57). Highest benefit cost ratio of 1.94 was also obtained by the same treatment. Hence the application of FYM (5 t/ha) + inorganic N (50%) + *Azospirillum* 1.5 kg (seed treatment) was found to be the best treatment among the different treatment imposed in the study.

The study at Hisar revealed that the significant differences were obtained for all the parameters. On the basis of average yield of two years (2003-2004 and 2005-2006) (Table 58) the maximum seed yield (1795 kg/ha) was recorded with Inorganic N (100%) + *Azospirillum* + 5 t FYM/ha which was closely followed by inorganic N (100%) and inorganic N (75%) + *Azospirillum* + 5 t FYM/ ha.

The trial conducted at Kumarganj on variety Pant Paritima revealed application of 10 t/ha of FYM + 1.5 kg/ha of *Azospirillum (T6)* produced maximum seed yield of 1.54 t/ha. Seed yield by application of 5 t/ha of FYM was at par with application of 10 t/ha of FYM and 1.5 kg/ha of *Azospirillum* during 2006-07. Three years pooled yield data showed maximum seed yield of 1.78 t/ha (T_6) as shown in Table 59.

6.5.2 Effect of bioregulators on coriander

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

An experiment to evaluate the effect of bio-regulators on coriander at Jobner revealed that application of NAA 50 ppm resulted in significant enhancement of seed yield in both the years but it was at par with Triacontanol 1.0 ml/l. Triacontanol 1.0 ml/l was also significantly superior over Triacontanol 0.5 ml/l and water spray. Data further indicated that with the increase in number of sprays, the seed yield also showed increasing trend but the significant response was observed only up to 2 sprays (40 and 60 DAS). Significantly lesser seed yield was recorded in the absolute control as compared to the mean of all other treatments.

The experiment was conducted on variety Pant Haritima at Kumarganj during 2006-07. Maximum seed yield of 2.11 t/ha was obtained when

Table 60. Effect of bio-regulators on coriander (2004-07) at Guntur

Treatments	Tria. 0.5 ml/l	Tria. 1 ml/l	NAA 10 ppm	NAA 50ppm	Water Spray	Control	Mean
40 DAS	723	780	811	646	701	689	725
40 and 60 DAS	842	882	904	775	735	698	806
40, 60 and 80 DAS	833	828	831	766	729	689	779
Mean	799	830	848	729	721	692	
CD (Factor1)	39.5						
CD (Factor2)	27 9						
Interaction	NS						
CV (%)	5.4						

crop was sprayed with *Tricantanol* 1 ml/l of water after 30, 40 and 60 days of sowing (T_6) followed by 2.04 t/ha of seed yield in the treatment NAA (50 ppm) after 40 days of sowing. Highest yield of 1 70 t/ha of seeds were obtained in treatment T_6 in three years mean yield data.

Among the different treatments tried at Guntur, NAA 10 ppm recorded highest yield (933.2 kg/ha) which was on par with Triacantanol @ 1ml (914.6 kg/ha), Triacantanol @ 0.5 ml (906.6 kg/ha), and NAA 50 ppm (822.3 kg/ha). Number of sprays are concerned, two sprays at 40 and 60 DAS recorded highest yield (895.8 kg/ha). The pooled data of three years (2004-07) indicated that application of NAA 10 ppm / Triacontanol @ 1ml/l at 40 and 60 DAS resulted in increased yield (Table 60).

Interaction found significant effect regarding plant height, number of umbels per plant, number of grains per umbel and yield (t/ha) at Dholi. While non significantly effect was recorded in branches per plant and umbellets per umbel. However, three sprays (40, 60 and 80 DAS) of Triacontanol @ 0.5 ml/liter gave the maximum plant height (144.28 cm), branches per plant (7.60), umbels per plant (53.10), grains per umbel (33.94) and yield (1.92 t/ha) as compared to other treatments. The three sprays Triacontanol @ 0.5 ml/liter (40, 60 and 80 DAS) recorded the maximum return Rs. 1.37 per unit cost (1:1.37).

The results at Coimbatore centre revealed that the highest grain yield of 853.3 kg/ha was obtained in spraying of Triacontanol 0.5 ml/l at 40 days of sowing.

On the basis of two years average yield (2004-2005 and 2005-2006) at Hisar, maximum seed yield was recorded with the application of NAA @ 50 ppm followed by triacontanol @ 1.0 ml/litre. Regarding number of sprays, maximum seed yield was recorded with three sprays followed by two sprays.

6.5.3 Identification of drought and alkalinity tolerant source in coriander

(Coimbatore, Guntur and Kumarganj)

Among the fifty high yielding genotypes evaluated at Coimbatore for the drought tolerance, the genotype CS 196 recorded the highest yield of 140 g of grain yield/plot ($5m^2$) when drought was imposed during the vegetative phase. Nine genotypes *viz.*, CS 161, 184, 78, 164. 131, 195, 70, 126 and 128 recorded the yield of 125 g/plot. The genotypes CS 122, 178, 121 and 188 recorded the highest grain yield of 150g/plot when subjected to drought during the flowering stage. The genotypes CS 31, 201, 79 and 103 recorded a highest grain yield of 175 g/plot under control.

During 2006-07 at Guntur, ten entries were selected from the germplasm based on the physiological parameters and evaluated for yield.

Table 61. Performance of coriander germplasm for drought tolerance at Guntur

Drought parameter	Min.	Max.	Range
RWC	LCC-179	LCC-190	57 - 81
CSI	LCC-195	LCC-212	0 58 - 0.85
SLA (cm^2/gm)	LCC-172	LCC-212	41.1 - 135.2
SLW (gm/cm^2)	LCC-212	LCC-172	7 4 - 24.3
Biomass (g/5plants)	LCC-157	LCC-176	14.0 - 82.0
Root length (cm)	LCC-157. LCC-187	LCC-217	5.6 - 13.2
Shoot length (cm)	LCC-157. LCC-187	LCC-220	35 6 - 84.8
Root shoot ratio	LCC-213	LCC-175	0.092 - 0.269

Among the entries, LCC-159 (1368 kg/ha) followed by LCC-183 (1338 kg/ha) recorded significantly higher yields over best check Swathi (1046 kg/ha). Among the forty lines tested for drought physiology, the relative water content (RWC) values at 75 DAS (days after sowing) ranged from 57.0 (LCC-179) to 81.0 (LCC-190). The chlorophyll stability index (CSI) at 45 DAS ranged from 0.58 (LCC-195) to 0.85 (LCC-212). The specific leaf area content (SLA) at 75 DAS ranged from 41.07 (LCC-172) to 135.15 (LCC-212) (Table 61).

During 2006-07 at Kumarganj, ten genotypes of coriander were tested with four levels of ESP and found that the highest yield 44.5 and 44.41 g/plant was recorded under 10 and 20 ESP levels. On the basis of pooled mean of three years data indicated that increase in ESP levels decreases the yield. The maximum yield (44.80 g/plant) was obtained at 10 ESP level with the genotype NDCor-2 and highest yield (42 24 g/plant) at 20 ESP level was also recored in the same genotype. The next best genotype was NDCor-8 with yield level of 38.24 and 36.49 g/plant at 10 and 20 ESP levels, respectively.

6.6 Disease Management Trial

6.6.1 Management of powdery mildew and stem gall in coriander

(*Coimbatore, Raigarh,* Jagudan and *Jobner*)

A field trial was conducted to test the efficacy of biocontrol agents against stem gall and powdery mildew diseases during 2006-07 at Coimbatore. The results revealed that seed treatment with *Pseudomonas fluorescens* IISR 6 @ 10 g / kg of seed followed by foliar spraying @ 10^8 CFU on 60 days after sowing was found to be effective to contain the powdery mildew disease (18 PDI) and recorded the maximum cost benefit ratio of 1:2.5. There was no stem gall disease symptom in the entire experimental plots.

At Raigarh, minimum disease intensity of powdery mildew (17.2 %) was observed in the treatment T5 followed by T6 (17.33%). Maximum plot yield (1.03 kg) was recorded in T5 followed by T6 (1.0) and was statistically at par in respect of disease intensity and yield. Maximum disease intensity (70.26%) and minimum plot yield (0.32 kg) was observed in treatment T7. Minimum disease intensity of stem gall was observed in Treatment T4 (13.74%) followed by T1 (14.66%) and T5 (15.41%). Maximum plot yield was observed in treatment T1 (0.94 kg). Maximum disease intensity (43.74%) and minimum plot yield (0.39 kg) was observed in T7 (Table 62).

Among 141 entries screened for powdery mildew resistance at Jagudan, none of the entries were found to be resistant. Five germplasm lines found to be moderate, 22 entries showed susceptible reaction and all other entries recorded as highly susceptible reaction under natural condition. The PDI ranged from 25 % to 100 %. The results of the different treatments were found to be significant for the management of powdery mildew disease. Minimum incidence of powdery mildew was recorded in T4 and it was at par with T6 and T5. Similarly, the yield performance of different treatments was also found to be significant and highest yield was reported in T4 (seed treatment + soil drench + spray with Tridemoph @ 0.01% at 60 DAS).

Experiment on management of powdery mildew and stem gall at Jobner revealed that out of the seven treatments tested, minimum powdery mildew disease incidence (28 33 %) with the maximum seed yield (1873 kg/ha) was recorded in T1 (Soil solarization + soil application of *Trichoderma* + spray with Calixin), followed by T6 (spray with wettable Sulphur) with the seed yield of 747 kg/ha. The control resulted in maximum disease incidence (90 % powdery mildew) and lowest seed yield 1398 kg/ha as compared to all other treatments. Out of twenty one CVT entries tested against wilt, powdery mildew and stem gall, UD-796 and UD-797 were found free from wilt and powdery mildew with the seed yield of 875 and 861 kg/ha respectively. Out

Table 62. Influence of different treatments on powdery mildew at Raigarh

Treatments	Average disease intensity*	Yield (kg/plot)	Projected yield (q /ha)
T1. Soil solarization + Soil application of *Trichoderma* (1kg/plot) + Spray with Tridemorph (calixin) 0.1% after 60 days of sowing	25 43 (30 3)	0 84	7 8
T2. Seed treatment with *Pseudomonas florescence (Pf)* (IISR-6) + Spray with *Pf.* (IISR-6) 10^8 cfu after 60 days	55 46 (48 14)	0 43	4 1
T3. Soil application *of Bacillus subtilis (B s.)* 10^8 cfu + Spray with B s after 60 days	53.96 (47.31)	0.45	4.2
T4. Seed treatment, soil drench Tridemorph (calixin) 0.1% + Spray with calixin 0.1% after 60 days	23.73 (28 92)	0 79	7 5
T5 Carbendazim (Bavistin) as soil drench and spray (0.1%)	17 20 (24.47)	1 0	9 3
T6. Spray with Wettable sulphur (0.2%)	17.33 (25.59)	1 03	9 4
T7. Spray of NSKE (5%)	30 80 (31.51)	0.63	6
T8 Control.	70 26 (56.96)	0.32	3 03
CD (P=0 05)	5 57	0 06	1 11

* Disease incidence observation on only 20 plants

Table 63. Effect of fungicides, soil solarization, bio-agent on the incidence of stem gall, powdery mildew disease and yield in coriander during 2004-07 at Kumarganj

	Treatments	Diseases		Yield (t/ha)	Decrease in disease (%) over control		Increase in yield (%)
		Stem gall	Powdery mildew		Stem gall	Powdery mildew	
T_1	Soil solarization + soil application + *Trichoderma* (1 kg) + spray with Calixin (0 1%) after 60 days	30 17	30.28	0 832	38.05	43 56	23.25
T_2	Seed treatment with *Pseudomonas florescence* + spray with Ps fl 10^8 CFU after 60 days	32.54	34.13	0 742	33 61	36 38	9 92
T_3	Soil application of *Bacillus subtilis* (BS) 10^8 CFU + spray with BS after 60 DAS	30 99	28 35	0.960	36.78	47.15	42 22
T_4	Seed treatment + soil drenching calixin 0.1% + spray with calixin 0.1% after 60 DAS	35 71	28 67	0.811	27 15	46 56	20.14
T_5	Carbendazim as soil drench and spray 0.2% after 60 DAS	19.18	31.87	0 938	60 87	40 59	38 96
T_6	Spray with wettable sulphur (0 2%)	25.44	17 97	0 942	48 10	66 50	32 59
T_7	Control	49.02	53 65	0 675	-	-	-

of ten IET entries tested against wilt. powdery mildew and stem gall, UD-475 and UD-20-130-278 were found to be free from both the diseases with the maximum seed yield of 1240.74 and 1046.30 kg/ha respectively. Out of 15 entries tested against stem gall disease at farmer's field at Danta (Sikar), none of the entry was found to be free from disease. Out of 15 entries tested against root knot disease at ARS, Durgapura UD-118, UD-480 were found to be resistant.

At Kumarganj, soil drenching and foliar spray of Carbendazim (0 2 %) 60 DAS showed lowest incidence of stem gall disease (10.76 %) and lowest incidence of powdery mildew disease (17.56 %) was observed with wettable sulphur (0.2 %) spray. Maximum seed yield of 1.00 t/ha was observed with spray of wettable sulphur. Three years pooled data showed disease control with maximum seed yield in soil application of *B subtilis* 10^8 CFU and spray with *B. subtilis* after 60 DAS, showing 42.22 % increase in yield over control (Table 63).

7. CUMIN

7.1 Genetic Resources

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

(*Jagudan* and *Jobner*)

Two hundred and seventeen genotypes were characterized (Table 64) in comparison with three checks (GC-2, GC-3 and GC-4) during 2005-06 at Jagudan.

Table 64. Characterization of cumin germplasm at Jagudan

Characters	Observation	Promising number of accessions
Dwarf types (plant height)	< 27 cm	7
Branches per plant	> 8	9
Umbels per plant	> 32	9
Umbellates per umbel	> 6	9
Seeds per umbellate	> 7	10
Early maturity	< 97 days	9
Volatile oil	> 4.1	8
High yielders	> 850 kg/ha	10

Thirty one entries were screened for resistance against blight under natural conditions. None of the entry was found to be free from blight disease. The minimum incidence was noticed in GC-4 (24 %) followed by GC-3 (55 %), whereas, all other entries showed highly susceptible reaction (75 % to 96.25 %). Thirty one entries were screened for its resistance against powdery mildew under natural conditions. The incidence ranged from 78.25 % to 98.50 % and all the entries were found highly susceptible. Nineteen entries were screened for wilt under sick plot conditions. Only the genotype, GC-4 (39.30 %) was found to be moderately resistant and other two varieties GC-3 (52.10 %) and JC-2000-53 (57.50 %) showed susceptible reaction.

Jobner centre maintains 376 accessions including 6 exotic ones. The cumin germplasm maintained under different centres are given in Table 65.

Table 65. Cumin germplasm collection under AICRPS centres

Center	Indigenous	Exotic	Total
Jobner	370	6	376
Jagudan	240	7	247
Total	**610**	**13**	**623**

7.2 Coordinated Varietal Trial

7.2.2 CVT 2005

(*Jobner, Jagudan*)

At Jobner, ten entries were evaluated during 2005-06. The analysis of variance revealed significant differences among the entries for all the traits including seed yield (Table 66). The days to flowering ranged from 78.25 (local Check) to 81.25 days (UC-347), plant height from 25.83 (GC-3 check) to 33.80 cm (UC-345), branches per plant from 4.80 (Local check) to 6.50 (JC-95-30), umbels per plant from 16.65 (GC-3 check) to 22.40 (UC-345), umbellets per umbel from 3.29 (Local check) to 5.30 (JC-95-30), seeds per umbel from 26.10 (Local check) to 31.85 (UC-345) and test weight from 3.29 (GC-3 check) to 4.06 g (UC-345). The seed yield ranged from 263.54 to 607.67 kg/ha. Of the ten entries evaluated, UC-345 recorded maximum seed yield of 607.64 kg/ha followed by RZ-209 check (557.29 kg/ha), JC-95-30 (523.96 kg/ha), RZ-19 check (512.15 kg/ha), UC-347 (510.76 kg/ha) and GC-3 check (450.00 kg/ha), while local check recorded lowest yield of 263.54.

Out of ten entries UC-345 recorded the minimum disease incidence (5 % wilt, 10 % blight and 8 % powdery mildew) with seed yield of 608 kg/ha followed by JC-95-30 (5 % wilt, 20 % blight

Table 66. Performance of CVT 2005 cumin entries at Jobner

Entries	Days to flowering	Plant height (cm)	Branches per plant	Umbels per plant	Umbellets per umbel	Seeds per umbel	Test weight (gm)	Seed Yield (kg/ha)	(%) Increase over check
UC-345	80 25	33 80	6 15	22 40	5 00	31 85	4.06	607 64	9 03
UC-346	81 00	30 70	5 90	20 30	5 05	28 10	3 64	339 58	-39 07
UC-347	81 25	31 75	5 45	18 80	4 90	26 35	4 03	510 76	-8 35
UC-348	80 75	30 30	5 75	19 80	4 90	28 75	3 64	352 43	36 76
JC-95-12	79 25	30 50	6 25	21 25	5 15	29 95	3 94	346 53	-37 82
JC-95-30	78 75	33 10	6 50	22 10	5 30	30 90	3 87	523 96	-5 98
GC-3 NC	81 25	25 83	5 20	16 65	4 70	28 20	3 29	450 00	-19 25
RZ-19 C	78 75	30 40	5 75	18 40	4.78	28 95	3 72	512 15	8 10
RZ-209 C	80 25	32 10	5 50	20 50	4 95	30 95	3 86	557 29	Check
Local C	78 25	32 70	4 80	15 55	4 65	26 10	3 74	263 54	-52 71
CD (P=0 05)	1 13	1 52	1 18	2 99	0 38	2 51	0 27	95 40	
CV (%)	0 98	3 36	14 24	10 54	5 24	5 97	4 89	14 73	

and 10 % powdery mildew) and seed yield of 524 kg/ha. Maximum disease incidence was in local check (25 % wilt, 85 % blight and 80 % powdery mildew) with seed yield of 253 kg/ha.

