



वार्षिक रिपोर्ट Annual Report 2007 - 08

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

AICRPS



भारतीय मसाला फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद)

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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

ANNUAL REPORT
2007-08



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

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परियोजना समन्वयक की रिपोर्ट

अखिल भारतीय रामन्वित मसाला अनुसंधान परियोजना (ए आई सी आर पी एस) अपना मुख्यालय भारतीय मसाला फसल अनुसंधान संस्थान, कालिकट में 12 मसाले फसलों में अनुसंधान का आयोजन और समन्वय करने के लिए निहित होता है। ए आई सी आर पी एस का अब 19 केन्द्र है, 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 प्रस्तावित ग्यारहवीं योजना की बजट 1400 लाख रूपए है जिसमें वर्ष 2007-08 का 231.00 लाख रूपए (भा कृ अनु प का हिस्सा) भी शामिल होता है। अधिदेश मसाले फसलों का लगभग 115 शोध कार्यक्रम विभिन्न केन्द्रों में आयोजित किये जा रहे हैं।

काली मिर्च

ए आई सी आर पी एस के विभिन्न केन्द्रों में काली मिर्च के पाँच सौ पचासी अक्सशनों को बनाये रखे जाते हैं जिसमें कल्टिवेटड, विजातीय, वन्य और संबन्धित स्पीसीस भी शामिल होते हैं। जर्मप्लासम के चरित्रांकन के फलस्वरूप उच्च उपज वाले अक्सशनों जैसे पन्नियूर केन्द्र से करिमुंडा II (5.60 कि. ग्राम हरे/बेल) और वलियारमुंडी (3.45 कि. ग्राम हरे बरी/बेल) की पहचान की गई। पन्नियूर I (2.63 कि. ग्राम सूखे/बेल) और पी एन-57 (4.0 कि. ग्राम हरे/बेल) को क्रमशः सिरसी और येरकाड केन्द्र से प्राप्त उच्च उपजवाले के रूप में पहचान की गई। पन्नियूर केन्द्र में विकसित अन्तर प्रजातीय संकरजो के बीच पी-6 x पी-5 को 1.1 कि. ग्राम/बेल के ताजी उपज देने में आशाजनक देख लिया। अम्बलवयल में सीवीटी में मूल्यांकन किये काली मिर्च के विभिन्न कल्टिवर्स के बीच सीयूएल-5489 में उच्चतम रपाइक लंबाई (13.34 से. मीटर) देख ली और सीयूएल-5308 (12.46 से. मीटर) और पन्नियूर-1 (12.41 से. मीटर) उसके निकट आते हैं। पन्नियूर केन्द्र में अधिकतम उपजता/बेल सीयूएल-5489 (1.847 कि. ग्राम हरे बरी/बेल) में अंकित किया और करिमुंडा ओपी, सीयूएल-5308, पन्नियूर-1 करिमुंडा और कलक्शन 1041 उसके बाद आते हैं। धापोली केन्द्र में काली मिर्च कतरनों के सीधे तने की मूल लगाई से यह सूचित करता है कि दो नोडवाली कतरनें तीन और पाँच नोडवाली कतरनों की अपेक्षा उत्तम हो गये। एकीकृत पोषण प्रबन्ध उपचार करने पर पन्नियूर और सिरसी केन्द्रों में जैविक और अजैविक उपचारों की अपेक्षा अधिकतम उपजता अंकित की जहाँ अजैविक और एकीकृत पोषण प्रबन्ध उपचार दोनों पीचीपराई केन्द्रों में काफी दूर पर हैं। खुर गलन रोग प्रबन्धन के लिए उपलब्ध प्रचलित तकनीकियों के बीच सभी उपचारों ने पाम्पाडुमपारा केन्द्र में खुर गलन रोग आपतन कम करने में महनीयता प्रस्तुत की। चिन्तापल्ली, पन्नियूर और पाम्पाडुमपारा केन्द्रों में रोग नियन्त्रण में पोटैशियम फॉस्फोनट का (0.3%) छिड़काव, दवा लगाना और ट्राइकोडेरमा हरजियानम 50 ग्राम/बेल की दर से 1 कि.ग्राम नीम केक के साथ लगाना चिन्तापल्ली, पन्नियूर और पाम्पाडुमपारा केन्द्रों में रोग नियन्त्रण करने के लिए उत्तम उपचार के रूप में देख लिया जहाँ मुडिगरे केन्द्र में बोर्डियो मिश्रण

(1%) छिड़कना और सीओसी (0.3%) लगाना प्रभावी देखा गया। मूल्यांकन किये बयोरेशनल में नीम गोल्ड (0.5%) को सीपी शल्क (लेपिडो साफस पाइपरिस) की संख्या का दमन करने में प्रभावी देख लिया और शल्कों की सबसे कम संख्या बेलों पर डिमैथोयट (0.05%) उपचार करने पर प्राप्त की!

इलायची

ए आई सी आर पी एस के दो केन्द्रों (पाम्पाडुमपारा और मुडिगरे) में तीन सौ पाँच जर्मप्लासम को बनाये रखे गये। सी वी टी के अन्तर्गत सी एल-722, पी एस-27, एम सी सी-309 और एम सी सी-246 को मुडिगरे में सूखे कैप्सूल उपजता में (337.96 कि. ग्राम/हेक्टर) आशाजनक देख लिया। उपज परीक्षण के आधार पर पी एस-27 और एम एच सी-26 को पाम्पाडुमपारा केन्द्र में आशाजनक प्रविष्टि के रूप में पहचान किया गया। इलायची में आयोजित जैव उर्वरक परीक्षण से प्रकट होता है कि अजैविक फॉस्फोरस अकेला लगाना या पी.सोलुबिलाइजर के साथ लगाना अन्य उपचारों की अपेक्षा अत्यन्त महत्वपूर्ण देख लिया। कैप्सूल पर बाधित पनिकल और क्लम्प बाधा तथा राइजोम गलन रोग को टी. हरजियानम के साथ उपचार किये प्लोटों में और बैक्टीरिया कनसोर्टियम 50 ग्राम/पौधे की दर से लगाकर उपचार किये प्लोटों में बहुत कम देख लिया। चार कीटनाशियों जैसे फोराइट, फिप्रोनिल, थियामेथाक्सम और इमिडाक्लोप्रिड और तीन जैविक कीटनाशियों जैसे नीम केक, मत्स्य तेल रोसिन साबुन और नीम बीज गरी सार की प्रभावोत्पादकता को नये रोपण किये इलायची बागों में तना मकखी के प्रबन्धन के लिए तुलना की गई और यह देख लिया कि फोराइट, इमिडाक्लोप्रिड, थियामेथाक्सम, और नीम केक को अन्य रसायन उपचारों की अपेक्षा प्रत्येक झुरमुट में मर गये इलायची की न्यूनतम संख्या अंकित करने में उच्चतम देख लिया। इलायची के मूल सूंडी की संख्या में महत्वपूर्ण कमी इमिडाक्लोप्रिड (0.006%) और एच. इन्डिका (100 आई जे/सूंडी) का संयुक्त उपचार किये प्लोटों में देख लिया।