The experiment was vitiated at Jagudan due to cent per cent wilt incidence in all the entries

7.3 Varietal Evaluation Trial

7.3.1 Initial evaluation trial 2005

(Jobner; Jagudan)

The analysis of variance revealed significant differences among the entries for all the traits including seed yield (Table 67). The days to flowering ranged from 77 25 (UC-299) to 81 25 days (UC-334), plant height from 26.80 (UC-273) to 31.70 cm (RZ-19 check), branches per plant from 4 40 (UC-273) to 6 00 (UC-299), umbels per plant from 12 70 (UC-273) to 17 85 (UC-299), umbellets per umbel from 4 30 (UC-239) to 5 00 (UC-225), seeds per umbel from 21 60 (Local check) to 27 60 (UC-299) and test weight from 3.47 (UC-334) to 4 03 g (UC-273). The seed yield ranged from 338 19 to 692 01 kg/ha Of the ten entries evaluated, UC-299 recorded maximum seed yield of 692.01 kg/ha followed by UC-239 (654 17 kg/ha), RZ-223 check (559 38 kg/ha), RZ-19 check (541 32 kg/ha), UC-331 (507 47 kg/ha) and UC-225 (503.47 kg/ha), while UC-273 recorded lowest yield of 338 19 kg/ha.

Out of ten entries UC-225 recorded 5 % wilt, 5 17 % blight and 8 % powdery mildew with the seed yield of 503 kg/ha followed by UC-331 with 7 5 % wilt, 5 % blight and 15 % powdery mildew and seed yield of 507 kg/ha Maximum

Table 67. Yield performance of IET 2005 entries at Jobner

Entries	Days to flowering	Plant height (cm)	Branches per plant	Umbels per plant	Umbellets per umbel	Seeds per umbel	Test weight (gm)	Seed Yield (kg/ha)	Increase over check (%)
UC-225	78 50	31 65	5 00	15 10	5 00	26 70	3 89	503 47	-9 99
UC-239	80 75	30 25	5 90	17 35	4 30	25 20	3 93	654 17	16 95
UC-273	78 75	26 80	4 40	12 70	4 60	22 95	4 03	338 19	-39 54
UC-274	78 75	30 75	4 80	15 15	4 70	25 20	3 72	448 26	-19 86
UC-299	77 50	31 10	6 00	17 85	4 90	27 60	4 01	692 01	23 71
UC 331	80 50	29 60	5 10	15 45	4 35	24 15	3 74	507 64	-9 25
UC-334	81 25	31 35	4 80	15 25	4 60	25 45	3 47	499 65	-10 68
RZ-223 Ch	80 50	31.15	5 15	16 25	4 65	26 15	3 82	559 38	Best Check
RZ-19 Ch	78 75	31 70	5 60	15 35	4 75	27 05	3 79	541 32	-3 23
Local Check	78 50	30 50	4 85	12 85	4 45	21 60	3 94	346 88	-37 99
CD (P=0 05)	1 08	3 41	0 77	1 53	0 42	2 99	0 31	105 76	
CV (%)	0 94	7 70	10 22	6 88	6 30	8 19	5 58	14 32	

Table 68. Volatile oil contents of cumin entries

Entry	Seed yield (kg/ha)	Volatile oil (%)	Volatile oil yield (l/ha)
UC-345	607 64	4 78	29 00
UC-346	339 58	4 55	15 44
UC-347	510.76	5 30	27 06
UC-348	352 43	4 30	15.15
JC-95-12	346.53	4 38	15.17
JC-95-30	523 96	4.85	25 40
GC-3 NC	450 00	5.03	22.63
RZ-19 C	512 15	4 78	24 45
RZ-209 C	557 29	5 25	29 36
Local C	263 54	4.20	11.00
CD (P=0 05)	*95 40*	*0 18*	*5 01*
CV (%)	14 73	2.61	16 10

disease incidence was in local check (20 % wilt, 32.7 % blight and 50 % powdery mildew) with seed yield of 253 kg/ha.

The experiment was vitiated at Jagudan due to cent per cent wilt incidence in all the entries.

7.4 Quality evaluation trial

7.4.1 Quality evaluation in cumin

(Jobner)

The volatile oil content among ten entries ranged from 4.20% to 5.30%. The maximum volatile oil of 5 30% was observed in UC-347 followed by 5.25% in RZ-209 check, 5.03% in GC-3 check. 4.85% in JC-95-30 and 4.78% in UC-345 and minimum of 4.20% in local check (Table 68). The maximum volatile oil yield was observed in RZ-209 check (29.36 l/ha) followed by UC-345 (29.00 l/ha), UC-347 (27.06 l/ha), JC-95-30 (25.40 l/ha) and minimum in local (11.00 l/ha).

The volatile oil content of ten IET entries ranged from 4.10% to 4.58%. The maximum volatile oil of 4.58% was recorded in UC-239 and UC-299 followed by 4.53% in RZ-223 check and 4.35% in UC-231 and minimum of 4.10% in local check. Highest volatile oil yield was recorded in UC-299 (31.67 l/ha) followed by UC-239 (29.93 l/ha) and RZ-223 check (25.32 l/ha) and minimum was recorded in Local check (14.18 l/ha).

7.5 Disease Management Trial

7.5.1 Management of wilt and blight disease in cumin

(Jobner and *Jagudan)*

A field experiment with ten treatments was conducted at Jobner. Out of ten treatments minimum wilt incidence (5 %) and blight (3.33 %) was recorded in the treatment Soil solarization – soil application of *Trichoderma* + FYM (5 t/ha) + spray with Mancozeb 0.25% with maximum seed yield 485 kg/ha, followed by vermicompost (2 t/ha)+ *Trichoderma* + spray with Mancozeb 0.25% with wilt (7 %) and blight (4.67 %) and the seed yield of 449 kg/ha. The control resulted maximum disease incidence of wilt (30 %) and blight (50.15 %) and lowest seed yield of 173 kg/ha as compared to all other treatments (Table 69).

The experiment was vitiated at Jagudan due to cent per cent wilt incidence in all the treatments.

Table 69. Effect of different treatments on incidence of wilt and blight in cumin at Jobner

	Treatments	Wilt (%)	Blight (%)	Seed yield (kg/ha)
1	Soil solarization + soil application of *Trichoderma* + FYM (5 t/ha) + spray with Mancozeb 0 25% (60 DAS)	5.0	3 33	485.00
2	*Trichoderma* + FYM + spray with Mancozeb 0 25% (60 DAS)	10.0	5 00	438 33
3	Vermicompost (2 t/ha)– *Trichoderma* + spray with Mancozeb 0 25% (60 DAS)	7 0	4.67	449.33
4	Neem cake (2 t/ha) + *Trichoderma* + spray with Mancozeb 0 25% (60 DAS)	11 0	8 00	349.00
5	Soil drench with Carbendazim 0 1% + spray with Mancozeb 0 25% (60 DAS)	8.0	4.90	433.00
6	*Pseudomonas fluorescens* (IISR-6) 10^8 cfu as seed treatment and spray (60 DAS)	12 0	25.17	316 67
7	*Bacillus subtilis* as soil application and foliar spray (60 DAS)	28 0	28.90	198.00
8	*Pseudomonas fluorescens* – *Trichoderma* as soil application + Pf (IISR-6) 10^8 cfu as spray (60 DAS)	25 0	32.13	251 67
9	*Bs* + *Trichoderma* as soil application + *Pf* (IISR-6) 10^8 cfu as spray (60 DAS)	22 0	30 70	211.00
10	Control	30 0	50 15	173 33
	CD (P = 0 05)	2 05	4 13	48 21

8. FENNEL

8.1 Genetic Resources

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

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

The germplasm evaluation at Jobner revealed moderate to high variability for all the characters studied. Among 117 accessions, 13 accessions recorded better yield than the best check RF-125. The promising accessions identified on the basis of yield performance were UF-114, UF-157, UF-136, UF-177, UF-189, UF-20, UF-79, UF-138, UF-145, UF-153 and UF-187.

At Jagudan, 103 indigenous and 4 exotic entries were evaluated for different yield attributes with three checks (GF-1 GF-2 and GF-11). Eight entries had high volatile oil (≥ 1.8 %) and 11 entries identified as high yielding with more than 3200 kgha ^{1}. Sixty six entries were screened against blight disease and none of the entry was found to be free from disease incidence. The minimum incidence was noticed in JF-275, JF-566, EC-386375 and GF-1 as 20 % followed by JF-376, JF-528, JF-535-1 and JF-584 with 25% disease incidence.

At Hisar, 94 accessions were evaluated using PF-35, GF-1 and local as checks during 2005-2006. The seed yield per plot ranged from 470 g (HF-174) to 1200 g (HF-125). On the basis of umbels per plant and yield performance, 42 lines recorded higher seed yield than the highest yielding check PF-35. The promising lines were HF-107, HF-119, HF-124, HF-125, HF-128, HF-129, HF-139, HF-157, HF-159 and HF-178.

At Kumarganj, among 42 germplasm tested NDF-5 was the highest seed yielder with 1.30 t/ha followed by NDF-41 (1.16 t/ha). The fennel germplasm at different centres are given in Table 70.

Table 70. Fennel germplasm collection at AICRP centres

Center	Indigenous	Exotic	Total
Jobner	261	20	281
Jagudan	135	4	139
Hisar	122	-	122
Kumarganj	44	-	44
Dholi	31	-	31
Total	593	24	617

Table 71. Yield performance of fennel CVT entries at Jobner

Entries	Yield (kg/ha)		
	2004-05	2005-06	Mean
UF-205	1256.67	1253 33	1255 00
UF-206	933.33	1191 11	1062 22
UF-207	1076 67	1231 11	1153 89
JF-376	983 33	1022 22	1002 78
JF-421	923 33	1133 33	1028.33
JF-444-1	1053 33	1204 44	1128 89
HF-118	996.67	1026 67	1011 67
HF-125	966.67	1226 67	1096 67
NDF-5	-	911 11	911 11
NDF-6	-	986 67	986.67
NDF-12	673 33	964 44	818 89
GF-2 Check	1126 67	942 22	1034 45
RF-101 Check	980 00	1071 11	1025 56
Local Check	843 33	897.78	870 56
CD (P=0.05)	188 17	218 24	
CV (%)	11 29	12 09	

8.2 Coordinated Varietal Trial

8.2.1 CVT-2004-Series VI

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

Mean performance of the entries evaluated in CVT over 2004-05 and 2005-06 at Jobner revealed superior performance of UF-205 (1255.00 kg/ha) followed by UF-207 (1153.89 kg/ha), JF-444-1 (1128.89 kg/ha), HF-125 (1096.67 kg/ha), UF-206 (1062.22 kg/ha) and GF-2 check (1034.45 kg/ha), while lowest mean yield of 818.89 kg/ha was recorded in NDF-12 (Table 71).

Table 72. Yield performance of CVT 2004 fennel at Kumarganj

Entries	Yield (kg/ha)		
	2004-05	2005-06	Mean
GF-2 (Check)	1 08	1 42	1 25
JF-421	1 01	1.49	1 25
HF-125	1 01	1 77	1 39
JF-444	1 07	1 14	1 10
HF-118	1.18	1 73	1 45
RF-18	1 23	1 84	1 53
JF-303	1 01	1 56	1 28
UF-144	1 31	1 66	1 48
AF-119	1 12	1 49	1 30
JF-376	1 02	1 39	1 20
UF-205	1 25	1 42	1 33
UF-206	1 12	1 28	1 20
UF-207	1 04	0 94	0 99
NDF-12	1 66	1 72	1 69
NDF-6	1 78	0 83	1 30
RF-101 (Check)	1 19	1 28	1 23
CD (P=0 05)	0 11	0 72	-
CV (%)	5 55	30 90	-

At Jagudan, yield differences among the entries were found significant JF-421 significantly out yielded the check GF-11 (1340 kg/ha) by 12 89 per cent. The pooled data over two years showed significant yield differences due to treatments But none of the entry gave significantly superior yield than local check GF-11. However. maximum yield (1413 kg/ha) was recorded in JCr-421, which was 10.30 per cent higher than check GF-2.

At Kumarganj among 13 entries tested, maximum seed yield of 1.87 t/ha was obtained in FNL-20 and FNL-22 followed by 1.71 t/ha in NDF-12 Two years pooled data showed maximum seed yield of 1 69 t/ha in NDF-12 (Table 72)

8.3 Varietal Evaluation Trial

8.3.1 Initial evaluation trial

(*Jagudan. Jobner, Kumarganj* and *Hisar*)

At Jagudan the pooled data over two years showed significant yield differences due to genotypes But none of the entries recorded significantly superior yield over check. However. maximum yield was obtained in JF-501-2 (1903 kg/ha) which was 9 62 per cent higher than check GF-11 (Table 73)

Table 73. Yield performance of IET fennel entries at Jagudan

Entries	Yield (kg/ha)			Per cent
	2004-05	2005-06	Mean	increase
JF-456-2	1723	1049	1385	-
JF-472-2-3	2342	1309	1825	5 13
JF-485-1	2123	1018	1571	-
JF-494	2005	1045	1526	-
JF-501-2	2404	1403	1903	9 62
JF-514-2	2230	1198	1714	-
JF-529-1	2026	884	1455	-
JF-546	2205	1066	1635	-
JF-572	2120	934	1528	-
GF-11(Ch)	2254	1219	1736	-
SEm ±	156	108	87	
CD (P=0 05)	NS	NS	243	
CV (%)	12 52	16 81	13 47	

Twelve entries were evaluated at Jobner. The analysis of variance revealed significant differences among the entries for all the traits including seed yield The days to flowering ranged from 106 33 (RF-101 check) to 110.0 days (NS-63), plant height from 150.7 (RF-125 Check) to 147.27 cm (NS-32), branches per plant from 5 30 (Local check) to 6 80 (NS-37), umbels per plant from 6 13 (NS-45) to 16.33 (NS-63), umbellets per umbel from 16.73 (NS-3) to 24 27 (NS-32), seeds per umbel from 242 0 (NS-10) to 475 60 (NS-32) and test weight from 5.86 (RF-125 check) to 6 66 (NS-46) The seed yield ranged from 833 33 to 1907 41 kg/ha Of the twelve entries evaluated. entry NS-63 recorded maximum seed yield of 1907 41 kg/ha followed by NS-46 (1842 59 kg/ha), RF-125 check (1759 26 kg/ha). NS-41 (1555 56 kg/ha), NS-32 (1518.52 kg/ha) and NS-10 (1398.15 kg/ha), while lowest seed yield of 833.33 kg/ha was recorded in NS-11.

The trial was conducted at Kumarganj with 10 promising lines. Maximum seed yield of 1 26 t/ha was recorded in NDF -5 followed by 1 12 t/ha in NDF-12 The seed yield of NDF-6 and NDF-33 was at par with NDF-12

The trial was conducted with ten accessions with GF-2 as check during 2004-2005 and 2005-2006 at Hisar The results indicated significantly superior yield in HF-131 and HF-143 over check showing 24 3 and 24 5 per cent increase in yield, respectively.

Table 74. Mean volatile oil content in fennel

Entries	Mean seed yield (kg/ha)	Volatile oil (%)			Mean volatile oil yield (l/ha)
		2004-05	2005-06	Mean	
UF-205	1255 00	3.0	2 43	2 72	34 14
UF-206	1062 22	2 53	2 37	2 45	26 02
UF-207	1153 89	2 80	2.60	2 70	31 16
JF-376	1002 78	2 47	2.23	2 35	23 57
JF-421	1028 33	2.07	2.30	2 19	22 52
JF-444-1	1128.89	2 53	2 23	2 38	26 87
HF-118	1011.67	2.53	2 27	2.40	24.28
HF-125	1096 67	2.47	2 27	2 37	25 99
NDF-5	911 11	-	2 30	2 30	20 96
NDF-6	986 67	-	2 27	2 27	22 39
NDF-12	818 89	2 73	2 37	2.55	20 88
GF-2 Check	1034.45	2.33	2.23	2 28	23.59
RF-101 Check	1025 56	2 53	2.37	2 45	25.13
Local Check	870.56	2 67	2.17	2 42	21.07

8.4 Quality Evaluation Trial

8.4.1 Quality evaluation in fennel

(Jobner)

The volatile oil content of CVT entries ranged from 2.17% to 2.60%. The maximum volatile oil of 2.60% was observed in UF-207 followed by 2.43% in UF-205; 2.37% in NDF-12, UF-206 and RF-101 check, and minimum of 2.17% in local check. Highest volatile oil yield was recorded in UF-207 (32.01 l/ha) followed by UF-205 (30.51 l/ha), UF-206 (28.18 l/ha) and HF-125 (27.90 l/ha) and minimum was recorded in local check (19.45 l/ha). On the basis of two years data (2004-05 and 2005-06), the highest mean volatile oil content of 2.72% was recorded in UF-205 followed by 2.55% in NDF-12, 2.45% in UF-206 and RF-101 (check) and 2.42% in local check, whereas minimum 2.19% was recorded in JF-421 (Table 74). The maximum mean volatile oil yield was observed in UF-205 (34.14 l/ha) followed by UF-207 (31.16 l/ha), JF-444-1 (26.87 l/ha), UF-206 (26 02 l/ha) and minimum in local check (20.88 l/ha).

The volatile oil content among 12 IET entries ranged from 2.17% to 2.80%. The maximum volatile oil of 2 80% was recorded in NS-46 and NS-63 followed by 2.77% in NS-41 and RF-125 (check). 2.73% in NS-45 and 2.70% in RF-101 (check) whereas minimum of 2 17% in local check The entries NS-63, NS-46, RF-125 (check) and RF-101 (check) have shown better performance as compared to local check with respect to volatile oil yield in terms of litre per hectare.

8.5 Nutrient Management Trial

8.5.1 Effect of biofertilizer, *Azospirillum* on fennel

(Kumarganj)

Experiment was conducted during 2006-07 with the variety NDF-6. The results revealed application of FYM @ 10 t/ha + 1.5 kg/ha of *Azospirillum* as seed treatment (T_6) produced maximum seed yield (0 91 t/ha) followed by application of 5 t/ha of FYM (T_5) (0.74 t/ha). The treatment, inorganic nitrogen 100 % + 1.5 kg/ha *Azospirillum* as seed treatment + 5 t/ha of FYM (T_1) was at par with T_5. Similar observation was recorded in three years pooled data. The maximum seed yield (1.05 t/ha) was recorded in T_6 followed by 0.92 t/ha in T_5 (Table 75).

8.5.2 Identification of drought/ alkalinity tolerant source in fennel

(Kumarganj)

During 2006-07, ten genotypes were tested with four levels of ESP and found that the highest yield of 50.75 and 48.48 g/plant was recorded under 10 and 20 ESP levels. On the basis of pooled mean of three years data indicated that

Table 75. Effect of NPK, FYM and *Azospirillum* on yield of fennel

Treatments		Yield (t/ha)			
		2004-05	2005-06	2006-07	Mean
T_1	Inorganic nitrogen (100 %) + *Azospirillum* + 5 t/ ha FYM	1 04	0 69	0 73	0.82
T_2	Inorganic nitrogen (75 %) + *Azospirillum* + 5 t/ha FYM	1.18	0.62	0.69	0 83
T_3	Inorganic nitrogen (50 %) · *Azospirillum* + 5 t/ha FYM	1.13	0.72	0 67	0.84
T_4	FYM 5t/ha + *Azospirillum*	1.07	0 72	0 73	0.84
T_5	FYM 5t/ha	1 29	0 74	0 74	0 92
T_6	FYM 10 t/ha + *Azospirillum*	1 36	0 90	0.91	1 05
T_7	FYM 10t/ ha	1 23	0 72	0.74	0 89
T_8	100% Inorganic nitrogen	0 97	0 54	0.63	0 71
T_9	*Azospirillum* 1 5 kg/ ha	0 90	0.69	0.67	0 75
T_0	Control	0.80	0.64	0 57	0 67
CD (P=0.05)		0.14	0 32	0.19	-
CV (%)		8 19	26.81	13.70	-

increasing in ESP levels decrease the yield of fennel. The maximum yield per plant (51.69 g/ plant) was obtained at 10 ESP level with the genotype NDF-6 and it also gave highest value (49.38 g/plant) at 20 ESP level. The next best genotype was NDF-5 with the yield of 51.02 g and 47.27 g/plant at 10 and 20 ESP levels, respectively.

9. FENUGREEK

9.1 Genetic Resources

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

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

The germplasm evaluation at Jobner revealed the variability for all the characters studied. Out of 270 accessions, 29 accessions recorded better yield than best check RMt-303. The promising accessions identified on the basis of yield were UM-152, UM-202, UM-134, UM-187, UM-163, UM-353, UM-62, UM-133, UM-192, UM-196, UM-84, UM-174, UM-176, UM-49, UM-194, UM-70, UM-224, UM-262, UM-173 and UM-354.

The eight accessions were collected from Udaipur (Rajasthan) by Jagudan centre. The 66 entries including GM-1 and Methi local as checks were evaluated for different characters. Seven entries were found promising for yield with more than 2075 kg/ha. Fifty one entries screened against powdery mildew disease under natural condition revealed the disease incidence range of 37.50% to 100.00%. None of the entry was found to be free from powdery mildew. The minimum incidence was noticed in JFg-244 (37.50%) followed by JFg-213 and Sel.ACC-181-2 with 50 per cent incidence. All other entries showed susceptible to highly susceptible reaction.

Among germplasm entires evaluated at Dholi, maximum yield was recorded in RM-187 and RM-70 (0.95 kg/4.5 m^2) followed by RM-188, RM-190 and RM-15 (0.90 kg/4.5 m^2). The yield among promising accessions varied from 0.95 kg/4.5 m^2 (RM-187 and RM-70) to 0.80 kg/4.5 m^2 (RM-186, RM-191, RM-33, RM-27 and RM-18).

At Hisar, 79 accessions were evaluated using local, Pusa Early Bunching and Hisar Sonali as checks. The seed yield ranged from 1050 kg/ha (GC-106 and GC-107) to 2400 kg/ha (GC-6). Forty lines recorded higher seed yield than Pusa Early Bunching and eighteen out yielded Hisar Sonali. The promising lines identified were GC-6, GC-14, GC-20, GC-71, GC-81, GC-84, GC-129, GC-130, GC-131, GC-135 and GC-172. In other trial, 55 accessions of germplasm along with five checks were evaluated. The mean seed yield of desi methi ranged from 784 kg/ha (IC-143817 and IC-398080) to 2016 kg/ha (Hisar Sonali) and yield in Kasuri methi ranged from 476 kg/ha (IC-371770) to 336 kg/ha of Kasuri check.

Among the 55 accessions evaluated at Guntur, LFC – 85 recorded highest yield of 2342 kg/ha followed by LFC-73, LFC-75, LFC-98 and LFC-92 with 2155, 2113, 1917 and 1909 kg/ha respectively. The check Lam Selection I recorded an yield of 1317 kg/ha.

Out of 76 germplasm evaluated at Kumarganj, NDM-19 produced maximum seed yield of 2.31 t/ha. The seed yield of NDM-61 was at par with NDM-19, followed by 2.10 t/ha of seed yield in NDM-20. Among NBPGR germplasm accessions, maximum yield of 1.58 t/ha was observed in IC-144260 followed by IC-336796 (1.51t/ha). The fenugreek germplasm at different centres are given in Table 76.

Table 76. Fenugreek germplasm collections under AICRP centres

Center	Indigenous	Exotic	Total
Jobner	353	12	365
Jagudan	64	-	64
Hisar	240	-	240
Kumarganj	77	-	77
Dholi	106	-	106
Guntur	125	-	125
Total	**965**	**12**	**967**

Table 77. Yield performance of fenugreek CVT -2001 entries at Jagudan

Entries	Yield (kg/ha)					Increase over check (%)	
	2002-03	2003-04	2004-05	2005-06	Mean	GM-1	His. Son.
JFg-244	2049	1906	2079	1971	2001	11 29	18.89
JFg-270	1838	2029	2000	1704	1893	5 28	12 48
UM-351	1821	1575	1772	1673	1711	-	1.66
UM-352	1809	1674	1630	1750	1716	-	1.90
HM-65	1361	1734	1566	1526	1547	-	-
HM-372	1544	1729	1815	1765	1714	-	1 78
HM-376	1880	1947	2059	1726	1903	5 84	13 07
HM-444	1931	1900	1797	1787	1854	3.11	10.10
NDM-19	1657	1677	1786	1633	1689	-	0 30
NDM-25	1549	1682	1675	1549	1639	-	-
Hisar Sonali *	-	-	1748	1617	1683	-	-
GM-1©	1842	1760	1846	1748	1798	-	6 83
SEm ±	71	80	102	61	42		
CD (P=0 05)	205	231	295	174	116		
CV (%)	8 08	8 98	11 22	7 15	9 06		

9.2 Coordinated Varietal Trial

9.2.1 CVT 2001 – Series V (final report)

(Jagudan)

The mean data of four years (2002-03 to 2005-06) on yield and yield attributing characters is presented in Table 77. Moderate to high variability was recorded for all the characters *viz.*, days to 50 per cent flowering ranged from 52 (GM-1) to 59 days (HM-65 and HM-372). days to maturity from 115 (Hisar Sonali) to 120 (HM-65), plant height from 58.4 (Hisar Sonali) to 65.9 cm (Jg-244), branches per plant from 5.0 (Hisar Sonali) to 6.0 (HM-65), pods per plant from 32.8 (Hisar Sonali) to 62.9 (HM-372), length of pod (cm) from 9.7 (UM-352) to 11.7 (Hisar Sonali), seeds per pod from 16.2 (HM-372) to 17.5 (JFg-244 and HM-65) and test weight from 11.57 (Hisar Sonali) to 16.49 g (JFg-244). The pooled data over four years showed significant yield differences due to entries. JFg-244 recorded significantly superior yield (2001 kg/ha) than check GM-1, it was 11.29 and 12.16 per cent higher than the checks GM-1 and Hisar Sonali, respectively.

9.2.2 CVT-2005 Series VI

(Jobner, Jagudan and Hisar)

Twenty entries were evaluated at Jobner. the analysis of variance revealed significant differences among the entries for all the traits including seed yield. The days to flowering ranged from 58.0 (J.Fg-239) to 68.00 days (Local check). plant height from 45.60 (LFC-87) to 72.13 cm (J.Fg-273), branches per plant from 4.20 (Local check) to 6.13 (UM-361), pods per plant from 32.07 (NDM-20) to 46.73 (UM-361), pod length from 9.0 (J.Fg.-273) to 11.77 cm (NDM-25), seeds per pod from 14.80 (NDM-19) to 17.07 (J.Fg.-273) and test weight from 7.60 (Local check) to 10.74 g (UM-362). The seed yield ranged from 787.04 to 1490.74 kg/ha. Of the twenty entries evaluated, entry UM-361 recorded maximum seed yield of 1490.74 kg/ha followed by NDM-25 (1379.63 kg/ha), HM-232 (1337.96 kg/ha), RMt-303 check (11305.66 kg/ha), UM-362 (1300.93 kg/ha), HM-219 (1287.04 kg/ha), RM-70 (1240.74 kg/ha) and NDM-19 (1222.22 kg/ha), while lowest yield of 787.04 kg/ha was recorded in local check (Table 78).

Among the CVT entries evaluated at Jagudan none of the entries recorded significantly superior yield than the local check GM-1 and national check Hisar Sonali. However, HM-219. HM-232 and JFg-239 recorded hiher yield (1833, 1805 and 1770 kg/ha, respectively) of 22.69, 20.82 and 18.47 per cent than GM-1, respectively.

At Hisar. the significant differences were obtained for all the parameters among CVT entries. Plant height ranged from 80.3 to 92.6, number of branches 4.8 to 6.6. pods per plant 43 0 to 60.8, length of pods 10 4 to 11.9 and seeds per pod 14.2 to 16.7. Maximum seed yield (1925 kg/ha) was recorded in HM-232 followed by RM-18 (1860 kg/ha) and JFg -273 (1855 kg/ha)

Table 78. Performance of CVT 2005 fenugreek entries at Jobner

Entries	Days to flowering	Plant height (cm)	Branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	Test wt. (gm)	Seed yield (kg/ha)	Increase (%) over check
UM-361	59 33	63 47	6.13	46 73	10.87	15 67	10 40	1490.74	14.18
UM-362	61 00	59 00	5 60	42.20	9.43	15.47	10 74	1300 93	-0 35
UM-363	61.33	57.47	5.93	45 47	10.23	15 73	10.46	1247 69	-4.43
J Fg.- 239	58 00	65 13	5 47	41 07	9 30	16 00	10.46	824.07	-36.88
J. Fg - 273	61 00	72 13	5 73	42.93	9.00	17.07	9 50	962.96	-26 24
HM-219	59.33	57 13	6.07	32 33	9 53	16.87	9 20	1287 04	-1.42
HM-232	61 67	63.40	5.80	40 93	9 60	16 07	9.95	1337.96	2 48
HM-292	61.67	55 80	5.53	35.87	10.30	15 40	9 37	819.44	-37.23
LFC-84	61.67	59.33	5 73	34.60	11.13	17.00	10 44	861 11	-34 04
LFC-87	62.00	45 60	5 53	34 13	9 63	14 93	9 82	791.67	-39.36
NDM-19	60.00	61.27	5.67	38 87	11 20	14 80	9.78	1222.22	-6.38
NDM-20	62.00	56 60	5 47	32.07	9 97	15.20	9 53	1027.78	-21 28
NDM-25	58.67	62 73	5 80	45 40	11.77	16 13	10 28	1379.63	5.67
RM-18	61 67	64.40	5.40	34 40	10 27	15.07	8 91	1055.56	-19.15
RM-28	62 00	58 53	5.80	36.53	9.67	16.33	9 11	1101 85	-15.60
RM-70	59.67	60 93	6 07	37.07	9.57	15.93	9 06	1240.74	-4 96
Hisar Sonali	60 67	56 93	5.47	33.93	9 67	15 73	9.20	993 06	-23.94
RMt-1 C	60 67	60 67	5.27	38 20	10.47	15 47	9.547	1138.89	-12 77
RMt-303 C	60 67	63 20	6.00	44 60	11 13	16 97	10.52	1305.56	Best check
Local check	68.00	57.73	4.20	32.67	9.93	15.33	7.60	787.04	-39.72
CD (P=0.05)	2 25	7 04	0.53	7.4	0.79	1 02	0 88	270.92	
CV (%)	2.22	7 09	5 69	11.6	4.69	3.88	5 52	14 78	

9.2.3 CVT 2006

(*Kumarganj, Dholi* and *Guntur*)

During 2006-07, eighteen genotypes were tested in Guntur. Among the entries Code No. 6 (1305 kg/ha), Code No. 9 (1303 kg/ha), Code No. 10 (1301 kg/ha), Code No. 11 (1301 kg/ha) and Code No.5 (1295 kg/ha) recorded significantly higher yield (Table 79) than the check LS-1 (1085 kg/ha).

Evaluation results at Dholi centre revealed that all the entries were found to be non significant regarding plant height and number of branches per plant. None of the entry was found significantly superior over local check Rajendra Kanti regarding number of pods per plant, number of grains per pod, pod length, yield per plot and yield (t/ha). However, maximum yield was recorded in FGK-12, FGK-13, FGK-15 (1.30, 1.25 and 1.20 t/ha respectively) which was 12.07 7.76 and 3.45 percent higher yield compared to Rajendra Kanti.

At Kumarganj. maximum seed yield of 1.76 t/ha was obtained in FGK-12 followed by FGK-14 with 1.41 t/ha.

9.3 Varietal Evaluation Trial

9.3.1 Initial evaluation trial

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

Twelve entries were evaluated at Jobner and the analysis of variance revealed significant differences among the entries for all the traits including seed yield. The days to flowering ranged from 106.33 (RF-101 check) to 110.0 days (NS-63), plant height from 150.7 (RF-125 Check) to 147.27 cm (NS-32), branches per plant from 5.30 (Local check) to 6.80 (NS-37), umbels per plant from 6.13 (NS-45) to 16.33 (NS-63), umbellets per umbel from 16.73 (NS-3) to 24.27 (NS-32), seeds per umbel from 242.0 (NS-10) to 475.60 (NS-32) and test weight from 5.86 (RF-125 check) to 6.66 (NS-46). The seed yield ranged from 833.33 to 1907.41 kg/ha. Of the twelve entries evaluated, entry NS-63 recorded maximum seed yield of 1907.41 kg/ha followed by NS-46 (1842 59 kg/ha), RF-125 check (1759.26 kg/ha), NS-41 (1555.56 kg/ha), NS-32 (1518.52 kg/ha) and NS-10 (1398.15 kg/ha), while lowest seed yield of 833.33 kg/ha was recorded in NS-11

Table 79. Yield performance of CVT-2006 fenugreek entries at Guntur

Entries	Yield (kg/ha)	Increase over check (%)
Code No 1	622	-42 6
Code No.2	701	-35 3
Code No.3	973	-10 3
Code No.4	916	-15 6
Code No.5	1295	19.4
Code No.6	1305	20.3
Code No.7	772	-28 8
Code No.8	944	-13 0
Code No 9	1303	20 2
Code No 10	1301	19 9
Code No 11	1301	20 0
Code No 12	1092	0 6
Code No 13	617	-43.1
Code No.14	1161	7.0
Code No 15	1023	-5 7
JF-244	811	-25 2
PEB	969	-10 6
LSI	1085	-
CD (P=0.05)	198.9	
CV (%)	12 30	

The results at Jagudan revealed non-significant yield differences among the entries. However, JFg-178, JFg-220 and JFg-252 recorded higher yield (2681, 2572 and 2565 kg/ha) than the check GM-1, which was 32.46, 27.08 and 26.73 per cent higher than GM-1, respectively.