अदरक

ए आई सी आर पी एस के केन्द्रों के अन्तर्गत 659 अक्सशनों का अदरक जर्मप्लासम बनाये रख दिया गया। पोटांगी में किये सी वी टी परीक्षण से अधिकतम उपजता $वी_4-5$ (29.21 टन/हेक्टर) में देख लिया और $वी_5-2$ (28.29 टन/हेक्टर) 32.29% और 28.12% अधिक उपजता प्रदान करके राष्ट्रीय चेक सुप्रभा इसके पीछे आता है। जीन प्रकार जैसे एसजी-27/04, एस जी-45/04, एस जी-896 707, एस जी-827, एसजी-716, एसजी-682 और 51/04 को उच्च उपजता एवं उच्च गुणवत्ता के प्रकार के रूप में पहचान की गई। पोटांगी केन्द्र में $वी_4-2$ को उच्च उपजवाले कम रेशा वाले अदरक अक्सशन के रूप में जारी करने के लिए आशाजनक होते हैं। विभिन्न केन्द्रों में किये परीक्षणों से यह प्रकट होता है कि जिक सल्फेट (60 और 90 डीएपी) 0.05%, बोराक्स (60 और 90 डीएपी) 0.2%, और फरस सल्फेट (60 और 90 डीएपी) 1.0% पत्तों पर छिड़कने से उपजता और गुणवत्ता पैरामीटर्स में वृद्धि हुई। कुमारगंज में राइजोम गलन रोग के लिए किये गये अध्ययन से यह प्रकट होता है कि राइजोम गलन का कम आपतन (24.00%) और अधिकतम राइजोम उपजता 45.55 किन्टल/हेक्टर जब राइजोम को 51° से ग्रेड तक गरम किये पानी में 30 मिनट ट्राइकोडरमा हरजियानम में और 30 मिनट नीम केक के मिश्रण में रखकर बीज उपचार करने पर प्राप्त होता है।

हल्दी

ए आई सी आर पी एस के अन्तर्गत आठ केन्द्रों में एक हजार दो सौ अस्सी जर्मप्लासम अक्सशनों को बनाये रख दिये! इनमें से पर्ण चित्ती और पर्ण दाग रोगों के प्रति प्रतिरोधकता की छानबीन किये 265 हल्दी जर्मप्लासम अक्सशनों में हल्दी जर्मप्लासम अक्सशनों जैसे सी एल -1, 2, 3, 6, 14, 22, 25, 31, 32, 33, 53, 54, 148, 153, 230 को पर्ण चित्ती (8-10 पीडीआई) के लिए प्रतिरोधक देख लिया और पर्ण दाग के लिए अक्सशने जैसे, सी एल - 8, 9, 139, 153, 160 और 161 प्रतिरोधक (10 पीडीआई) होते हैं! रोग आपतन के लिए किये गये सर्वेक्षण से सूचित होता है कि तीन प्रमुख रोगों जैसे टफरीना स्पीसीस द्वारा होनेवाले पर्ण दाग, कोलटोड्राइकम स्पीसीस द्वारा होनेवाले पर्ण चित्ती और राइजोम गलन कूचबिहार के दो ब्लोक में और एक कूचबिहार जिला के दिनहटा ब्लोक में प्रतिरोधक देख लिया! दुग्गिराला रेड चेक प्रजाति की तुलना में पोटांगी में, पीटीएस -15 को अधिक ताजा राइजोम उपज (25.5टन/हेक्टर) के लिए अंकित किया जिसके बाद आता है आई टी.1 (24.2टन/हेक्टर)! जर्मप्लासम अक्सशनों में कुरकुमिन की मात्रा में कोयंबतोर में 3.0 से 3.5% तक का अन्तर होता है! कुरकुमिन की अधिकतम मात्रा 3.5% अक्सशन संख्या सीएल-57 द्वारा अंकित किया! ओलिओरसिन की मात्रा में 8.5 से 12.5% तक का अन्तर होता है और अधिकतम ओलिओरसिन की मात्रा सीएल-219 (12.5%) द्वारा अंकित किया! अक्सशनों के बीच सुगन्ध तेल की मात्रा में 2.0 से 4.5% तक का अन्तर होता है! सुगन्ध तेल की अधिकतम मात्रा (4.5%) सीएल-20 द्वारा अंकित किया! अक्सशन पी.टी.एस-43 को पोटांगी केन्द्र में उच्च उपजता एवं अधिक कुरकुमिन मात्रा के रूप में जारी करने के लिए आशाजनक पहचान की गई! एकीकृत उपचार से अधिकतम राइजोम उपजता (24.8टन/हेक्टर) अंकित किया जिसके बाद आता है अजैविक (22.9टन/हेक्टर) जहाँ जैविक उपचार के द्वारा जगतियाल केन्द्र में हल्दी के जैविक खेती परीक्षण में 21.2टन/हेक्टर अंकित किया! मृदा में अहाता खाद 30 टन/हेक्टर+20 क्विन्टल/हेक्टर वर्मी कम्पोस्ट+8 क्विन्टल/हेक्टर नीम ओयल केक लगाने पर पौधों की अधिकतम उंचाई (126.67 से. मी.) प्रत्येक पौधों के टिल्लर्स की संख्या (5.40), प्रत्येक टिल्लर्स में पत्तों की संख्या (14.60) और प्रत्येक बरतन से उपजता (15.20 कि. ग्राम/3मीटर²) या उपजता (50.67 टन/हेक्टर) प्रदान किये जिसके बाद धोली केन्द्र में मृदा में अहाता खाद 30 टन/हेक्टर+ 15 क्विन्टल/हेक्टर वर्मी कम्पोस्ट+ 8 क्विन्टल/हेक्टर नीम ओयल केक लगाने पर प्राप्त होता है!

वृक्ष प्रजातियों

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 जर्मप्लासम के लक्षण वर्णन से छाल की उपजता 469ग्राम सूखे छाल/पौधा और पत्तों की उपजता 6.3 कि.ग्राम/पौधा देनेवाले सेलक्शन 65 की पहचान की गई! पीचिपराई से एक साधारण संग्रह की भी पहचान की गई जो अधिक पर्ण उपजता 6.2 कि.ग्राम/पौधा और छाल उपजता 464.5 ग्राम/पौधा प्रदान करनेवाला है!