At Hisar, the trial was conducted with ten accessions along with Hisar Sonali as check. The maximum seed yield was recorded in HM-348 (2675 kg/ha) followed by HM-355 showing an increase of 25.5 and 17.9 per cent respectively.

During 2006-07 at Guntur, among the twelve entries tested LFC-103 recorded significantly highest yield of 1692 kg/ha followed by LFC - 105 with 1691 kg/ha than check Lam Selection-1(1387 kg/ha).

Out of ten promising lines tested at Kumarganj, NDM-25 produced the maximum seed yield of 2.44 t/ha followed by 2.25 t/ha in NDM-19.

9.4 Nutrient Management Trail

9.4.1 Effect of biofertilizers using *Azospirillum* on fenugreek (final report)

Coimbatore

To find out the efficacy of *Azospirillum* and graded levels of nitrogen on growth and yield parameters of fenugreek this project was started during 2000 and it is in 4th year of progress. The objective of this project are i) to study the effect of *Azospirillum* and graded levels of N on growth and yield of fenugreek. ii) evolving integrated nutrient management strategy for the optimum yield. The trail was laid out with the following treatments in Randomized block design with three replications. The treatments were imposed on the variety Co 2.

The pooled analysis over three year data (Table 80) revealed that the yield varied from 275 kg/ha to 690 kg/ha. The highest seed yield of 690 kg/ha was recorded by the application of FYM (5 t/ha) + Inorganic nitrogen (100%) – *Azospirillum* (1.5 kg/ha) as seed treatment (T_1) followed by (T_2) N (75%) + *Azospirillum* 1.5 kg/ha seed treatment + FYM 5 t/ha (627.33 kg/ha). Regarding the benefit cost ratio, it was found to be higher for the treatment T_1 and T_2 (2.23 and 2.04 respectively). Regarding the quality parameter the alkaloid content varied from 0.50 to 0.52 percent among the treatments. Hence for fenugreek the application of FYM (5 t/ha) – Inorganic nitrogen (100 %) and *Azospirillum* (1.5 kg/ha) was highly suitable among the different treatments imposed for getting a higher seed yield.

Treatment details for nutrient management trial at Coimbatore

T_1	Inorganic N (100%) + *Azospirillum* (1.5 kg seed treatment) + 5 t/ha FYM
T_2	Inorganic N (75%) + *Azospirillum* (1.5 kg seed treatment) + 5 t/ha FYM
T_3	Inorganic N (50%) + *Azospirillum* (1.5 kg seed treatment) + 5 t/ha FYM
T_4	FYM (5 t/ha) + *Azospirillum* (1.5 kg seed treatment)
T_5	FYM (5 t/ha)
T_6	FYM (10 t/ha) – *Azospirillum* (1 5 kg seed treatment)
T_7	FYM (10 t/ha)
T_8	*Azospirillum* (1.5 kg seed treatment)
T_9	Urea (100%)
T_{10}	Control

Table 80. Effect of *Azospirillum* and different levels of nitrogen on growth and yield of fenugreek cv. CO 2 at Coimbatore

Treat ments	Plant height (cm)	Pods/ plant	Yield / ha (kg)	Diosgenin (%)	Benefit Cost ratio
T_1	56.39	33.46	690.0	0 51	2.23
T_2	53 21	30.29	627.33	0.52	2 04
T_3	47.64	30.33	537 76	0.51	1 81
T_4	46 01	23 79	352 66	0 50	0 62
T_5	40.52	24 58	294 96	0 51	0 53
T_6	46 68	24 76	383 30	0 51	0 59
T_7	44 60	26.94	305 30	0 52	0 50
T_8	41 00	20 02	275 00	0 52	0 42
T_9	42 29	21 45	299.33	0 51	0 43
T_0	53.56	30 70	490.66	0 52	0 94
SEd	3.315	1.78	24.49		
CD (P=0 05)	6 96	3 74	51 46		

Kumarganj

Application of 10 t/ha of FYM produced maximum seed yield of 0.96 t/ha during 2006-07. Three years pooled data showed highest yield of 1.19 t/ha by application of 10 t/ha FYM and seed treatment of *Azospirılum* @ 1.5 kg/ha (Table 81).

9.4.2 Identification of source of drought tolerance in fenugreek

(*Guntur*)

Among the germplasm lines, biomass varied from 12.0 (LFC-101) to 66.0 (LFC-102 and LFC-84) g/five plants (Table 82). The root length of the germplasm lines varied from 8.0 cm (LFC-101) to 16.4 cm (LFC-91). Variation in shoot length was 40.0 cm (LFC-116) to 58.0 cm (LFC-82). The root-shoot ratio of the germplasm lines varied from 0.17 (LFC-73) to 0.36 (LFC-91)

9.4.3 Effect of bio-regulators on fenugreek

(*Jobner, Coimbatore* and *Dholi*)

At Jobner, the experiment consisting of thirteen treatmental combinations comprising 4 bio-regulators *viz.*, triacontanol 0.5 ml/l, triacontanol 1.0 ml/l. NAA 50 ppm and water spray; and 3 levels of spray *viz.*, one (40 days after sowing - DAS), two (40 and 60 DAS) and three (40, 60 and 80 DAS) along with one absolute control. Application of NAA 50 ppm resulted in significantly higher seed yield of fenugreek but it was at par with Triacontanol 1.0 ml/l. Triacontanol 1.0 ml/l was also significantly superior over Triacontanol 0.5 ml/l and water spray. Data further indicated that with the increase in number of sprays, the seed yield also showed increasing trend but the significant response was observed only up to 2 sprays i.e. at 40 and 60 DAS. Significantly lower seed yield of fenugreek was recorded in the absolute control as compared to the mean of all other treatments (Table 83).

At Dholi, among the four factors of bio-regulators *viz.* Triacontanol @ 0.05 ml/l, NAA @ 50 ppm GA @ 50 ppm and water spray, all the treatments had significant effect on yield and yield attributing characters except pod length. Spraying of Triacontanol @ 0.5 ml/l had significantly increased the plant height (69.69 cm), number of pods per plant (58.51), number of grains per pod (17.38) and yield (1.61 t/ha) compared to water spray. However, spraying of Triacontanol @ 0 5

Table 81. Effect of NPK, FYM and *Azospirillum* on yield of fenugreek at Kumarganj

Treatments		Yield (t/ha)			
		2004-05	2005-06	2006-07	Mean
T_1	Inorganic nitrogen (100%) + *Azospirıllum* + 5 t/ha FYM	1 59	0.90	0.90	1.13
T_2	Inorganic nitrogen (75%) + *Azospirıllum* + 5 t/ha FYM	1.84	0 85	0 86	1 18
T_3	Inorganic Nitrogen (50%) + *Azospirıllum* + 5 t/ha FYM	1.59	0 83	0 89	1.10
T_4	FYM 5 t/ha + *Azospirıllum*	1 76	0.85	0.93	1.18
T_5	FYM 5 t/ha	1 53	0 69	0 82	1 01
T_6	FYM 10 t/ha + *Azospirillum*	2.10	1 07	0 96	1 37
T_7	FYM 10 t/ha	1 87	0.89	0 82	1.19
T_8	100% Inorganic nitrogen	1 53	0 88	0 75	1.05
T_9	*Azospirıllum* (1 5 kg/ha)	1 63	0 87	0 77	1 09
T_0	Control	1 43	0 67	0 72	0.94
SEm ±		-	0.13	0 06	-
CD (P=0 05)		6 22	0 39	0 23	-
CV (%)		8 44	26 54	13 74	-

Table 82. Screening fenugreek genotypes for drought tolerance

Parameter	Range	Germplasm lines	
		Low	High
Biomass (g/5 plants)	12-66	LFC-101 (12 0), LFC-89 (16.0)	LFC-102 (66 0), LFC-84 (66 0)
Root length	8-16 4	LFC-101 (8 0), LFC-88 (8.4)	LFC-91 (16 4), LFC-125 (15 5)
Shoot length	40.4-58	LFC-116 (40 4), LFC-122 (43 2)	LFC-82 (58 0), LFC-110 (57 0)
Root-Shoot Ratio	0 17-0.36	LFC-73 (0 17), LFC-109 (0 17)	LFC-91 (0 36), LFC-125 (0 31)

ml recorded maximum plant height (69.69 cm), branches per plant (7.38), pods per plant (58.51), grains per pod (17.38) and yield (1.61 t/ha) followed by NAA @ 50 ppm. Among number of sprays, one spray (25 DAS), two sprays (25 and 45 DAS) and three sprays (25, 45 and 70 DAS) had significant effect on plant height, number of branches per plant, number of pods per plant, number of grains per pod and yield (t/ha). Only length of the pod was found to be non significant. However, three sprays (25,45 and 70 DAS) recorded the maximum plant height (66.42 cm), number of branches per plant (6.86), number of pods per plant (55.53), number of grains per pod (16.90) and yield (1.47 t/ha) followed by two sprays (25 and 45 DAS). Interaction was found to be non significant for yield and yield attributing characters. However, three sprays (25, 45 and 70 DAS) of Triacontanol @ 0.5 ml recorded the maximum plant height (74.60 cm), number of branches per plant (7.87), number of pods per plant (67.33), number of grains per pod (18.07) and yield (1.76 t/ha) followed by two sprays (25 and 45 DAS) of Triacontanol @ 0.5 ml.

Table 83. Effect of bio-regulators on fenugreek seed yield at Jobner

Treatments	Seed yield (kg/ha)
Bio-regulators	
Triacontanol @ 0 5ml/litre	1251
Triacontanol @ 1 0 ml/litre	1331
NAA @ 50 ppm	1360
Water spray	1051
CD (p = 0.05)	82
Sprays	
One (40 DAS)	1150
Two (40 & 60 DAS)	1266
Three (40, 60 & 80 DAS)	1330
CD (p = 0 05)	71
Control v/s Rest	
Control	1043
Rest	1248
CD (P = 0 05)	101

Study on the effect of bio regulators was conducted during 2006-07 at Coimbatore. The maximum grain yield of 625.5 kg/ha was obtained in spraying of Triacontanol 0.5 ml at 40 days of sowing.

10. PAPRIKA

10.1 Genetic Resources

10.1.1 Germplasm collection, characterization, evaluation and conservation of paprika

(Coimbatore, Guntur and Yercaud)

Twenty two accessions obtained from IISR, Calicut was evaluated during 2006-07 and among the accessions Acc. 8, 12 and 2 recorded the highest fresh fruit yield of 687.5, 637.5 and 607.5 g/plant, respectively

ICAR- Adhoc Projects

I

1. **Project title** : Strengthening the cause of geographical indication appellation of major spices using molecular and quality profiling techniques

2. **Investigators** : B. Sasikumar

   T. John Zachariah

3. **Location** : Indian Institute of Spices Research, Calicut

4. **Duration** : 1-11-2004 to 31-10-2007

5. **Total cost of the scheme** : Rs. 23.524 lakhs

6. **Progress of the work (2006-07)**

Analysis of the Cardamom essential oil

A comparative study of the oil profile of the export grade cardamoms from India, Guatemala and Sri Lanka was done. The essential oil yield of Indian, Guatemalan, Sri Lankan cardamom was found to be 10%, 5% and 14%. respectively. GCMS profile of the oil is given in Table 84.

GC/MS profiling has shown a total of 33 compounds in Indian, 26 in Guatemalan and 35 in Sri Lankan cardamoms, and 22 of them are common for all three produces. The quantitative result of Indian cardamom indicates the high yield of 1, 8-cineole (27.59%) and α -terpinyl acetate (41.65%) compared to the other produces. GC profiling of oil indicates that Indian produce is rich in 1, 8-cineole and á -terpinyl acetate.

Standardized the protocol for the isolation of genomic DNA from dried berries of black pepper.

A modified CTAB method was standardized to isolate genomic DNA from the powdered berries of export grade black pepper from India, Vietnam Malaysia and Indonesia

GC analysis of essential oil of black pepper from India, Indonesia, Malaysia and Vietnam were completed.

GC profile of the essential oil of export grade black pepper from India, Vietnam, Indonesia and Malaysia revealed a total of 8 compounds (Table 85).

Technology/protocol/prototype/model/: process/ product(s) developed

An efficient protocol for the isolation of high molecular weight DNA from powdered berries of traded black pepper.

Table 84. Composition of essential oils of Indian, Guatemalan and Sri Lankan cardamoms

Peak no	Compound	RT	Indian	Guatemalan	Sri Lankan
1	α-phellandrene	4.22	0.37	-	0.33
2	α-pinene	4.36	2.37	2.30	2.50
3	Sabinene	5.23	4.93	4.61	4.32
4	Myrcene	5.64	2.62	2.56	2.34
6	Octanal	5.95	0.14	0.14	0.17
7	α-terpinene	6.32	0.28	0.24	0.22
8	**1,8 cinede**	6.86	**27.59**	**26.99**	**26.85**
9	Trans β-ocimene	7.25	0.09	0.17	0.19
10	γ-terpinene	7.56	0.62	0.51	0.19
11	Cis sabinene hydrate	7.82	0.29	0.10	0.18
12	Tri cyclo heptane	8.00	-	-	0.17
13	α-terpinolene	8.46	0.36	0.49	0.37
14	Linalool	8.87	1.23	6.99	5.44
15	4,8,dimethyl-1,3,7-nona triene	9.44	0.20	-	0.15
16	2-cyclohexen-1-ol	9.59	0.20	0.20	0.19
17	δ-terpineol	11.27	0.13	0.19	0.17
18	Terpineol-4	11.67	2.78	2.98	2.70
19	β-fenchyl alcohol	12.21	2.97	6.61	4.23
20	Octyl acetate	13.15	-	-	0.11
21	Z-citral	14.19	0.36	-	-
22	Neral	14.25	-	0.33	0.36
23	Nerol	14.84	2.56	-	-
24	β-ocimene	14.90	-	4.44	-
25	Linalyl acetate	14.94	-	-	5.60
26	Geranial	15.46	0.56	0.51	0.69
27	Delta-terpinyl acetate	17.31	0.44	0.25	0.36
28	2,6,-octadienoicacid	17.61	0.37	-	0.28
29	**α-terpinyl acetate**	18.89	**41.65**	**35.18**	**35.27**
30	Neryl acetate	19.31	-	0.30	0.45
31	2-decenoicacid	19.54	0.17	-	-
32	Methyl cinnamate	19.87	0.14	-	-
33	Geranyl acetate	20.10	0.86	1.50	1.42
34	Trans –β caryophyllene	21.29	-	-	0.13
35	Camphene	22.05	0.30	0.23	0.17
36	β-selinene	23.90	1.55	0.30	1.29
37	α selinene	24.26	0.51	-	0.37
38	α-amorphene	25.02	0.32	-	0.27
39	Germacrene	26.58	0.14	-	0.12
40	Nerolidol	27.08	1.78	1.88	1.97

Table 85. GC profile of volatile oil of black pepper

Constituent Area(%)	TGEB	MG	Mala bar	Viet nam-1	Viet nam-2	Indo nesia-1	Indo nesia-2	Malay sia-1	Malay sia-2	Pan niyur	Kari munda	Wya nad
Pinene	6.79	6.72	8.64	5.67	6.55	7.82	6.53	6.12	7.30	10.91	16.50	12.48
Sabinene	24.90	21.93	21.30	12.74	13.92	20.05	17.76	13.18	0.20	28.75	13.95	22.43
Myrcene	15.80	17.94	17.64	24.75	24.34	17.58	15.71	31.01	15.70	6.10	24.94	12.63
Limonene	21.40	18.79	19.05	18.40	17.78	15.89	13.22	20.35	24.67	20.47	25.00	27.74
Linalool	0.29	0.95	1.19	1.54	1.27	1.04	0.85	1.19	-	0.81	-	-
Terpene-4-ol	1.02	1.32	2.25	-	-	0.92	0.83	-	0.41	1.00	-	0.64
α-terpenene	0.18	0.19	0.28	-	-	-	-	-	0.18	0.07	-	-
β-caryophyllene	11.52	12.06	10.48	27.46	23.10	19.08	20.90	16.35	20.28	14.29	12.39	10.41

II 1. **Project title** : Cloning of *Phytophthora* resistance and defense genes from *Piper colubrinum*

2. **Investigator(s)** : K. Johnson George
M. Anandaraj

3. **Location** : Indian Institute of Spices Research, Calicut

4. **Duration** : Nov.2004 to Nov. 2007

5. **Total cost of the scheme** : Rs. 16,53,000

6. **Progress of the work**

7. **Technology/protocol/prototype/model/: process/product(s) developed** Nil

RACE (Rapid Amplification of cDNA Ends) and chromosome walking for identification of 5' end of the *Phytophthora* resistance gene

RACE (Rapid Amplification of cDNA Ends) allows the isolation and characterisation of the extreme 5' end of the transcript. The method is used to extend partial cDNA clones by amplifying the 5' sequences of the corresponding mRNAs. The technique requires knowledge of only a small region of sequence within the partial cDNA clone. The primer designed based on the nucleotide composition of the partially sequenced *Phytophthora* resistance gene was used in the reaction. The product from the RACE reaction was cloned and revealed that it is derived from the result of priming of the designed primer alone. The experiments are being repeated. As an alternate approach, primers were designed for gene walking using DNA. Fragments of different sizes were found in the amplification reactions and are being cloned and sequenced.

Primer designing and chitinase gene amplification

Chitinase sequences (both protein and nucleic acid) were obtained from SWISS-PROT and TrEMBL (Protein knowledge base) in ExPASy (Expert Protein Analysis System) Molecular Biology Server. Barley chitinase structure was taken as a model to design primers. Sequence homologues was obtained by FASTA search in PDB. The chitinase sequences were subjected to Basic Local Alignment Search Tool-(BLAST) heuristic search algorithm to search the sequence databases at NCBI to get the sequence alignments with E-values to identify those sequences that shared the highest percent identity with the query sequence. Then the chitinase sequences were submitted for multiple alignment program provided by different online softwares CLUSTAL-W by Genebee software. The conserved amino acid sequences was used to design degenerate primers using primer Premier 5 software. A total of 12 primers were designed based on conserved sequence motiffs of chitinase gene. RT-PCR was done employing the designed primers to amplify the chitinase specific cDNA fragment. A cDNA product of 313 bp was obtained (Fig.1). These cDNA fragments were eluted from the gel and reamplified using the respective primers. These cDNA fragments were cloned into pTZ5R/T vector (Fermentas) and transformed into TOP10F' cells. The recombinant plamids were purified and the presence of clones were confirmed by PCR using the respective primers. Sequencing of the clone was done using ABI prism technology (Table 86).

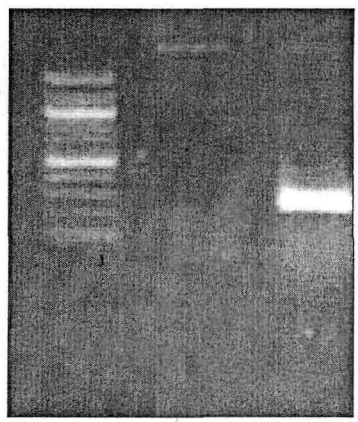

Fig 1. Amplification product of the chitinase gene fragment. Lane1 - marker, lane 3- chitinase gene fragment (313 bp).

Table 86. List of matching sequences and their identity (%) with the chitinase gene fragment based on NCBI-Blast2

Alignment	DB:ID	Source	Length	Score	Identity%	Positives
1 ☑	UNIPROT:O82552_CAPAN	Chitinase class II (Chi2).	253	115	66	79
2 ☑	UNIPROT:Q6SPQ7_BAMOL	Chitinase (EC 3.2.1.14).	334	115	42	54
3 ☑	UNIPROT:Q9SDW1_PRUPE	Basic chitinase type I (Fragment).	156	114	43	53
4 ☑	UNIPROT:Q84LQ7_SOLDU	29 kDa chitinase-like thermal hysteresis protein (Fragment).	267	112	66	76
5 ☑	UNIPROT:Q688M5_ORYSA	Putative chitinase.	334	111	63	76
6 ☑	UNIPROT:Q8VWZ5_ORYSA	Chitinase (EC 3.2.1.14).	333	111	63	76
7 ☑	UNIPROT:Q9ZWS3_TOBAC	Chitinase 134.	265	111	40	54
8 ☑	UNIPROT:Q42992_ORYSA	Chitinase precursor (EC 3.2.1.14).	333	111	63	76
9 ☑	UNIPROT:Q6SZS3_ORYSA	Chitinase (EC 3.2.1.14).	333	111	63	76
10 ☑	UNIPROT:Q42428_CASSA	Chitinase Ib (Endochitinase).	316	111	42	54
11 ☑	UNIPROT:Q5RLX9_MEDSA	Chitinase.	328	110	32	43
12 ☑	UNIPROT:P93680_PERAE	Endochitinase precursor (EC 3.2.1.14).	326	110	40	54
13 ☑	UNIPROT:Q4PJV8_9ROSA	Chitinase.	317	110	66	76
14 ☑	UNIPROT:Q7X9F6_9FABA	Class Ib chitinase.	326	110	38	55
15 ☑	UNIPROT:P93327_MEDTR	Chitinase.	325	109	66	76
16 ☑	UNIPROT:P94084_MEDSA	Class I chitinase.	327	109	66	76
17 ☑	UNIPROT:Q1T5W7_MEDTR	Glycoside hydrolase, family 19; Chitin-binding, type 1.	325	109	66	76
18 ☑	UNIPROT:Q9FEW1_NICSY	Endochitinase precursor.	324	109	66	76
19 ☑	UNIPROT:Q7X9F5_9FABA	Class Ia chitinase.	326	109	66	76

Studies on differential induction of chitinase activity in response to inoculation with *Phytophthora capsici*

Plant chitinases have been of particular interest since they are known to be induced upon pathogen invasion. Inoculation of *P. colubrinum* leaves with the foot rot fungus, *P. capsici* leads to increase in chitinase activity. A marked increase in chitinase activity in the inoculated leaves was observed, with the maximum activity after 60 hours of inoculation and gradually decreased thereafter. Older leaves showed more chitinase activity than young leaves. The level of chitinase in black pepper (*Piper nigrum* L.) upon inoculation was found to be substantially high when compared to *P. colubrinum*. However, hyphal extension assays revealed no obvious differences in the ability of the protein extracts to inhibit growth of *P. capsici in vitro*.

III 1. Project title : Studies on nematode problems of seed spice crops

2. Investigators : I. J. Pruthi

3. Location : Department of Nematology, CCS Haryana Agricultural University Hisar-125 004

4. Duration : 1-04-2005 to 31-03-2008

5. Total cost of the scheme : Rs. 19.05 Lakhs

6. Progress of the work

Survey

A number of nematode genera found associated with these crops (*Hoplolaimus, Meloidogyne, Tylenchorhynchus, Helicotylenchus, Heterodera, Pratylenchus, Basiria, Rotylenchulus, Rotylenchus* etc). Nematode population varied from sample to sample and locality to locality by survey of seed spice crops of Haryana conducted during Feb to April, 2006. In fenugreek and coriander, root-knot nematode was recorded in 44.44% and 57.14% samples respectively with medium to high population (11 out of 12 in fenugreek and 7 out of 8 in coriander. Other nematode pests associated with these crop were *Hoplolaimus* in 33.33% and 50% samples respectively with low to medium population in most of the samples. *Heterodera avenae* and *Rotylenchulus* were reported in 11.11% and 14.81% samples respectively with low population in Fenugreek. *Meloidogyne* was not reported from fennel in Haryana, While the *Hoplolaimus, Helicotylenchus and Tylenchorhynchus* were found in 33.33, 33.33 and 41.66 per cent samples respectively with low to medium population. Only three samples of cumin were collected in which one sample was found predominantly infested with root-knot nematode besides other nemadodes while in other samples, important nematode species were *Hoplolaimus and Tylenchorhynchus.*

A number of nematode genera (*Pratylenchus, Coslenchus, Psilencus, Tylenchorhynchus, Helicotylenchus, Hoplolaimus, Rotylenchulus, Meloidogyne, Heterodera and Rotylenchus, Ditylenchus, Aphelenchus, Basiria, Rhabditids* etc.) were found associated with these crops. Their number varied from sample to sample. Although *Rhaiditids* were present in almost all the sample collected, it is not of much importance because it is a free living nematode. *Ditylenchus and Aphelenchus* were also found but due to their fungal feeder and are of least importance for agricultural point of view by survey of seed spice crops of Rajasthan conducted during March, 2006.

Pathogenicity of root-knot nematode (*Meloidogyne incognita*) on seed spice crops

In desi fenugreek, all growth parameters except root and shoot length, differed significantly at and above 1000 level. Although these parameters were minimum at the inoculum level of 10,000 J_2/plant but were statistically at par with that of 1000 J_2 level. Similarly, number of galls/plant was also highest (93.3) at 10,000 J_2/plant which was significantly higher from all the other inoculum levels. Similarly, in kasuri fenugreek significant reduction in all growth parameters (except fresh root weight) was observed at and above 100 J_2/plant. Although minimum growth parameters were observed at an inoculum level of 10,000 J_2/plant but these were statistically at par with 1000 J_2/plant. Most of the galls at 10,000 J_2 level were compound and highest (83.0) which differed significantly from other inoculum.

The data revealed that there was significant decrease in plant growth parameters of coriander with the increase in inoculum level at and above 1000 J_2/plant. Maximum number of galls (72.8) was found at the inoculum level of 10,000 J_2/plant which differed significantly from that of 100 and 1000 J_2 levels.

In cumin, except root length, significant reduction in plant growth parameters (shoot length, shoot weight, root weight) was observed at and above inoculum level of 100 J_2/plant. Gall number per plant was maximum (47) at the highest inoculum level of 10,000 J_2/plant which was also significantly higher than that of other inoculum levels.

In fennel, although the significant differences in plant growth parameters (except root length and dry shoot weight) were observed at and above 1000 J_2/plant but the formation of very less number of small sized simple galls (28/plant) even at the highest inoculum level of 10,000 J_2/plant indicated its poor response against *M. incognita.*

Screening of germplasms

None of the lines of coriander showed resistant response against this nematode. All the lines of fennel except HF139 and HF-140 showed highly resistant response against and *M. incognita*

7. Technology/protocol/prototype/model/: Process/product developed

Management studies showed the effectiveness of carbosulfan 25 SD @ 2% a.i. (w/w) as seed dressing method for the management of root knot nematode in fenugreek and coriander crops. The results of the present study on the seed

treatment experiments clearly revealed that seed dressing with chemicals better than the seed soaking treatments for the management of *M incognita* in fenugreek and coriander crops.

In coriander crop, applicaton of mustard cake showed maximum improvement in plant growth parameters and reduction in galling as compared to untreated control Amongst cakes minimum galling (23 7) was observed in mustard cake followed by 27 7 in neem cake in comparison to 59.7/plant in untreated inoculated control treatment The effect of higher dose (10 g/kg soil) differed significantly in most of the plant growth parameters, except root length and dry root weight. However their Interaction effect was non significant in most of the cases.

The results clearly revealed that application of mustard cake even at the lower rate (5 g/kg soil) has been found very effective for the management of *M. incognita* in fenugreek and coriander.

IV 1. Project title : Bioecology and integrated management of root mealybug (*Planococcus* sp.) infesting black pepper

2. Investigators : S. Devasahayam
K.M Abdulla Koya
M Anandaraj

3. Location : Indian Institute of Spices Research, Calicut

4. Duration : 1-7-2003 to 30-6-2006

5. Total cost of the scheme : Rs. 12,71,069/-

6. Progress of the work (2006-07)

Evaluation of natural enemies

Evaluation of microbial pathogens

Four isolates of microbial pathogens namely, *Nomurae rileyi*, *Verticillium lecanii*, *Metarrhizium anisopliae* and *Aspergillus* sp. and four commercial products of microbial pathogens namely, *Paecilomyces* sp., *Beauveria bassiana*, V. *lecanii*, and *M anisopliae* were evaluated in laboratory bioassays for their efficacy against root mealybug. The trials indicated that none of the isolates of microbial pathogens were effective against root mealybug and the reduction in population of ranged from 24.0% to 32.0 in various treatments 30 days after spray None of the commercial products of microbial pathogens were also effective against root mealybug and the reduction in population of ranged from 9.6% to 13.3% in various treatments 30 days after spray.

Evaluation of eco-friendly products

Evaluation of plant extracts

Alcoholic and water extracts of 8 and 10 plant species, respectively, were evaluated in various concentrations against root mealybug in laboratory bioassays. The trials indicated that among the various treatments, alcoholic extracts of six plant species (*Azadirachta indica*, *Clerodendron infortunatum*, *Glycosmis pentaphylla*, *Ocimum basilicum*, *Pongamia glabra* and *Vitex negundo*) could result in over 50% reduction in population of root mealybug 30 days after treatment Among them, *A indica* and *V negundo* were more effective resulting in over 75% reduction in root mealybug population 30 days after treatment. Among the water extracts, none of the treatments were effective and maximum reduction in population of root mealybug population (27%) 30 days after treatment was observed in *Samadera indica* and *Strychnos nuxvomica*.

Evaluation of neem products

Three commercial products of neem, neem oil and neem seed kernel extract were evaluated at two concentrations against root mealybug in laboratory bioassays. The trials indicated that among the neem products, Nimbicidine was the most promising resulting in over 50% reduction in population of root mealybug 30 days after treatment.

The reduction in population in the other treatments ranged from 17.8% to 43.8%.

Evaluation of organic products

Seven organic products namely, kerosene, garlic extract. custard apple seed extract, tobacco extract, neem oil + garlic extract + soap emulsion, tobacco extract + soap emulsion and kerosene + soap emulsion were evaluated against root mealybug in laboratory bioassays. The trials indicated that among the organic products, tobacco extract 3% and custard apple seed extract 2% were more promising resulting in 88% and 85% reduction in population of root mealybug, respectively, 30 days after treatment. The reduction in population of root mealybug in the other treatments ranged from 12.6% to 64.8%.

In the second experiment various concentrations (1%, 3% and 5%) of paraffin base oil (Agrospray Oil) were prepared and evaluated against root mealybug in laboratory bioassays. The trials indicated that among the various treatments Agrospray Oil 3% was the most effective resulting in 85.3% reduction in population 7 days after the third spray.

Evaluation of insecticides

Various experiments were undertaken in the laboratory to identify insecticides that were promising against root mealybug for evaluation in the field. In the first experiment 11 insecticides namely, acephate, carbosulfan, chlorpyriphos, quinalphos, dimethoate, carbaryl (0.075% each), fenvalerate, imidacloprid, lamda-cyhalothrin, acetamiprid and thiomethoxam (0.025% each) were evaluated in laboratory bioassays for their efficacy against root mealybug. The insecticides were sprayed on pumpkins and 30 adult females of root mealybug were introduced 1 day after spraying and removed after 7 days. The results of the experiment indicated that all the insecticides except fenvalerate and thiomethoxam caused above 90% reduction in root mealybug population 15 and 30 days after treatment.

In the second experiment the root mealybug was inoculated 30 days after spray the results indicated that acephate, carbosulfan. chlorpyriphos, dimethoate, carbaryl, imidacloprid. lamda-cyhalothrin and acetamiprid caused above 90% reduction in root mealybug population at 15 and 30 days after treatment.

In the third experiment the promising insecticides namely, acetamaprid, imidacloprid and lamda-cyhalothrin were evaluated at 0.0125%, 0.075% and 0.005% each and carbosulfan and chlorpyriphos were evaluated at 0.05% each. The root mealybug was inoculated 1 day after spraying, the results indicated that all the insecticides could cause above 90% reduction in root mealybug population at 15 and 30 days after treatment.

In the fourth experiment the promising insecticides namely, acetamaprid, imidacloprid and lamda-cyhalothrin were evaluated at 0.0125%. 0.075% and 0.005% each and carbosulfan and chlorpyriphos were evaluated at 0.05% concentrations and the root mealybug was inoculated 30 days after spraying, The results of the experiment indicated that all the insecticides except carbosulfan and chlorpyriphos caused above 90% reduction in root mealybug population 15 and 30 days after treatment.

Management of root mealybugs in the field

The insecticides that were promising in laboratory bioassays namely, imidachloprid 0.0125%, acetamaprid 0.0125% and carbosulfan 0.075% were evaluated in the field along with the present recommendation of chlorpyriphos 0.075% at Peruvannamuzhi for utilizing in developing integrated schedules against root mealybug. The insecticides were drenched once on affected vines and the population of root mealybugs was recorded 1 and 2 months after treatment. The trials indicated that all the insecticides were significantly effective and were on par in reducing the population of root mealybugs up to 60 days after treatment. At 30 days after treatment, there was no population of root mealybugs in all the treatments. At 60 days after treatment there was no population of root mealybug in vines treated with acetamaprid and imidacloprid, whereas in vines treated with carbosulfan and chlorpyriphos, there was a mild build up of pest population 60 days after treatment which was however, on par with acetamaprid and imidacloprid.

In the second trial, three natural products, namely, custard apple seed extract 2%, neem leaf extract 1% and tobacco extract 3% that were promising in laboratory bioassays were evaluated

in the field against root mealybugs along with the present recommendation of chlorpyriphos 0.075% at Peruvannamuzhi. The natural products and insecticides were drenched on mildly affected vines thrice at 21 day intervals and the population of root mealybugs was recorded 21 days after each treatment The trials indicated that at 21 days after I treatment, only tobacco extract was promising in reducing the population of root mealybugs among the various natural products. At 21 days after II treatment, neem leaf extract and tobacco extract were promising in reducing the population of root mealybugs. At 21 days after III treatment all the natural products were effective significantly effective in reducing the population of root mealybugs Among the natural products custard apple seed extract 2% and tobacco extract 3% were on par with each other.

V **1. Project title** : Identification and development of diagnostics for the viruses causing stunted disease in black pepper.

2. Investigators : A. Ishwara Bhat
R. Suseela Bhai

3. Location : Indian Institute of Spices Research, Calicut

4. Duration : 01-07-05 to 30-06-06

5. Total Cost : Rs.15, 29,616/-

6. Progress of the work

Random survey of black pepper plantations at the major black pepper growing regions of Karnataka and Kerala revealed that incidence of the disease was highest in Wyanad district (45.4%) followed by Idukki district (29.4%) in Kerala. In Karnataka, Kodagu district (14.9%) had the highest incidence of the disease followed by Hassan district (5 2%) In general, disease incidence and severity were more in Kerala than in Karnataka. Among the areas surveyed incidence and severity were more in the black pepper plantations situated at higher altitudes such as Idukki and Wyanad.