धनिया

विभिन्न केन्द्रों में धनिया की एक हजार आठ सौ पचानबे जर्मप्लासम बनाये रख दिये गये! हिसार में किये आई ई टी में डीएच 220 और डीएच 233 जैसे दो प्रविष्टियों को उच्च उपजवाले के रूप में पहचान की गई और

अधिक मूल्यांकन के लिए समन्वित प्रजातीय परीक्षण में शामिल किया! कोयंबतोर में किये सीवीटी परीक्षण से एलसीसी 170 और यूडी 206 को क्रमशः 928.33 कि. ग्राम/हेक्टर और 923.33 कि. ग्राम/हेक्टर उपजता के साथ उच्च उत्पादक के रूप में पहचान की गई! प्रस्तुत वर्ष हिसार से तीन प्रविष्टियाँ जैसे सीओआर 5 (1913 कि. ग्राम/हेक्टर) सीओआर 4 (1825 कि. ग्राम/हेक्टर) और सीओआर 2 (1670 कि. ग्राम/हेक्टर) को उच्च उत्पादक के रूप में पहचान की गई! एलसीसी 244 (18.9 टन/हेक्टर) एलसीसी 233 (18.5 टन/हेक्टर) और एलसीसी 234 (18.0 टन/हेक्टर) को कोयंबतोर केन्द्र में अच्छे पूर्ण प्रकार के रूप में पहचान की गई! सीओआर 4ए सीओआर 10, सीओआर 11, सीओआर 12, सीओआर 13, सीओआर 14, सीओआर 15 को धोली केन्द्र में देर से पकनेवालों के रूप में पहचान की गई! कुमारगंज में सीओआर 9 (19.90 क्विन्टल/हेक्टर) सीओआर 8 (19.37 क्विन्टल/हेक्टर) को उच्च उपजवालों के रूप में पहचान की गई! धनिया पर जैव नियामकों के प्रभाव पर किये अध्ययन से यह सूचित करता है कि धान उपज में 693 कि.ग्राम/हेक्टर से 901.2 कि. ग्राम/हेक्टर तक का अन्तर होता है! अधिकतम धान उपज 901.2 कि. ग्राम/हेक्टर बुआई के 40 दिन बाद ट्राइकोन्टानोल 0.5 मि. लिटर छिड़कने से प्राप्त हो गये! कोयंबतोर में सूखा सह्यता के लिए मूल्यांकन किये पचास उच्च उपजवाले जीन प्रकारों में, जीन प्रकार सीएस 127 को आशाजनक देख लिया! बुआई के 60 दिनों के बाद प्र्यूडोमोनास (आई आई एसआर 6 वियुक्तियाँ) बीज उपचार एवं पत्तो पर छिड़कना धनिया में पाउडरी मिल्ड्यू के आधिक्य को कम करने में प्रभावी हो गये!

जीरा

जोबनर और जगुदान केन्द्र ने जीरा के 623 जर्मप्लासम बनाये रख दिये! जोबनर में म्लानी, ब्लाइट और पाउडरी मिल्ड्यू के प्रति आई ई टी परीक्षण किये दस प्रविष्टियों से युसी-331 और युसी-225 को म्लानी, ब्लाइट और पाउडरी मिल्ड्यू के प्रति प्रतिरोधक पहचान की गई! जगुदान में जीरा की वृद्धि और उपजता पर रिजोबैक्टीरिया के प्रभाव पर अध्ययन करने के लिए किये परीक्षण से यह देख लिया कि रिजोबैक्टीरिया लगाने से जीरा की उपजता और गुणवत्ता बढ़ाने लायक कोई महत्वपूर्ण स्वभाव नहीं देख लिया ! ब्लाइट को नियन्त्रण करने के लिए मैनकोजेब 0.25% बुआई के 40, 50, 60 और 70 दिनों के बाद छिड़कना प्रभावी होता है! ब्लाइट को नियन्त्रण करने के लिए प्रभावी देखे गये अन्य तरीके हैं मध्या सौरीकरण + मैनकोजेब 0.25% की दर में बुआई के 60 दिनों के बाद छिड़कना और वर्मीकम्पोस्ट + ट्राइकोडरगा हर्जियानम मिट्टी में लगाना + मैनकोजेब 0.25% की दर में बुआई के 60 दिनों के बाद छिड़कना भी उत्तम होता है।

सौंफ

ए आई सी आर पी एस के अन्तर्गत कुल 617 सौंफ जर्मप्लासम बनाये रख दिये गये! हिसार से एच एफ 131, और एच एफ 143 और जोबनर से एनएस 63, एनएस 46, आरएफ 125 और आरएफ 101 को सीवीटी में अधिक मूल्यांकन करने के लिए आईईटी से आशाजनक प्रविष्टियों के रूप में पहचान की गई! जोबनर में सीवीटी की प्रविष्टियों में बाष्पशील तेल की मात्रा में 1.60% से 2.47% तक अन्तर होता है! अधिकतम बाष्पशील तेल 2.47% एफएनएल 17 में देख लिया और एफएनएल 15 और एफएनएल 20 में 2.27% उसके बाद आता है जबकि न्यूनतम 1.60% एफएनएल 14 में देख लिया! बाष्पशील तेल की उपजता (41.36 लि. हेक्टर) में एफएनएल 15 प्रथम स्थान पर आते हैं और एफएनएल 16 (40.04 लि. हेक्टर), आर एफ 125 चेक (34.36 लि. हेक्टर), एफएनएल 17 (32.

93 लि हेक्टर) और एफएनएल 14 (28 52 लि हेक्टर) उराके बाद आते है। सबसे कम बाष्पशील तेल की मात्रा 20.07 लि हेक्टर एफएनएल 23 मे अकित किया। प्रत्येक पौधे के पुष्प छत्र की संख्या, प्रत्येक पुष्प छत्र के पुष्पछत्रियों की संख्या, प्रत्येक पुष्पछत्री मे धान की संख्या और प्रत्येक प्लॉट या प्रति हेक्टर मे अजैविक नाइट्रोजन (100%) + अहाता खाद (5टन/हेक्टर) + अजोस्परिल्लम, अजैविक नाइट्रोजन (75%) + अजोस्परिल्लम + अहाता खाद (5टन/हेक्टर) और अजैविक नाइट्रोजन (50%) + अजोस्परिल्लम + अहाता खाद (5टन/हेक्टर) और अजैविक नाइट्रोजन (50%) + अजोस्परिल्लम + अहाता खाद (5टन/हेक्टर) को नियन्त्रण से तुलना करने पर अपेक्षतया उत्तम देख लिया।