Mosaic, reduction in leaf size and internodal length leading to the stunting and bright yellow mottling along the veins were the important symptoms observed on diseased vines. All cultivars and improved varieties including hybrids were susceptible to the disease under natural conditions. Vines of all ages were found affected by the disease. A few of the weeds found in and around black pepper plantations showed typical virus symptoms, which might act as potential virus source.

When isolates were subjected to immunological analysis through enzyme linked immunosorbent assay (ELISA) using antisera to different viruses, majority of the isolates reacted either to *Cucumber mosaic virus* (CMV) (Genus: *Cucumovirus*) or *Banana streak virus* (BSV) (Genus: *Badnavirus*) indicating the involvement of at least two viruses with the stunted disease of black pepper.

CMV isolated from naturally infected black pepper was propagated on *Nicotiana benthamiana* and *N glutinosa*. CMV particles were purified from these hosts by differential centrifugation and sucrose density gradient centrifugation. Electron microscopy of negatively stained purified preparations showed the presence of isometric particles of about 28 nm in diameter. The antiserum against CMV was raised in New Zealand white rabbit. 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 CMV in diseased black pepper vines collected from different regions of Karnataka and Kerala.

The badnavirus infecting black pepper was identified as a strain of *Piper yellow mottle virus* (PYMoV) PYMV particles were purified from infected black pepper leaves. The purification

procedure included extraction of sap, clarification and precipitation of virus particles by polyethylene glycol followed by differential and sucrose density gradient centrifugation. 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 vines collected from different regions of Karnataka and Kerala.

DAS-ELISA procedure was used to index mother vines of black pepper. Of the 2186 black pepper mother vines belonging to eleven different varieties indexed for the presence of PYMoV and CMV, 714 plants were tested positive for either one or both the viruses. More than 50% of DAS-ELISA positive black pepper mother vines did not exhibit any external symptoms indicating the need of sensitive technique like ELISA to identify virus-free plants.

To know the variation in virus titre, virus infected black pepper plants belonging to five varieties were tested by DAS-ELISA for PYMV and CMV at monthly intervals from April 2004 to March 2005. Results indicated that the concentration of both the viruses varied during different months of the year The concentration of both the viruses was found to be higher during October to January.

Three varieties of infected black pepper vines were selected to study the distribution of PYMoV and CMV in different parts of the plant through DAS-ELISA Results indicated that concentration of PYMV was more in young leaf, old leaf and stem followed by spike and root. The concentration of CMV was found to be more in young leaf and old leaf followed by stem, spike and root.

An effective and reproducible protocol for meristem culture in black pepper was established. It was also established that the same technique can be employed successfully in elimination of CMV and PYMoV infecting black pepper. The use of TDZ-containing medium to induce the initial growth of dissected meristem and subsequent transfer of the enlarged meristem to MS containing 1mg/l BAP and 1mg/l IAA was found to be promising. The fully developed shoots were then transferred to Woody Plant Medium (WPM) containing 0 5% charcoal without any growth regulator for rooting. The rooted plantlets were hardened under green house conditions and screened for the presence or absence of PYMoV and CMV through ELISA and Polymerase Chain Reaction (PCR).

VI 1. Project title : Molecular characterization and Maintenance of National repository of *Phytophthora*

2. Investigators : Dr. M. Anandaraj
Dr. A. Ishwara Bhat
Dr. R Suseela Bhai

3. Location . Indian Institute of Spices Research, Calicut

4. Duration January 2005 - January 2008

5. Total Cost . Rs 25,53.000/-

6. Progress of work

Maintenance of National repository of *Phytophthora*

National Repository of *Phytophthora* (NARPH) at Indian Institute of Spices Research (IISR), Calicut has a collection of 410 *Phytophthora* isolates obtained from 30 different hosts. These isolates are subcultured regularly and maintained in agar slants at 15°C and also in sterile distilled water at room temperature (25±1°C) The phenotypic and pathogenic characters of these isolates have been documented

Morphological characterization of *Phytophthora* isolates

Morphological characterization was done for eighty-six *Phytophthora* isolates based on, sporangial morphology and caducity. Growth rate was studied on carrot agar at three different temperatures; 15°C, 25°C and 35°C *Phytophthora* isolates showed variations in their optimum temperature for growth Mating or compatibility type was determined for 87 isolates of *Phytophthora* from different hosts by the single unknown isolate method on carrot agar plates containing b-sitosterol (30 mg/l) Of the 67 isolates tested for mating type 72.4% were A1 and 27 6% were A2.

Pathogenicity

Seventy *Phytophthora* isolates of black pepper were tested for pathogenicity on black pepper plants using stem inoculation technique in the green house condition After 72 hours of incubation, observations were taken as lesion length in millimeter and depth of penetration as index in a scale of 0-4. Average lesion length ranged from 5 7mm-55mm and lesion index 1 0-4.0. Among these 35 isolates were highly virulent, 24 were moderately virulent and 11 were less virulent

Molecular characterization

The advancements in molecular techniques has resulted in the use of DNA- based techniques such as analysis of sequences in the internal transcribed spacer region (ITS) region of the nuclear ribosomal RNA (rRNA) gene cluster and mitochondrial DNA ITS regions have typically been most useful for molecular systematics at the species level, and even within species (e g , to identify geographic races) because of its higher degree of variation. In recent years, restriction fragment length polymorphism (RFLP) is particularly significant for taxonomy at the species level. Most commonly, the RFLP of PCR-amplified rDNA is used since it provides a quick insight into relationships between moderately distant fungi. Sequencing of rDNA gene clusters provide a relatively rapid identification procedure and enables to distinguish isolates that had previously been identified by morphological methods.

PCR-RFLP of Internal transcribed spacer region

Polymerase chain reaction amplification of ITS regions using the primers ITS-6 and ITS-4 produced amplicon of ~800 to 975bp for all isolates. The ITS amplicon was analysed by RFLP as well as sequencing. The ITS amplicon digested with restriction enzymes, Alu-1, Taq-1, Hind III. Sau 3A1 and Msp-1 produced banding pattern conformity with the species identity. High levels of intraspecific and interspecific variability in the ITS regions were observed among all the isolates. High levels of intraspecific variation were found among black pepper isolates of *P capsici*

Cloning, sequencing and analysis of ITS region

ITS amplicon was excised and purified from agarose gels and cloned. Selected clones were sequenced at the automated DNA sequencing facility at Bangalore Genei, Bangalore, India The three sequenced black pepper isolates were 99% similar to *P capsici* as well as *P tropicalis*. Sequenced cardamom isolates were 100% similar with *P meadii*. Sequences were submitted in GenBank (AM422703, AM422704 and AM422705). Based on ITS rDNA sequences obtained for various *Phytophthora*, species specific primers were designed for *P capsici* and *P palmivora* and are being tested for their specific detection in soil and host plants

VII	1. Project title	:	Conservation and evaluation of Ajwain (*Trachyspermum ammi* L.) germplasm for identification high yielding quality oil genotypes
	2. Investigators	:	R.V. Paliwal Rajesh Pandya S. R. Ahmad
	3. Location	:	Agriculture Research Sub Station, Pratapgarh-312605, (Maharana Pratap University of Agriculture & Technology, Udaipur), Rajasthan
	4. Duration	:	1-08-2003 to 3-10-2006
	5. Total cost of the scheme	:	Rs. 10.88 Lakhs
	6. Progress of the work		
VIII	1. Project title	:	Studies on salt tolerance in seed spices (Fennel, Coriander and Fenugreek)
	2. Investigators	:	A.C. Yadav Avtar Singh S.K. Sharma
	3. Location	:	Chaudhary Charan Singh, Haryana Agricultural University, Hisar
	4. Duration	:	01-04-2004 to 31-03-2007
	5. Cost of the scheme	:	Rs.752790/-
	6. Progress of work	:	
IX	1. Project title	:	Investigations on the etiology and integrated management of rhizome rot of ginger and turmeric in northern Karnataka
	2. Investigators	:	Dr. Srikant Kulkarni Mr. S.A. Kulkarn Mr. R.V. Hegde
	3. Location	:	Department of Plant Pathology, University of Agricultural Sciences College of Agriculture, Dharwad-590 005, Karnataka
	4. Duration	:	01-04-06 to 31-12-06
	5. Total Cost	:	Rs.16,16,306/-
	6. Progress of work		

List of Publications

Coimbatore

1 M. Velmurugan and N. Chezhiyan. 2005. Effect of organic manures and biofertilizers on growth, yield and quality of turmeric (*Curcuma longa L*) cv BSR 2. South Indian Horticulture 53 392

2. T. Prabhu and G. Balakrishnamoorthy. 2005. Evaluation of short duration coriander (*Coriandrum sativum* L) accessions under irrigated conditions for growth, yield and quality of greens and grains. South Indian Horticulture 53 397

3. S. Subramanian, E. Rajeswari and N Chezhiyan 2005 Evaluation of turmeric genotypes for yield and quality. South Indian Horticulture 53 163

4. S. Subramanian, E Rajeswari and N. Chezhiyan. 2005. Screening of coriander genotypes for yield, quality and powdery mildew resistance South Indian Horticulture 53 168

5. S. Subramanian, E Rajeswari and N. Chezhiyan 2005. Evaluation of fenugreek germplasm for morphological and yield characters. South Indian Horticulture 53 · 172

6. H Usha Nandhini Devi and N Cheziyan 2006. Impact of gamma rays on turmeric crop (*Curcuma longa* L). Journal of Horticultural Science 1 (2) 124-128.

Dholi

7 S P Singh, Rajendra Prasad and R. K Singh. 2005 Path co-efficient analysis of seed yield in Coriander (*Coriandrum Sativum* L.) International Journal of Agriculture Science 1(1). 58-61

6 S P. Singh, Rajendra Prasad and R. K. Singh. 2005 Association analysis coriander (*Coriandrum Sativum* L) International journal of Agriculture Science 1(1) 84-86.

7 Singh, S.P. and R Prasad. 2006. Studies on varietal performance of turmeric (*Curcuma longa* L) International Journal of Plant Science 1(1): 22-23

8 Singh, S P and R Prasad. 2006 Phenotypic stability in coriander (*Coriandrum Sativum* L.). International Journal of Agriculture Science 2(1). 50-53.

9. S. P. Singh, R Prasad and Devendra Singh. 2006 Variability and character association of grain yield and its component character in coriander (*Coriandrum Sativum* L.) Journal of Applied Biosci, 32(1). 64-67.

10. S. P. Singh, and R. Prasad. 2006. Genetic variability and path analysis on coriander (*Coriandrum Sativum* L.). Journal of Applied Biosci; 32(1)· 27-31.

11 A K Singh, and S P Singh 2006 Effect of level of nitrogen and phosphorus in conjuction with varying plant densities on some important bulb character and yield of garlic International Journal of Agriculture Science, 2(2): 490-492

12 S.P Singh and D.K. Wevedi. 2007. Impact of zinc, Boron and Iron elements on yield and economics of ginger (*Zingiber officinale* R.). International Journal of Agriculture Science, 3(1) 136-138

13. L.M. Yadav, B Singh and S.P. Singh 2003 Performance of Balck cumin (*Nigella Sativa* L) in North Bihar. Journal of Applied Biol, 13(1-2). 62-65

Guntur

14 K L. Narasimha Rao, K Giridhar and C Sarada 2006 Exploring drought tolerance of coriander (*Coriandrum sativum* Linn) some insights. Journal of current Sciences 2 667-672.

15 K L. Narasimha Rao, K Giridhar and C. Sarada 2006 Exploring drought tolerance of coriander (*Coriandrum sativum* Linn) some insights Journal of Current Sciences 2. 8437-8448.

16. K L Narasimha Rao, K Giridhar and C Sarada 2006 Drought tolerance of elite lines of coriander (*Coriandrum sativum* Linn) Journal of Current Sciences 2. 767-772.

Hisar

17. V K. Kalra, S.S. Sharma and S.K. Tehlan. 2006. Population dynamics of *Hyadaphis corianderi* on different cultivars and varieties of coriander and seed yield losses caused by it. Journal of Medicinal and Aromatic Plants Sciences 28 377-379.

Jobner

18. Engida Tsegaye, Nigussie Dechassa and E.V.Divakara Sastry. 2007 Genetic variability for yield and other agronomic traits in sweet potato. Journal of Agronomy 6(1) 94-99.

19 Kumhar, J P., K C. Sharma and E V.D Sastry 2007 Heterosis in taramira (*Eruca Sativa* (Mill) for seed yield and oil content Indian Journal of Genetics and Plant Breeding 67(1). 89-90

20. S. Agrawal, D Singh, V. Khandelwal and U. K. Jain. 2006. Correlation between seed yield, volatile oil content and its constituents in cumin. Journal of Medicinal and Aromatic Plant Sciences 28 547-549

21. D. Singh, U K. Jain, S. S Rajput, V. Khandelwal and K. N. Shiva 2006 Genetic variation for seed yield and its components and their association in coriander (*Coriandrum sativum* L) germplasm Journal of Spices and Aromatic Crops 15 (1).25-29.

22 O P. Balai, D Singh and U K. Jain 2006 Genetic variation and character association among yield and yield related traits in fenugreek Indian Journal of Agricultural Research 40 (2): 143-146

23 U K Jain. D Singh. O P Balai and K N. Shiva 2006 Genetic divergence in fenugreek (*Trigonella foenum-graecum* L) germplasm. Journal of Spices and Aromatic Crops 15 (1) 59-62.

24. Engida Tsegaye, E V.Divakara Sastry and Nigussie Dechassa. 2006. Correlation and path analysis in sweet potato and their implications for clonal selection Journal of Agronomy 5(3). 391-395.

25. V.V. Singh and E.V. Divakara Sastry. 2006 Genetic variance and expected selection response in fennel (*Foeniculum vulgare* Miller). Indian Journal of Genetics and Plant Breeding 66(1): 63-64.

Mudigere

26. M Dinesh Kumar, D. Madaiah and Venkatesh Murthy 2006. Effective recycling of coffee pulp and leaf vermi compost as potting and the mixtures on growth of bush pepper, vanilla and cardamom seedlings Karnataka Journal of Agricultural Sciences 19(1): 113-115

27. D. Jemla Naik, V.V. Belavadi, D. Thippesha and R. Raghunath 2006. Time of application of insecticides and their efficacy against orange headed leaf hopper under rice ecosystem. Karnataka Journal of Agricultural Sciences 19 (1). 304-306.

28. D Jemla Naik, V.V. Belavadi, D. Thippesha, M. Dinesh Kumar and D. Madaiah, 2006. Field efficacy of neem products against thrips and capsule borer of small cardamom. Karnataka Journal of Agricultural Sciences 19 (1) 144-145.

29. D. Jemla Naik and V.V. Belavadi 2006. Seasonal relationship between population of orange headed leaf hopper *T. subrufa* and its predators under rice ecosystem. Karnataka Journal of Agricultural Sciences 19 (2): 449-450.

Pampadumpara

30. S. Backiyarani, A. Josephrajkumar, P. Sainamolekurian, M. Murugan and G. Sivakumar. 2006. A bold capsuled cardamom [*Elettaria cardamomum* (L) Maton] variety PV-2- suitable for Cardamom Hill Reserves of Kerala The Indian Journal of Genetics and Plant Breeding 66(3): 267-268.

31. A. Josephrajkumar, C. Romit and George Thomas 2006 Midgut Proteases of Cardamom Shoot and Capsule Borer (*Conogethes punctiferalis* Guen) and their interaction with Apirotinin Bulletin of Entomological Research 96(1). 91-98

32. A Josephrajkumar. D. Ambika Devi. P. Sainamole Kurian, G. Sivakumar. S. Backiyarani and M Murugan 2006 Scale insects of black pepper and their management. Indian Journal of Arecanut, Spices and Medicinal Plants 8(3) 89-93

33. M. Murugan, A. Josephrajkumar, P. Sainamole Kurian, D Ambikadevi, K. Vasanthakumar and P.K Shetty. 2006. Critiques on critical issues of cardamom cultivation in cardamom hill reserves, Kerala, India. Indian Journal of Arecanut, Spices and Medicinal Plants 8(4): 132-149.

Pechiparai

34. T Thangaselvabai, J. Prem Joshua, C Gailce Leo Justin, M. Jayasekhar and S Balasubramaniyan. 2006. PPI(C)1 Cinnamon – a new high yielding variety for lower elevations Ibid P16

Pundibari

35. J.C Jana. 2006. Effect of *Azospirillum* and graded levels of nitrogenous fertilizer on growth, yield and quality of ginger (*Zingiber officinale* Rosc). Environment and Ecology 24 (3). 551-553.

Sakleshpur

36 S. Sreekrishna Bhat and M.R. Sudharshan 2006. Evaluation of cardamom genotypes in Karnataka for yield and quality. Journal of Plantation Crops, 34 (3) 212-215.