मेथी

ए आई सी आर पी एस के केन्द्रो में मेथी की 967 जर्मप्लाराम बनाये जाते है। सीवीटी प्रविष्टियों मे जेएफ 270 मे अधिकतम उपजता 573 कि. ग्राम/हेक्टर अकित किया जो कोयबतोर केन्द्र से प्राप्त आरएमटी 303 (543.33 कि. ग्राम/हेक्टर) से काफी दूर होता है। एफजीके 14 को धोली केन्द्र मे 2.18 टन/हेक्टर उपजता के साथ आशाजनक पहचान की गई। हिसार से एचएम 348 और एचएम 355 को आई ई टी मे आशाजनक रूप मे पहचान की गई और उसे अतिरिक्त मूल्याकन के लिए समन्वित प्रजाती परीक्षण मे शामिल किये जायेगे। मेथी के उपजो पर जैव उर्वरको के प्रभाव के अध्यन के लिए किये उपचारो मे अजैविक नाइट्रोजन (100%) + अजोस्परिल्लम + अहाता खाद (5टन/हेक्टर) लगाने पर प्रत्येक पौधे से अधिकतम फली (71.73) और उपजता (0.98 कि ग्राम/4 5मीटर² या 2.18 टन/हेक्टर) प्राप्त हुए और अजैविक नाइट्रोजन (75%) + अजोस्परिल्लम + अहाता खाद 5टन/हेक्टर (टी₂) जैसे 0.90 कि ग्राम/4 5मीटर² या 2.00टन/हेक्टर की उपजता उसके बाद आते है। जोबनर की प्रविष्टियों जे. एफजी 244 और एनएस 2006-3 को सूखा सह्यता के रूप मे पहचान की गई। मेथी मे जैव नियामको के प्रभाव पर किये अध्ययन से अधिकतम धान उपजता 595 कि. ग्राम/हेक्टर बुआई के 40 दिनों के बाद 1.0 मि लिटर/लिटर ट्राइकोन्टानोल छिडकने से प्राप्त हो गये। रिजोबैक्टीरियल स्ट्रैन एफएल 18 का बीज उपचार करने पर धोली मे उपजता की वृद्धि और उपज की गुणवत्ता स्वभाव मे भी प्रभावित हुई।

वर्ष 2007-08 मे विभिन्न परियोजनाओ के अन्तर्गत प्राप्त प्रमुख उपलब्धियों इस रिपोर्ट मे प्रस्तुत की जाती है।

एम. आनन्दराज

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 proposed XI Plan budget of AICRPS is Rs. 1400 lakhs with Rs. 231.00 lakhs (ICAR share) during 2007-08. About 115 research programmes covering the mandate spice crops are being conducted at various centres.

Black pepper

Five hundred and eighty five accessions of black pepper germplasm consisting of cultivated, exotic, wild and related species are maintained under different AICRPS centres. The characterization of germplasm resulted in identification of high yielding accessions viz., Karimunda-II (5.60 kg green berry/vine and Vallyaramundi (3.45 kg green berry/vine) from Panniyur centre. Panniyur -1 (2.63 kg dry/vine) and PN-57 (4 kg dry/vine) were identified as high yielders from Sirsi and Yercaud centres respectively. Among the intervarietal hybrids developed at Panniyur centre, P-6 x P-5 was found to be promising with a fresh yield of 3.54 kg/vine. Among the different cultivars of pepper evaluated at Ambalavayal in CVT, Cul.5489 showed the highest spike length (13.34 cm) followed by Cul.5308 (12.46 cm) and Panniyur-1 (12.41 cm). At Panniyur centre maximum yield/vine was recorded in Cul.5489 (1.8 kg green berry/vine) and was on par with Karimunda OP, Cul.5308, Panniyur-1, Karimunda and Coll.1041. Rooting of orthotropic shoot of black pepper cuttings at Dapoli centre indicated that two noded cuttings was superior to three and five noded cuttings. Integrated nutrient management treatment recorded maximum yield at Panniyur and Sirsi centres when compared to organic and inorganic treatments whereas, inorganic and integrated nutrient management treatments were found to be on par at Pechiparai centre. Among the current technologies available for foot rot management all the treatments were found to be significant in reducing the foot rot incidence at Pampadumpara centre. Spraying potassium phosphonate (0.3%) and application of *Trichoderma harzianum* @ 50 g/vine with 1 kg of neem cake was found to be the best treatment in controlling the disease at Chintapalle, Panniyur and Pampadumpara centres whereas, Bordeaux mixture (1%) spray and COC (0.3%) drenching was found to be effective at Mudigere centre. Among the biorationals evaluated, neem gold (0.5%) was found to be effective in the suppression of mussel scale (*Lepidosaphes piperis*) population and the least scale population was recorded on vines treated with dimethoate (0.05%).

Cardamom

Three hundred and five germplasm have been maintained by two (Pampadumpara and Mudigere) AICRPS centers. Under CVT, entries CL-722, PS-27, MCC-309 and MCC-246 were found promising for dry capsule yield (337.96 kg/ha) at Mudigere centre. Based on the yield trial, PS-27 and MHC-26 were identified as promising entries from Pampadumpara centre. The yield of cardamom treated with inorganic P alone or with P-solubilizer was significantly superior over other treatments. Panicle and clump infections due to capsule and rhizome rot diseases were found to be minimum in plots treated with *T. harzianum* and consortium of

bacteria @ 50 g/plant. The efficacy of four insecticides viz., phorate, fipronil, thiamethaxam and imidacloprid and three organic insecticides viz., neem cake, fish oil rosin soap and neem seed kernel extract were compared for the management of shoot fly in newly planted cardamom plantation and it was found that phorate, imidacloprid, thiamethaxam and neem cake were found superior in recording lowest number of dead hearts per clump compared to other chemical treatments. Significant reduction of cardamom root grub was observed in plots treated with combined application of imidacloprid (0.006%) and *Heterorhabditis indica* (100 IJ/grub).

Ginger

Ginger germplasm of 659 accessions have been maintained under various AICRPS centers. The CVT trial at Pottangi showed maximum yield in V₁E₄-5 (29.21 t/ha) followed by V₂E₅-2 (28.29 t/ha) with 32.29% and 28.12% higher yield over national check Suprabha. The genotypes viz. SG-27/04, SG-45/04, SG-827, SG-716, SG-682 and 51/04 were identified as high yielding and high quality lines. Pottangi centre has identified V1E8-2 as a promising high yielding low fibre ginger accession for release. The experimental results at various centers revealed that foliar spray of 0.05% zinc sulphate (60 and 90 DAP), 0.2% of borax (60 and 90 DAP) and 1.0% of ferrous sulphate (60 and 90 DAP) increased the yield and quality parameters. Study on rhizome rot of ginger at Kumarganj revealed that seed treatment of ginger rhizome in hot water at 51°C for 30 minutes and *Trichoderma harzianum* for 30 minutes mixed with neem cake is effective in reducing the disease incidence (24%).

Turmeric

One thousand three hundred and twelve turmeric germplasm accessions have been maintained by eight centers under AICRPS. Out of the 265 germplasm accessions screened for resistance against leaf spot and leaf blotch diseases at Coimbatore centre, accessions viz., CL-1, 2, 3, 6, 14, 22, 25, 31, 32, 33, 53, 54, 148, 153, 230 were resistant to leaf spot (8 to 10 PDI) and for the leaf blotch, the accessions viz., CL- 8, 9, 139, 153, 160 and 161 were resistant (10 PDI). Survey for disease incidence indicated that three major diseases namely, leaf blotch caused by *Taphrina* spp., leaf spot caused by *Colletotrichum* spp. and rhizome rot were prevalent in 2 blocks of Coochbehar and one block of Dinhata of Coochbehar District. At Pottangi, PTS-15 has recorded more fresh rhizome yield (25.0 t/ha) followed by IT-1 (24.2 t/ha) in comparison to Duggirala Red check variety (25.5 t/ha) in CVT. Curcumin content in the germplasm accessions ranged from 3.0 to 3.5% at Coimbatore. The highest curcumin content of 3.5 per cent was recorded by the accession CL-57. Oleoresin content varied from 8.5 to 12.5% and the highest oleoresin content was recorded by CL-219 (12.5%). The essential oil content varied from 2.0 to 4.5% among the accessions. The highest essential oil content (4.5%) was recorded in CL-20. Pottangi centre has identified PTS-43, as a promising high yielding, high curcumin accession for release. Integrated nutrient application recorded highest rhizome yield (24.8 t/ha) followed by inorganic (22.9 t/ha) whereas, organic treatment recorded 21.2 t/ha in the trial on organic farming in turmeric at Jagatjal center. Soil application of FYM (30 t/ha) + vermicompost (20 q/ha) + neem oil cake (8 q/ha) produced maximum plant height (126.67 cm), number of tillers per plant (5.40), number of leaves per tillers (14.60) and yield per plot (15.20 kg/3m²) or yield (50.67 t/ha) followed by soil application of FYM (30 t/ha) + vermicompost (15 q/ha) + neem oil cake (8 q/ha) at Dholi center.

Tree spices

A total of 38 clove, 119 nutmeg, 39 cinnamon and 10 cassia germplasm have been maintained under three AICRPS centres. Characterization of cinnamon germplasm at Pechipara led to the identification of Sel.65 with a bark yield of 469 g of dried bark/tree and leaf yield of 6.3 kg/tree. A local collection from Pechipara was also identified for high leaf yield of 6.2 kg/tree and bark yield of 464.5 g/tree.

Coriander

One thousand nine hundred and eleven germplasm of coriander have been conserved at various AICRPS centres for further evaluation and characterization. Two entries viz. DH-220 and DH-233 were identified as high yielders in IET at Hisar and would be included in coordinated varietal trial for further evaluation. The CVT trials at Coimbatore identified LCC-170 and UD-206 as high yielders with an yield of 928 kg/ha and 923 kg/ha respectively. Three entries, COR-5 (1913 kg/ha) COR-4 (1825 kg/ha) and COR-2 (1670 kg/ha) were identified as high yielders from Hisar during the year. LCC-244 (18.9 t/ha), LCC-233 (18.5 t/ha) and LCC-234 (18.0 t/ha) were identified as good leafy types at Coimbatore center. COR-4, COR-10, COR-11, COR-12, COR-13, COR-14 and COR-15 were identified as early maturing types from Dholi center. At Kumarganj, COR-9 (19.90 q/ha) and COR-8 (19.37 q/ha) were identified as high yielders. Studies on the effect of bioregulators on coriander at Jobner recommends two foliar sprays of 50 ppm NAA or 1.0 ml/l triacontanol at 40 and 60 DAS for obtaining higher seed yield as well as net returns from coriander crop. Among the fifty high yielding genotypes evaluated for drought tolerance at Coimbatore, the genotype CS-127 was found to be promising. Seed treatment with *Pseudomonas fluorescens* (ISR-6) at the rate of 10 g/kg of seed followed by foliar application at 108 cfu on 60 days after sowing was found to be effective in reducing the powdery mildew intensity in coriander. Seed treatment and soil application of rhizobacterial strain FL-18 gave an yield of 1779 kg/ha in coriander followed by the application of *Trichoderma* MTCC- 5179 (1611 kg/ha).

Cumin

Jobner and Jagudan centres hold 526 accessions of cumin germplasm. Out of ten entries in IET tested against wilt, blight and powdery mildew, UC-331 and UC-225 was identified as resistant entries against wilt, blight and powdery mildew at Jobner. In an experiment to study the effect of rhizobacteria on growth and yield of cumin at Jagudan, it was observed that application of rhizobacteria was not effective in promoting growth and yield significantly. Spraying mancozeb @ 0.25% at 40, 50, 60 and 70 DAS was found to be effective in controlling blight. Soil solarization + soil application of *Trichoderma harzianum* + spraying mancozeb @ 0.25% at 60 DAS and application of vermicompost + soil application of *Trichoderma harzianum* + spraying mancozeb @ 0.25% at 60 DAS were also effective for controlling the disease.

Fennel

Six hundred and twenty five accessions are conserved in different centres under AICRPS. HF-131 and HF-143 from Hisar and NS-63, NS-46, RF-125 and RF-101 from Jobner were identified as promising entries from IET for further evaluation in CVT. The volatile oil content in the entries of CVT at Jobner ranged from 1.60% to 2.47%. The maximum volatile oil of 2.47% was observed in FNL-17 followed by 2.27% in FNL-15 and FNL-20, while, minimum of 1.60% in FNL-14. FNL-15 recorded an yield of 41.36 l/ha followed by FNL-16 (40.04 l/ha). RF-125 check (34.36 l/ha), FNL-17 (32.93 l/ha) and FNL-14 (28.52 l/ha). Application of inorganic nitrogen (100%) + FYM 5 t/ha + *Azospirillum*, inorganic nitrogen (75%) + *Azospirillum* + FYM 5t/ha, inorganic nitrogen (50%) + *Azospirillum* + FYM 5 t/ha and inorganic nitrogen (50%) + *Azospirillum* + FYM 5t/ha were found significantly superior as compared to control regarding number of umbels per plant, number of umbellet per umbel, number of grains per umbellet and grain yield.