List of Research Programme (2006 – 07)

Project Code	Title	Centers
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	Intervarietal hybridization to evolve high yielding varieties	Panniyur
PEP/CI/3	**Coordinated Varietal Trial (CVT)**	
PEP/CI/3.1	CVT 1991 - Series IV	Yercaud and Ambalavayal
PEP/CI/3.2	CVT 2000 – Series V	Chintapalle, Pampadumpara, Panniyur, Sirsi and Ambalavayal
PEP/CI/3.3	CVT 2006	Chintapalle, Dapoli, Panniyur, Pampadumpara, Pundibari, Sirsi and Yercaud
PEP/CM/4	**Nutrient Management Trial**	
PEP/CM/4.1	Effect of biofertilizers, *Azospirillum* on black pepper production *(Final report)*	Panniyur, Sirsi and Yercaud
PEP/CM/4 2	Effect of biofertilizers, P-solubilizer on black pepper *(Final report)*	Panniyur, Sirsi, Yercaud and Ambalavayal
PEP/CM/4 3	Organic farming in black pepper (*Final report*)	Panniyur, Sirsi, Yercaud and Ambalavayal
PEP/CM/4 4	Development of organic package for spices based cropping system – Observational trial	Chintapalle, Sirsi, Panniyur, Yercaud and Dapoli
PEP/CM/4.5	Organic farming in black pepper - 2006	Panniyur, Dapoli, Ambalavayal, Peechiparai, Sirsi and Yercaud
PEP/CP/5	**Disease Management Trial**	
PEP/CP/5.1	Adaptive trial on management of *Phytophthora* foot rot of black pepper in farmers field	Ambalavayal, Chintapalle, Dapoli, Panniyur, Pampadumpara, Mudigere and Sirsi
PEP/CP/5.2	Trail on management of *Phytophthora* foot rot of black pepper in existing plantation	Ambalavayal, Chintapalle, Dapoli, Panniyur, Pampadumpara, Mudigere and Sirsi
PEP/CP/5.3	Trail on management of *Phytophthora* foot rot of black pepper in new plantation	Ambalavayal, Chintapalle, Dapoli, Panniyur, Pampadumpara, Mudigere and Sirsi
PEP/CP/6	**Pest Management Trial**	
PEP/CP/6 1	Management of scale-insects of black pepper with organic products	Mudigere ,Pampadumpara

CARDAMOM

CAR/CI/1	**Genetic Resources**	
CAR/CI/1.1	Germplasm collection. characterization, evaluation and conservation	Mudigere and Pampadumpara
CAR/CI/2	**Hybridization and Selection**	
CAR/CI/2.1	Evaluation of OP progenies under intensive management	Mudigere
CAR/CI/3	**Coordinated Varietal Trial**	
CAR/C1/3.4	CVT 2000- Series IV	Mudigere, Pampadumpara, Myladumpara and Sakleshpur
CAR/CI/3.5	CVT 2005-series V	Pampadumpara, Mudigere
CAR/CI/4	**Varietal Evaluation Trial (VET)**	
CAR/CI/4.1	Initial evaluation trial - I	Mudigere
CAR/CI/4.2	Initial evaluation trial - II	Mudigere
CAR/CM/5	**Nutrient Management Trial**	
CAR/CM/5.1	Integrated nutrient management in cardamom	Mudigere
CAR/CM/5.2	Effect of biofertilizer, *Azospirillum* on cardamom	Mudigere, Pampadumpara and Myladumpara
CAR/CM/5.3	Effect of biofertilizers, P. solubilizers on cardamom	Mudigere, Pampadumpara and Myladumpara
CAR/CM/5.4	Effect of neem cake on productivity, pest and disease incidence in cardamom	Mudigere and Pampadumpara,
CAR/CP/6	**Pest Management Trial**	
CAR/CP/6.1	Bioecology of natural enemies of major pests of cardamom	Mudigere and Pampadumpara
CAR/CP/6.2	Estimation of quantitative and qualitative losses due to thrips damage in cardamom	Mudigere and Pampadumpara
CAR/CP/6.3	Management of shoot fly in cardamom	Mudigere and Pampadumpara
CAR/CP/6.4	Management of cardamom root grub through entomopathogenic nematodes	Mudigere and Pampadumpara
CAR/CP/6.5	Trial on management of panicle and clump rot of cardamom in existing plantation	Mudigere and Pampadumpara
CAR/CP/6.6	Trial on management of panicle and clump rot of cardamom in new plantation	Mudigere and Pampadumpara

GINGER

GIN/CI/1	**Genetic Resources**	
GIN/CI/1.1	Germplasm collection. characterization. evaluation and conservation	Dholi, Kumarganj, Pottangi. Pundibari. Raigarh, Chintapalle and Solan
GIN/CI/2	**Coordinated Varietal Trial**	
GIN/CI/2.1	CVT 2000 – Series V	Pundibari, Raigarh and Pottangi
GIN/CI/2 2	CVT 2005 – Series VI	Solan

GIN/CI/3	**Varietal Evaluation Trial**	
GIN/CI/3.1	Initial evaluation trial (IET)	Solan, Pottangi. Raigarh
GIN/CI/4	**Quality Evaluation Trial**	
GIN/CI/4.1	Evaluation of germplasm for quality	Solan
GIN/CM/5	**Nutrient Management Trial**	
GIN/CM/5.1	Effect of micronutrients on ginger	Dholi, Kumarganj, Pottangi, Pundibari and Raigarh
GIN/CM/5.2	Organic farming in ginger - 2006	Solan, Pundibari, Pottangi, Dholi, Kumarganj and Raigarh
GIN/CP/6	**Disease Management Trial**	
GIN/CP/6.1	Disease surveillance and etiology of rhizome rot in ginger	Pundibari and Solan
GIN/CP/6.2	Biocontrol studies on rhizome rot of ginger *(Final report)*	Kumarganj, Pottangi, Raigarh and Ambalavayal
GIN/CP/6.3	Integrated management of *Pythium, Fusarium* and *Ralstonia* on ginger *(Final report)*	Dholi, Kumarganj, Pundibari and Raigarh
GIN/CP/6.4	Survey and monitoring of diseases in ginger	Pundibari, Kumarganj and Raigarh
GIN/CP/6.5	Management of rhizome rot in ginger	Mudigere, Pampadumpara, Chintapalle, Sirsi and Dapoli
TURMERIC		
TUR/CI/1	**Genetic Resources**	
TUR/CI/1.1	Germplasm collection, characterization, evaluation and conservation	Coimbatore, Dholi, Jagtial, Solan, Kumarganj, Pottangi, Pundibari and Raigarh
TUR/CI/2	**Coordinated varietal trial**	
TUR/CI/2.1	CVT 2000 - Series V	Jagtial, Pundibari, Raigarh, Coimbatore and Kumarganj
TUR/CI/2.2	CVT-2004-Series VI	Chintapalle, Coimbatore, Jagtial, Kumarganj, Pottangi, Pundibari and Raigarh
TUR/CI/3	**Varietal evaluation trial**	
TUR/CI/3.1	Comparative yield trial 1999-2000	Pundibari and Raigarh
TUR/CI/3.1	Comparative yield trial 2005-06	Jagtial and Coimbatore
TUR/CI/3.2	Initial evaluation trial	Dholi, Pottangi. Kumarganj and Pundibari
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/5	**Nutrient Management Trial**	
TUR/CM/5.1	Effect of biofertilizer, *Azospirillum* on turmeric *(Final report)*	Coimbatore, Kumarganj and Pundibari
TUR/CM/5.2	Organic farming in turmeric *(Final report)*	Pundibari, Pottangi

TUR/CP/6	**Disease Management Trial**	
TUR/CP/6 1	Survey and identification of disease causing organisms in turmeric and screening of turmeric germplasm against diseases	Coimbatore, Dholi, Pundibari and Raigarh
TUR/CP/6 2	Investigations on the causal organism of rhizome rot of turmeric and screening of biocontrol agents for its management *(final report)*	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 - clove	Yercaud and Pechiparai
TSP/CI/2 2	CVT 1992 - cinnamon	Ambalavayal
TSP/CI/2.3	CVT 2001- nutmeg	Dapoli and Pechiparai
TSP/CI/2.4	CVT 2001 - cassia	Dapoli, Pechiparai and Ambalavayal
TSP/CM/2	**Propagation/Multiplication Trial**	
TSP/CM/2 1	Softwood grafting in clove	Dapoli
TSP/CP/3	**Disease Management Trial**	
TSP/CP/3.1	Survey for disease incidence in tree spices	Dapoli, Pechiparai and Ambalavayal
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/2	**Coordinated Varietal Trial**	
COR/CI/2.1	CVT 2001 – Series V *(Final report)*	Coimbatore, Hisar, Jobner, Kumarganj, Dholi, Jagudan, Guntur and Raigarh
COR/CI/2 2	CVT 2004 – Production of leafy type coriander during off-season	Coimbatore, Guntur and Hisar
COR/CI/2 3	CVT 2005	Jagudan, Jobner, Guntur, Dholi, Raigarh and Kumarganj
COR/CI/3	**Varietal Evaluation Trial**	
COR/CI/3.1	Initial evaluation trial	Hisar, Guntur, Jobner and Jagudan
COR/CI/4	**Quality Evaluation Trial**	
COR/CI/4 1	Quality evaluation in coriander	Jobner

COR/CM/5	**Nutrient Management Trial**	
COR/CM/5.1	Effect of biofertilizer. *Azospirillum* on coriander	Hisar, Coimbatore and Kumarganj
COR/CM/5.2	Effect of bio-regulators on coriander	Jobner. Kumarganj, Dholi, Coimbatore, Hisar and Guntur
COR/CM/5.3	Identification of drought/ alkalinity tolerant source in coriander	Guntur and Kumarganj
COR/CP/6	**Disease Management Trial**	
COR/CP/6.1	Management of powdery mildew and stem gall in coriander	Coimbatore, Jagudan, Jobner,and Raigarh
CUMIN		
CUM/CI/1	**Genetic Resources**	
CUM/CI/1.1	Germplasm collection, characterization, evaluation conservation and screening against diseases	Jagudan and Jobner
CUM/CI/2	**Coordinated Varietal Trial**	
CUM/CI/2.1	CVT 2005	Jobner and Jagudan
CUM/CI/3	**Varietal Evaluation Trial**	
CUM/CI/3.1	Initial evaluation trial	Jobner and Jagudan
CUM/CI/4	**Quality Evaluation Trial**	
CUM/CI/4.1	Quality evaluation in cumin	Jobner
CUM/CP/5	**Disease Management Trial**	
CUM/CP/5.1	Management of wilt and blight diseases in cumin	Jagudan and 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	**Coordinated Varietal Trial**	
FNL/CI/2.1	CVT – 2004 --Series V	Dholi, Hisar, Jagudan, Jobner and Kumarganj
FNL/CI/3	**Varietal Evaluation Trial**	
FNL/CI/3.1	Initial evaluation trial	Hisar, Jobner and Jagudan
FNL/CI/4	**Quality evaluation trial**	
FNL/CI/4.1	Quality evaluation in fennel	Jobner

FNL/CM/5	**Nutrient Management Trial**	
FNL/CM/5.1	Effect of biofertilizer, *Azospirillum* on fennel	Kumarganj
FNL/CM/5.2	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	**Coordinated Varietal Trial**	
FGK/CI/2.1	CVT 2001 – Series V *(Final report)*	Jagudan
FGK/CI/2.2	CVT 2005 – Series VI	Jobner, Jagudan and Hisar
FGK/CI/2.3	CVT 2006	Kumarganj, Dholi, Guntur, Jobner, Jagudan and Hisar
FGK/CI/3	**Varietal Evaluation Trial**	
FGK/CI/3.1	Initial evaluation trial	Guntur, Hisar, Jagudan and Jobner
FGK/CM/4	**Nutrient Management Trial**	
FGK/CM/4.1	Effect of biofertilizers. *Azospirillum/ Rhizobium* on fenugreek *(Final report)*	Coimbatore and Kumarganj
FGK/CM/4.2	Identification of drought/tolerance source in fenugreek	Coimbatore and Guntur
FGK/CM/4.3	Effect of bio-regulators on fenugreek	Jobner, Coimbatore and Dholi
PAPRIKA		
PAP/CI/1.1	Germplasm collection, characterization, evaluation and conservation of paprika	Coimbatore, Guntur and Yercaud

Personnel

PROJECT COORDINATOR'S OFFICE

Project Coordinator		Dr M Anandaraj
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.	Breeder	:	Vacant since 15.07.2006 (Post shifted to RARS Ambalavayal)
2	Agronomist (Hort.)		Vacant since 05.11 2005
3	Jr. Entomologist	·	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.	Pathologist (Assoc. Professor)	.	Dr K P Mammootty
2	Jr Breeder (Assi Professor)		Dr V P Neema
3.	Jr. Pathologist		Vacant
4.	Jr. Horticulturist (Agronomy)		Vacant
5	Farm Supervisor (Gr. I)		Mr P J Joseph
6	Farm Supervisor (Gr II)	.	Mr K Lakshmanan
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	·	Dr S D Rangaswamy
2.	Agronomist (Hort.)	:	Dr M Dinesh Kumar
3	Breeder	·	Dr S Ganga Prasad
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)	.	Dr R Swarnapiria (Posted at HRS. Pechiparai)
3.	Lab Assistant	.	Mr P Pappu

6 *Department of Spices & Plantation Crops, TNAU, Coimbatore*

1	Breeder (Horticulturist)	:	Dr (Mrs) N Shoba
2.	Jr Pathologist	:	Dr. P. Muthulakshmi
3.	Agricultural Assistant	:	Mr R Swaminathan

7. *Regional Agricultural Research Station, ANGRAU, Chintapalle*

1	Horticulturist		Sri D Lakshminarayana
2	Junior Pathologist	.	Dr. N. Raja Kumar
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 G. Srikanth

9 *Regional Agricultural Research Station, ANGRAU, Guntur*

1.	Horticulturist	:	Dr 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 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	.	Vacant
2	Jr Breeder	:	Mr D K Dash
3.	Technical Assistant	.	Mr R C Dash
4.	Technical Assistant	.	Mr B N Sahoo

12 *Department of Genetics and Plant Breeding, SKN College of Agriculture, RAJAU, Jobner*

1	Sr Breeder	:	Dr EVD Sastry
2	Breeder	:	Dr Dhirendra Singh
3.	Jr Agronomist	:	Dr N L Jat
4	Jr. Pathologist	:	Dr K S Shekhawat
5.	Jr. Biochemist	:	Vacant
6	Technical Assistant	:	Dr S S Rajput
7.	Technical Assistant	:	Mr S R Kumawat

13 *Main Spices Research Station, SDAU, Jagudan*

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

15 Dept.of Horticulture, Tirhut College of Agriculture, RAU, Dholi

1.	Horticulturist	:	Dr S P Singh
2.	Jr. Pathologist	.	Vacant (since 01.1.2001)
3.	Technical Assistant		Vacant (since inception of the project)

16 Dept of Vegetable Science, NDUAT, Kumarganj

1.	Horticulturist	:	Dr J Dixit
2.	Jr. Pathologist	:	Dr R P Saxena
3	Jr Breeder	·	Dr V P Pandey
4.	Technical Assistant	:	Mr R K Gupta
5.	Technical Assistant	:	Mr VK Singh

17. Dept.of Horticulture, UBKVV, Pundibari

1.	Horticulturist	:	Vacant
2.	Jr. Breeder	:	Dr N Bhowmik
3.	Jr Pathologist	:	Mr S Bandyopaday
4.	Technical Assistant	:	Mr B Mazumder
5.	Technical Assistant	:	Mr B Dutta

18. Dept.of Horticulture, KKV, Dapoli

1.	Horticulturist	:	Dr A D Rangawala
2.	Jr. Pathologist	:	Prof U A Garde
3.	Jr. Breeder	:	Prof R G Khandekar
4.	Technical Assistant	:	Mr S D Tambe
5.	Technical Assistant	:	Mr A B Jadhav

19 Regional Agricultural Research station, IGAU, Raigarh

1.	Horticulturist	:	Dr C R Gupta
2	Jr. Breeder	:	Dr Shailesh Tripathi
3	Jr. Pathologist	:	Dr A K Singh
4.	Technical Assistant	:	Mr D S Kshatri
5.	Technical Assistant	·	Vacant

AICRPS - Budget Provision
(2006-07)

(Rs in lakhs)