Fenugreek

AICRPS centres maintain 978 germplasm accessions of fenugreek. Among CVT entries, JF-270 recorded the highest yield of 573 kg/ha, which was on par with Rmt-303 (543 kg/ha) from Coimbatore centre. FGK-14 was identified promising from Dholi centre with an yield of 2.2 t/ha. HM-348 and HM-355 were identified as promising in IET from Hisar and would be included in coordinated varietal trial for further evaluation. Among the treatments to study the effect of biofertilizers on yield of fenugreek, inorganic nitrogen 100% + *Azospirillum*

– 5t/ha FYM gave the maximum number of pods per plant (72) and yield (0.98 kg/4.5 m² or 2.18 t/ha) followed by inorganic nitrogen 75% + *Azospirillum* – 5 t/ha FYM (yield 0.90 kg/4.5 m² or 2.00 t/ha). Entries J Fg -244 and NS-2006-3 were identified as drought tolerant at Jobner. Studies on the effect of bioregulators in fenugreek indicated that highest grain yield of 595 kg/ha was obtained by spraying of triconanol 1.0 ml/l at 40 days of sowing. Treatment of seed with rhizobacterial strain FL-18 was effective in increasing yield and yield attributing characters in fenugreek at Dohli centre.

The salient findings during 2007-08, under different projects are presented in this report.

M. Anandaraj

1. Black Pepper

1.1 Genetic Resources and Crop Improvement

1.1.1 Germplasm collection, characterization, evaluation and conservation (Chintapalle, Dapoli, Panniyur, Pundibari, Sirsi, Yercaud)

Among the 22 accessions evaluated at Chintapalle centre, Vellanambar recorded the highest dry yield of 2.5 kg per vine followed by Neelamundi (2.14 kg/vine). The black pepper germplasm maintained at different AICRPS centres are given in Table 1.

The black pepper germplasm consisting of 85 accessions have been maintained at Dapoli centre and are being evaluated for various morphological and yield characters.

Two hundred and eighty nine accessions of black pepper, which consists of 214 cultivated, 72 wild and related species and 3 exotic types are being maintained at Panniyur center. During the year 2007-08, Karimunda-II recorded maximum green berry yield of 5.60 kg/vine followed by Valiyaramundi (3.45 kg/vine) and TMB-IV (1.80 kg/vine). The number of spikes was maximum for Karimunda-II (2532) followed by Valiyaramundi (1576). The spike length was maximum for Valli (11 cm) and number of berries/spike were more for Valiyaramundi (22 cm). Hundred-berry weight was higher for Moozhiyar and Vally (18 g) when compared to other accessions.

During the year, three new genotypes from Terai zone of West Bengal were added to the germplasm accessions maintained at Pundibari center making a total of 19 accessions.

At present 121 germplasm collections are maintained at Sirsi centre. All the collections are susceptible to *Phytophthora* foot rot disease. Among the six promising accessions Panniyur-1 recorded maximum dry yield of 2.63 kg/vine followed by Kudragutta (2.05 kg/vine).

Among the 137 germplasm accessions evaluated at Yercaud, berry set was observed in sixty three accessions. Accession PN-57 recorded 12.0 kg green berry/vine. PN-33 recorded the highest value for spike length (12.4 cm) and number of berries/spike (68).

Table 1. Black pepper germplasm collections under AICRPS centres

Centre	Indigenous		Exotic	Total
	Cultivated	Wild and related sp.		
Chintapalle	58	-	-	58
Dapoli	79	6	-	85
Panniyur	214	72	3	289
Pechiparai	12	1	-	13
Pundibari	16	3	-	19
Sirsi	120	-	1	121
Total	499	82	4	585

1 2 Hybridization Trial

1 2 1 Intervarietal hybridization to evolve high yielding varieties
(Panniyur)

Intervarietal hybridization is being carried out every year at Panniyur centre and the hybrids obtained are being planted and evaluated. Among the intervarietal hybrids, P-6 x P-5 was found to be promising with a fresh yield of 3.54 kg/vine.

1 3 Coordinated Varietal Trial (CVT)

1 3 1 CVT 1991 Series IV
(Yercaud)

Among the 14 accessions evaluated at Yercaud, Panniyur-3 performed well with a maximum mean yield of 12.0 kg of green berry/vine (3.6 kg dry berry/vine) and hundred-berry weight of 12.4 g. The increased yield in Panniyur-3 is perhaps due to long spike length and spike intensity.

1 3 2 CVT 2000 Series V
(Ambalavayal, Chintapalle, Pampadumpara, Panniyur, Sirsi)

Among the thirteen cultivars of pepper evaluated at Ambalavayal centre, Panniyur-1 recorded the highest fresh weight of 6.69 kg berries/vine and maximum dry weight of 0.717 kg berries/standard. Cul 5308 recorded maximum number of spikes/standard (367.36) followed by Karimunda-OP (327.15) and Panniyur-1 (289.83). The longest spike was registered in Cul 5489 (13.34 cm) followed by Cul 5308 (12.46 cm) and Panniyur-1 (12.41 cm) and lowest spike length was recorded in PRS-22 (6.63 cm). Among the thirteen cultivars, HP-1411 recorded the highest number of berries/spike (71.66) followed by Panniyur-1 (63.25) and Cul 5308 (61.04).

Among 12 varieties, early spiking was observed in Cul 5489 and Coll 1041 at Chintapalle centre. Coll 1041 recorded highest plant height (2.46 m) followed by HP-34 (2.03 m) whereas, Karimunda-OP recorded the lowest plant height (0.86 m).

In general, the yield performance was very low at Pampadumpara centre. Cul 5308 registered the highest yield (575 g/plant) and all the accessions except Cul 5308 (575 g/plant) and Coll 1044 (110 g/plant) recorded less than 100 g of dry berry yield per plant. Minimum dry weight per plant was recorded in OPKM (12.62 g), HP-813 (15.41 g) and HP-34 (38.61 g). Maximum spike length was observed in Panniyur-1 (16.4 cm) followed by OPKM (15.1 cm). Number of berries per spike ranged from 4.2 in OPKM to 58.8 in Cul 5308. Out of 12 accessions studied, Cul 5308 as well as Coll 1041 registered highest yield mainly due to maximum spike length and more number of berries per spike although its hundred-berry volume as well as weight was very low. Black pepper accessions, HP-1411, HP-105, PRS-21 and PRS-22 were found to be tolerant to *pollu* disease and Panniyur-1 was highly susceptible.

At Panniyur centre maximum yield/vine was recorded in Cul 5489 (1.847 kg green berry/vine) and was on par with Karimunda OP, Cul 5308, Panniyur-1, Karimunda and Coll 1041 (Table 2). The number of spikes/vine was maximum in Coll 1041 followed by Karimunda. There was no significant difference between cultures for number of spikes. The maximum spike length was recorded in Cul 5489 (12 cm) and this was significantly superior to all other entries except Panniyur-1 (10.7 cm). The number of berries/spike was more for Cul 5489 and Coll 1041 (35 berries/spike) and was significantly superior to all other genotypes.

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

Genotype	Yield (green berry kg/vine)	No. of spikes /vine	Spike length (cm)	No. of berries /spike	Weight of 100 berry (g)	Dry recovery (%)
Kalluvally-IV	1.020	316	8.0	16.7	13.00	39
Karimunda-II	0.343	155	7.3	16.7	11.00	36
Karimunda-III	0.587	254	9.7	18.0	12.00	39
Cul 5308	1.507	413	9.0	26.0	13.00	38
Cul 5489	1.847	455	12.0	34.7	14.00	41
HP-34	0.930	278	6.7	21.3	14.00	40
HP-105	0.750	274	7.7	20.0	12.00	35
HP-813	0.633	314	9.3	20.0	11.00	41
HP-1411	0.960	297	8.7	35.0	11.00	39
Karimunda OP	1.747	421	9.3	20.3	14.00	41
Coll. 1041	1.263	537	7.0	21.3	12.00	35
Panniyur-1	1.327	365	10.7	25.3	14.00	43
Karimunda	1.373	510	7.3	19.0	12.00	41
CD (P=0.05)	0.584	NS	2.1	3.6	NS	
CV (%)	32.000	37	14.0	20.0	14.00	
SE	0.200	75	0.7	2.5	0.99	

Fourteen entries were evaluated at Sirsi. The height of the plant was maximum in HP-05 (3.45m) followed by OP Karimunda (3.40 m). Spiking was initiated in entries viz. HP-34, HP-105, OP Karimunda, HP-813, HP-1411, PRS-22, and Panniyur-1.

1.3.3. CVT 2006

(Chintapalle, Dapoli, Pampadumpara, Panniyur, Pechiparai Pundibari, Sirsi, Yercaud)

Multiplication of the planting materials of 8 genotypes of black pepper namely, PRS- 67, HB-20052, Acc.33, Acc.53, Acc.57, Acc.106, C-1090, HP-39 is under progress to initiate the experiment during the ensuing season at Chintapalle, Dapoli, Pampadumpara, Panniyur, Pechiparai, Pundibari, Sirsi and Yercaud centres.

1.4 Nutrient Management Trial

1.4.1 Development of organic package for spice based cropping systems

(Chintapalle, Dapoli, Sirsi, Panniyur)

The trial was laid out in 2006 at Chintapalle centre and the vines are in the vegetative phase. The growth of vines was satisfactory at Dapoli and the organic and inorganic package recorded a mean vine length of 0.45 m and 0.30 m respectively during the first year. At Sirsi, the vines treated with recommended package of practices recorded higher dry berry yield (1.03 kg/vine) compared to those with only organics (0.82 kg/vine).

1 4 2 Organic farming in black pepper -2006

(Dapoli, Panniyur, Pechiparai, Sirsi, Yercaud)

At Panniyur, the integrated management treatment recorded the maximum green berry yield of 3 684 kg/vine followed by inorganic treatment (2 389 kg/vine). Integrated treatment was significantly superior to other two treatments. The number of spikes/vine was also maximum for integrated treatment (704) and this was significantly superior to other two treatments (Table 3).

Treatments were imposed in an established pepper garden at Pechiparai centre. The highest yield of 3 86 kg/vine was recorded in the inorganic treatment and it was on par with the integrated treatment, which recorded an yield of 3 58 kg/vine.

The plant growth was satisfactory under various treatments at Sirsi. Among three treatments, the maximum dry berry yield (1 03 kg/vine) was recorded in the vines treated with integrated inputs as compared to those with only inorganics (0 99 kg/vine) and organics (0 96 kg/vine).

Highest yield of 12 0 kg and 3 48 kg of green and dry berry yield was recorded in FYM 10 kg + Azospirillum 50 g + Phosphobacteria 50 g + VAM 200 g at Yercaud centre.

The experiment would be initiated during 2008-09 at Dapoli as the available *Erythrina* standards were damaged by gall fly infestations.

Table 3 Yield of black pepper under organic farming at Panniyur

Treatment	Yield (green berry kg/vine)	No. of spikes /vine	Spike length (cm)	Berries /spike	Dry recovery (%)
Organic	2 252	505	10	39	45
Integrated	3 684	704	12	45	46
Inorganic	2 389	529	10	40	44
CD (P=0.05)	0 519	74	NS	NS	
CV %	35 000	24			
SE	0 367	53			

1 4 3 Effect of micronutrients on black pepper (Adaptive trial)

(Panniyur)

The experiment was started as observational trial during 2007 at Panniyur centre. Vines showing yellowing/deficiency symptoms were selected and Zn So₄ @ 30 g/vine was applied. The stand of the crop is satisfactory without any yellowing.

1 4 4 Rooting of orthotropic shoots of black pepper

(Dapoli, Panniyur, Pechiparai, Sirsi, Yercaud)

A trial on rooting of orthotropic shoots of black pepper cuttings var Panniyur-1 with 72 treatment combinations was laid out at Dapoli centre. Rooting per cent was highest (28 89) in two noded cutting and

was found to be significantly superior to three and five noded cuttings. Among the rooting media, sand and sand:soil:FYM were found to be at par and were significantly superior to coir pith. Polybag humid chamber was significantly superior to poly shade for rooting. The interaction effect was not significant.

The experiment was started as observational trial during 2007 at Panniyur centre. The trials would be conducted during 2008 in other centres.

1.5 Disease Management Trial

1.5.1 Adaptive trial on management of *Phytophthora* foot rot of black pepper in farmers' field

(Chintapalle, Dapoli, Mudigere, Panniyur, Pampadumpara, Sirsi)

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 farmers. The observations on management of *Phytophthora* foot rot disease in black pepper at Chintapalle centre revealed that less foliar yellowing (8.53%), less defoliation (10.15%), less death of vines (2.38%) and highest green berry yield of 2.980 kg per vine was recorded when vines were treated before onset of monsoon (May), during rainy season (June-July) and during 2nd fortnight of August with potassium phosphonate (0.3%) as spray (2 l/vine) and application of *Trichoderma harzianum* 50 g per vine with 1 kg of neem cake to the root zone.

At Dapoli, the treatments were imposed during pre and post monsoon periods in farmers' field. Foot rot incidence, leaf infections, foliar yellowing, defoliation and collar infections were not observed in any of the treatments. The difference in mean dry berry yield recorded under various treatments was non-significant.