Name of the centers	Pay & Allowances		TA		RC		Tech.A	Total RC	Grand Total		Total
	Est.	(ICAR)	Total	(ICAR)	Total	(ICAR)	(ICAR)	(ICAR)	ICAR share	State share	
Pampadumpara (KAU)	9 407	7 055	0 627	0 470	1 961	1 471		1 471	8 996	2 999	11 995
Pannıyur (KAU)	9 947	7 460	0 837	0 628	2 614	1 961	0 100	2 061	10 149	3 383	13 532
Mudigere (UAS-B)	12 667	9 500	0 837	0 628	2 614	1 961		1 961	12 089	4 030	16 119
Sirsi (UAS-D)	2 660	2 000	0 418	0 314	1 307	0 980		0 980	3 294	1 098	4 392
Yercaud (TNAU)	4 973	3 730	0 418	0 314	1 307	0 980		0 980	5 024	1 675	6 699
Coimbatore (TNAU)	5 187	3 890	0 418	0 314	1 307	0 980	0 100	1 080	5 284	1 761	7 045
Chintapalli (APAU)	0 000	0 000	0 418	0 314	0 889	0 667		0 667	0 981	0 327	1 308
Jagtial (APAU)	3 773	2 830	0 418	0 314	1 307	0 980	0 050	1 030	4 174	1 392	5 566
Guntur (APAU)	1 452	1 089	0 418	0 314	1 307	0 980	0 050	1 030	2 433	0 811	3 244
Solan (YSPUHF)	6 820	5 115	0 627	0 470	1 961	1 471	0 050	1 521	7 106	2 369	9 475
Pottangi (OUAT)	3 346	2 510	0 418	0 314	1 307	0 980	0 100	1 080	3 904	1 302	5 206
Jobner (RAJAU)	7 733	5 800	1 050	0 787	3 269	2 452	0 150	2 602	9 189	3 063	12 252
Jagudan (GAU)	5 200	3 900	0 418	0 313	1 307	0 980	0 100	1 080	5 293	1 765	7 058
Hisar (HAU)	6 387	4 790	0 418	0 313	1 307	0 980	0 100	1 080	6 183	2 061	8 244
Dholi (RAU)	5 187	3 890	0 418	0 313	1 307	0 980	0 050	1 030	5 233	1 745	6 978
Kumarganj (NDUAT)	6 300	4 725	0 627	0 470	1 961	1 471		1 471	6 666	2 222	8 888
Pundibari (BCKVV)	6 300	4 725	0 627	0 470	1 961	1 471	0 050	1 521	6 716	2 239	8 955
Dapoli (KKV)	4 967	3 725	0 627	0 470	1 961	1 471	0 050	1 521	5 716	1 906	7 622
Raigarh (IGKVV)	6 300	4 725	0 627	0 470	1 961	1 471	0 050	1 521	6 716	2 239	8 955
AICRPS Workshop					0 313	0 313		0 313	0 313		0 313
Grand Total	**108.606**	**81.459**	**10.666**	**8.000**	**33.228**	**25.000**	**1.000**	**26.000**	**115.459**	**38.387**	**153.846**

Statement of fund released to AICRPS centres (2006-07) (Rs. in lakhs)

Name of the center	Allocation 2006-07	Amount Reseaed				Add. Fund released	Grand total released
		First half	Second half	Ass. Tech	Total		
Pampadumpara (KAU)	12 050	4.498	4 498	-	8.996	3 054	12 050
Pannıyur (KAU)	10 543	5 025	5.024	0 100	10 149	0.394	10 543
Mudigere (UAS B)	12 483	6.045	6.044	-	12.089	0.394	12 483
Sirsi (UAS-D)	3.688	1 647	1 647	-	3.294	0 394	3 688
Yercaud (TNAU)	5.024	2 512	2 512	-	5.024	-	5.024
Coimbatore (TNAU)	5 649	2 592	2.592	0 100	5 284	0 365	5 649
Chintapalli (APAU)	0 981	0 490	0 491	-	0 981	-	0.981
Jagtial (APAU)	3 744	2 062	1.632	0 050	3 744	-	3.744
Guntur (APAU)	2 433	1 191	1 192	0.050	2 433	-	2 433
Solan (YSPUHF)	7 106	3 528	3 528	0 050	7 106	-	7.106
Pottangi (OUAT)	3 904	-	3 804	0 100	3 904	-	3 904
Jobner (RAJAU)	9.189	4 520	4.519	0 150	9 189	-	9 189
Jagudan (GAU)	7 702	2 596	2 597	0.100	5 293	2 409	7 702
Hisar (HAU)	8 861	3.042	3 041	0 100	6 183	2.678	8 861
Dholi (RAU)	2 641	2.591	-	0 050	2.641	-	2 641
Kumarganj (NDUAT)	6 666	3 333	3.333	-	6 666	-	6 666
Pundibari (BCKVV)	0 050	-	-	0 050	0 050	-	0.050
Dapoli (KKV)	5 716	2 833	2 833	0.050	5.716	-	5 716
Raigarh (IGKVV)	6 716	3 333	3 333	0 050	6.716	-	6 716
AICRPS Workshop	0 313	0 313	-	-	0 313	-	0.313
Grand total	**115.459**	**52.151**	**52.620**	**1.000**	**105.771**	**9.688**	**115.459**

The sanctioned plan BE was Rs. 119 00 L the remaining balance of X Plan vide letter No. F. 1-14-2006 1 A (V) dated 14-8-2006 and 11-9-2006 fro (Hort). Based on the directions from US (Hort.) vide letter F. No. 15-15/2006 1A (V) dated 11-9-2006 that the X Plan expenditure should not e the each head, subhead, and total X Plan outlay and hence an amount of Rs. 3.541 lakhs has been surrendered to ICAR vide our lett PCS/IISR/22(1)06 dated 13 Oct 2006. Hence the RF 2006-07 has been limited to Rs. 115.459 L(ICAR Share). The RE 2006-07 of Rs. 115.46 lakl been communicated vide letter F. No.15-14/2006 dt 21.12.2006 and 23 2.2007 An amount of Rs. 9 688 L has been obtained as savings from Pun (Rs. 6.666 L), Dholi (Rs 2.592 L) and Jagtial (RS. 0.430 L) and out of which an amount of Rs. 7.747 L has been released as additional fund unde and allowance to Pampadumpara (Rs. 2.66 L), Jagudan (Rs. 2.409 L) and Hisar (Rs 2.678 L) centres to regularise the excess expenditure incurred i pay and allowances. An amount of Rs 1 941 L under TA and RC (Rs. 0.470 TA + Rs 1.471 RC) released to Pampadumpara (Rs 0.10 TA + Rs. 0 29 Pannıyur (RS. 0.10 TA + Rs. 0.294 RC), Mudigere (Rs. 0.10 TA + Rs 0 294 RC), Sirsi (Rs. 0.10 TA+ Rs. 0 294 RC) and Coimbatore (Rs. 0 07 TA+ Rs. RC) centres.

Weather Data (2006-2007)

Chintapalle

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	0	0	29 2	8 2	84	39 7
February	0	0	31.3	10.0	75 5	34 0
March	37 2	2	31.9	15 8	85.7	42.6
April	67 6	4	34.3	18 7	75 6	39.2
May	198 4	9	31 3	20 7	78.9	63.9
June	162 0	11	30 3	21.2	80 8	66.5
July	180 0	17	27 2	21.1	84 0	75.4
August	375 8	21	25.8	20.6	88 0	79.3
September	344 2	17	28.3	19.8	90.5	77.4
October	284.0	13	28.9	17.6	89 6	68 6
November	118.6	5	27.4	16.2	88.0	65.5
December	0	0	28 1	9.6	86.2	52.4

Coimbatore

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
June'06	62 6	6	31.6	23.1	57	57
July	8.7	-	31 4	23 9	73	51
August	9.5	2	31 9	22 6	82	51
September	69 3	7	30.6	22.6	87	60
October	201.8	10	30.8	22.4	90	60
November	297.2	12	28 4	21.9	94	67
December	0.6	-	28.6	18 9	89	48
January, 07	10 0	1	29.8	18.8	89	41
February	21 8	1	31.8	19.3	85	36
March	-	-	34 7	21 9	81	32
April	57.7	5	35 3	23 9	86	40
May	80.8	4	34.5	23.7	85	47

Dapoli

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	0	0	32 2	11 7	95	43
February	0	0	33.8	13.3	91	46
March	7 2	1	31 6	15 9	92	59
April	0	0	32 0	18 7	91	60
May	149 4	7	32.4	22.9	88	66
June	686 2	22	29 9	23.3	95	84
July	1248 6	30	28 0	23 5	95	92
August	821 8	28	27.4	22.8	96	92
September	444 2	12	29 4	22 7	96	86
October	140 4	5	32 6	21 2	94	71
November	39 0	3	33 2	18 8	93	58
December	0	0	32 8	13 6	95	49

Dholi

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	0	0	21 8	7 40	96 5	58 4
February	0	0	28 2	13.3	96.2	55 1
March	0	0	31.1	14 6	82.2	33 8
April	9 2	1	34.7	20 2	76 2	39.7
May	90.8	6	34 6	22 9	82 2	58 8
June	144	7	33.7	25 9	87.1	64.4
July	457.4	13	32 1	26.4	90 1	74.6
August	79.6	6	32 2	26 1	88.0	69.1
September	313.2	10	32 1	24 8	89 5	73.5
October	42	2	31.8	21 8	90.1	60 9
November	4.8	1	27 1	14 8	94 8	51.2
December	0	0	24.6	9 8	93 6	54 0

Guntur

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
June'06	156 6	2	37 3	27 0	77	51
July	56.4	14	36 0	27.1	71	51
August	85	10	34 3	25.7	82	59
September	152 2	8	33 5	24 9	85	63
October	150 4	15	32.9	23 8	83	61
November	91 2	3	29 6	21 6	90	66
December	0	1	30 2	17.9	90	51
January, 07	0	0	31.4	16 2	86	60
February	0	0	33 6	17.4	80	56
March	33 6	3	35 1	22.3	85	58
April	54.2	1	36 8	25 2	82	51
May	71 6	3	38 7	26 8	84	49

Hisar

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
April, 06	0.0	5 6	37 0	18 0	65 7	29.1
May	69.2	7 6	40 6	23 9	68.1	35.8
June	72 2	7 5	38.1	24 5	72 0	45 1
July	91.3	7.7	35 4	26.8	84 9	62.5
August	7.9	7 7	35.0	25 4	82 5	58 0
September	69 8	4 8	34.1	22.8	86.5	52 7
October	0 0	3 9	33 7	17 3	81 1	37.8
November	0 0	2 6	28 5	10 9	91 1	50.3
December	8.2	3 1	21 9	5 5	94 8	46 3
January, 07	0 0	2.8	20 1	3.3	94 0	43 0
February	75 3	4 8	22 8	8.8	96 0	72 0
March	44 3	5 0	27 0	11 2	90 0	45 0

Jagtial

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	0	2.3	30.7	14 0	73.2	30.8
February	0	2.2	34.6	15 7	67.8	28.1
March	48.0	3 7	34.1	19.6	74.4	44.5
April	18 0	3 4	40.1	22.7	60 1	33.4
May	48 2	5 5	41.7	24.6	60 4	29.8
June	90 4	8 3	38 5	26 6	62 4	42 0
July	108 2	10.8	31 6	24.9	79 3	65.8
August	216 0	11.9	31.6	24.4	76 1	64.9
September	372 6	5 5	33.0	24 0	83 8	63.9
October	10 6	2.3	32.8	21.8	81.0	51.2
November	59 8	1 5	30.2	18.2	82.5	52.0
December	0	101	30.1	15 0	76.0	40 4

Jobner

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	0	0	24.40	3 92	76 20	31.20
February	0	0	30 95	9 70	67 50	23.50
March	6.00	1.00	31 00	13 08	69.50	33.00
April	0	0	39.00	19.92	48.40	20.40
May	40.30	5 00	41.63	25 18	56.25	23.00
June	0	0	39.08	23 05	64.75	27.25
July	108 0	7 00	33 40	25 62	86 40	58.40
August	31.80	2.00	32 35	24.00	81 75	57 50
September	3 60	1.00	32 55	21.60	69 25	42 00
October	5.20	1 00	33 20	17.24	70 80	33 20
November	0	0	28.78	10 40	70.25	31 25
December	0	0	23.90	5.65	74 50	38.00

Mudigere

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	0	0	26.27	14 64	65 45	55.41
February	0	0	26 57	14.69	71.10	62.03
March	97.8	3	28 29	17.80	88 83	24 33
April	6.6	1	27 65	18 11	90 66	87 43
May	269.0	7	29 32	18 61	90 70	87 06
June	776.8	18	26.48	18 15	93 06	89 30
July	1062.4	30	25.16	17 85	93.77	90 58
August	595 8	20	25 85	17.48	91.74	88.51
September	337 2	14	26 11	17 76	93 80	90 90
October	199 0	7	26 16	17 19	91.58	89.00
November	248 6	6	26 38	18 16	92.50	90.13
December	0	0	26 87	13.77	87 25	78 12

Pampadumpara

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	22 60	2	26 40	13 00	92.74	63 61
February	0 00	0	29 00	13 40	84.46	40 89
March	54 40	4	31 00	16 80	91 68	53.03
April	59.60	5	32.00	18.00	94.62	59.13
May	185 00	10	30.00	16.50	93.97	71 48
June	199 80	10	31 00	16 00	96.90	77.07
July	379.40	24	25 00	16 50	98 10	90.52
August	194 00	14	26.50	16 50	98 29	81.94
September	168 00	17	28.00	16 00	96.03	82 03
October	303.20	17	26 50	16 00	96.68	79.87
November	128.80	8	26 50	16 50	96 47	78.03
December	3.60	1	26.00	13.50	92.03	62 10

Panniyur

Month	Rainfall (mm)	Rainy days	Relative Humidity (%)	Sunshine Hours/day	Temperature (°C)	
					Max	Min
January,06	3	1	84	9.0	35	22
February	0	0	78	8.9	36	21
March	0	0	81	7 0	38	26
April	0	0	82	8 0	37	25
May	778	11	85	6 0	35	26
June	879	19	91	4.0	30	25
July	921	30	93	2.0	30	25
August	701	22	92	4 0	30	25
September	586	19	92	5 0	32	26
October	327	18	99	5 0	33	25
November	74	14	90	6.0	33	25
December	0	0	85	8.0	34	23

Peechiparai

Month	Rainfall (mm)	Rainy days	Relative Humidity (%)	Temperature (°C)	
				Max	Min
January,06	42	5	79.7	31.5	20 8
February	24	1	85.0	34.9	20 0
March	79	8	88 4	33.8	22 3
April	86	4	92 7	33 2	23 2
May	550	18	95 3	32 1	23 8
June	173	8	93 7	32 1	22 8
July	170	13	94 2	30 2	23 8
August	120	12	91 5	30 8	22 5
September	396	18	89 5	29 9	22 3
October	576	19	92 4	31 0	21 7
November	235	14	87 5	30 8	21 4
December	4	1	74 8	33.7	20 5

Pottangi

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	35	1	26	17	83	61
February	0	0	29	16	81	60
March	43	4	30	17	90	55
April	72	1	35	20	95	60
May	233	9	30	19	98	66
June	399	13	29	18	98	78
July	529	21	28	18	98	88
August	724	20	26	16	99	89
September	775	19	25	16	99	91
October	0	0	25	16	99	92
November	0	0	22	15	85	72
December	0	0	20	14	81	70

Pundibari

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January.06	0	0	22 1	9 3	87	55
February	0	0	32 5	10.1	81	51
March	1.3	1	33.2	15 6	100	62
April	61.3	9	30.2	19.1	95	64
May	301 3	15	33 5	21.3	95	65
June	614 9	20	32 1	23 7	94	81
July	329 2	18	33.0	24 9	95	73
August	153.0	17	33 3	25.2	96	70
September	461.7	18	33 0	23 8	98	77
October	212 0	8	32.0	18 4	98	59
November	18.2	2	29.7	11 4	97	58
December	14 0	1	25 8	10 5	100	58

Sirsi

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January,06	0	0	31 31	13.87	89 81	40 60
February	0	0	33 50	12 27	85.11	34 11
March	19 6	2	36.61	16 45	80 13	40.16
April	0	0	35 43	20.47	74 77	41.67
May	223 8	4	33 02	21 95	79 35	57 06
June	441.2	18	28.82	23 03	87 33	79.70
July	1002.6	30	26 63	23 13	93 68	88 55
August	632.4	19	26 82	22.24	91 87	84 97
September	194 0	13	29 00	22 63	87 07	76 23
October	45 8	5	30 24	21 40	85 16	75.68
November	57.0	5	30 40	20 38	85 37	72 87
December	0	0	29 90	15 27	87.47	65 67

Solan

Month	Rainfall (mm)	Rainy days	Relative Humidity (%)	Sunshine Hours /day	Temperature (°C)	
					Max	Min
January,06	68	4	59	5 9	20 6	3.4
February	4 4	2	51	6 8	21.1	7.8
March	106 7	10	56	6.4	23 9	8.2
April	24.6	2	38	7 4	29.2	12 2
May	78 8	7	51	7 6	32 1	17.3
June	103 4	11	22	6 2	31.4	17 9
July	243.9	19	79	2.8	29 0	20.9
August	252 2	19	79	3 6	29.0	19 8
September	47 8	7	69	7 2	29 6	16.6
October	9.4	3	56	8 4	28.1	11 3
November	14.2	2	56	7 9	24 2	6 7
December	16	5	52	5 5	21.7	3.5

Yercaud

Month	Rainfall (mm)	Rainy days	Relative Humidity (%)	Temperature (°C)	
				Max	Min
April, 06	25.5	3	57 9	26 1	22 7
May	27.9	3	69.0	27.2	22.7
June	24.9	3	73 0	25 2	21 9
July	10 1	3	70 2	23.9	21.6
August	40.6	6	71.6	23 4	21.5
September	25 9	4	82 3	23 7	22 3
October	19 4	10	76.0	22.6	20.7
November	18 9	9	95 0	21.6	18.9
December	7 5	7	86.0	26 4	15.2
January, 07	1.0	8	73.0	27.2	13 6
February	0	1	50 0	27 2	12.4
March	0	1	49 0	29 5	16.8

Coordinating Centres

HEAD QUARTERS: Project Coordinator, Spices
All India Coordinated Research Project on Spices
Indian Institute of Spices Research, Calicut-673 012, Kerala
Phone: Off. (0495) 2731794
Fax: 0091-495-2731794
E-mail: pcspices@yahoo.com, aicrps@spices.res.in

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