Minimum foliage infection (7%) was recorded in 1% BM spray and 0.3% COC drench (T_2) which was followed by 0.3% potassium phosphonate + *T. harzianum* application (T_1) as compared to control (farmers' practice) at Mudigere centre. Fifty per cent reduction in leaf yellowing and defoliation was noticed in T_1 and T_2 as compared to farmers' practice (21% yellowing and more than 50% defoliation). Higher canopy size of 3.72 m and yield of 413.75 g/vine was recorded in T_1 as compared to farmers' practice (356.25 g/vine).

Potassium phosphonate + *Trichoderma* application gave less incidence of defoliation and was more effective in controlling the disease at Panniyur centre. There was no significant difference between treatments for yield and plant growth data.

All the treatments were found to be significant in reducing the foot rot incidence at Pampadumpara. The disease index ranged from 3.1 in potassium phosphonate (0.3%) + *T. harzianum* (@ 50 g/vine) treated vines to 10.1 on vines adopted by local practice of farmers. The plots treated with potassium phosphonate @ 0.3% and *T. 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% drench (Table 4).

At Sirsi, it was observed that black pepper vines were least infected with *Phytophthora* foot rot of black pepper where the vines were protected with potassium phosphonate (@ 0.3% as spray @ 2 l/vine) and drenching (@ 3 l/vine) and soil application of *T. harzianum* @ 50 g per vine with one kg of neem cake to the root zone during pre monsoon and peak monsoon.

Table 4. Management of *Phytophthora* foot rot of black pepper at Pampadumpara

Treatment	Disease index
Potassium phosphonate (0.3%) + <i>Trichoderma harzianum</i> (50 g/vine)	3.1
Bordeaux mixture (1% spray) + COC (0.2% drench)	6.9
Farmers' practice (Bordeaux mixture 1% spray and drench)	10.1
CD (P=0.05)	0.6

1.5.2 Trial on management of *Phytophthora* foot rot of black pepper in existing plantation (Chintapalle, Dapoli, Mudigere, Pampadumpara, Panniyur, Sirsi)

The observations on management of *Phytophthora* foot rot disease in black pepper at Chintapalle centre revealed less foliar yellowing (13.52%), less defoliation (15.28%), less death of vines (4.72%) and highest green berry yield of 2.46 kg per vine when vines were treated before onset of monsoon (May), during rainy season (June-July) and during 2nd fortnight of August with potassium phosphonate (0.3%) as spraying (2 l/vine) and drenching of *T. harzianum* 50 g/vine with 1 kg of neem cake to the root zone.

Management of *Phytophthora* foot rot of black pepper in coconut cropping system was conducted during 2007-08 at Dapoli center. First application of treatments was done during onset of monsoon (June) and again during third week of August. Disease incidence of *Phytophthora* foot rot of black pepper was not observed during this season. During the first year there was no significant difference between treatment means for disease incidence and dry berry yield (kg/ha). The dry berry yield ranged between 0.880 and 0.960 kg/ha among the treatments.

At Mudigere centre, all the treatments were effective in reducing the disease incidence as compared to control (Table 5). The maximum reduction in leaf yellowing (7.5%), defoliation (3.25%) and death of vines (1.50%) was recorded in T₂ (1% Bordeaux mixture spray and 0.2% COC drench). With respect to canopy size, the maximum diameter of 2.85 m was recorded in the application of bacterial consortium as compared to control (2.2 m) and maximum yield of 452.5 g/vine was recorded in T₂.

The treatments were imposed during pre and post monsoon periods at Pampadumpara centre. 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 *T. harzianum* and consortium of bacteria @ 50 g/vine followed by application of potassium phosphonate @ 0.3% and *T. harzianum* @ 50 g/vine. The disease index ranged from 3.19 to 11.3. 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 June at Panniyur centre. There was no significant difference between treatments for disease incidence and yield. The control plot showed more yellowing, defoliation and death of vine.

At Sirsi, *Phytophthora* foot rot of black pepper grown under arecanut cropping system was managed by application of vines with potassium phosphonate (@ 0.3 per cent as spray @ 2 l/vine and drench 3 l/vine) and bioagent *T. harzianum* (50 g with one kg of neem cake as soil application) during first week of June and

third week of August 2007 to the root zone. However, bioagent application to vines as spray and drench with consortium of bacteria along with *T. harzianum* (50 g/vine) as soil application with one kg of neem cake was effective in regulating the disease. In case of unprotected black pepper vine, disease was severe with respect to maximum leaf infection (54.55 PDI), maximum leaf yellowing (32.14 PDI), maximum defoliation (30.95 PDI), highest death of vines (35.70 per cent) and least green berry yield (0.36 kg/vine and 144.80 kg/ha projected yield) (Table 6).

Table 5 Effect of biocontrol agent and chemicals on the incidence of foot rot disease in black pepper at Mudigere

Treatment	Leaf yellowing (%)	Defoliation (%)	Death of vines (%)	Canopy size (m)	Yield/vine (g)
T ₁ Potassium phosphonate (0.3%) + <i>Trichoderma harzianum</i>	8.75	5.00	2.25	2.73	388.75
T ₂ Bordeaux mixture spray (1%) + COC (0.2%) drench	7.50	3.25	1.50	2.83	452.50
T ₃ Consortium of bacteria	11.75	6.00	2.00	2.85	381.25
T ₄ Consortium of bacteria + <i>T. harzianum</i>	11.00	7.25	1.50	2.68	334.00
T ₅ Control	15.00	12.00	2.50	2.20	322.50
CV%	21.13	23.16	29.61	13.52	9.94
CD (P=0.05)	3.51	2.39	0.89	0.55	57.56

Table 6 Management of *Phytophthora* foot rot disease in black pepper at Sirsi (Existing plantations)

Treatment	Leaf infection (PDI)	Yellowing (PDI)	Defoliation (PDI)	Death of vines (%)	Green berry yield (kg/vine)
T ₁ Potassium phosphonate (0.3%) + <i>Trichoderma harzianum</i>	13.09	9.52	10.71	7.14	0.83
T ₂ Bordeaux mixture (1%) + Copper oxychloride (0.1% a.i.)	14.28	15.47	15.47	10.71	0.69
T ₃ Consortium of bacteria	21.42	20.23	25.00	21.43	0.54
T ₄ <i>Trichoderma harzianum</i> + consortium of bacteria	17.85	16.66	15.48	14.28	0.63
T ₅ Control	54.55	32.14	30.95	35.70	0.36
SEm ±	3.23	2.33	3.09	6.11	0.04
CD (P=0.05)	9.94	0.18	9.52	18.84	0.11

*32 per cent dry recovery

1 5 3 Trial on management of *Phytophthora* foot rot of black pepper in new plantation (Chintapalle, Dapoli, Mudigere, Pampadumpara, Panniyur, Pechiparai, Sirsi)

The trial was initiated at Chintapalle, Panniyur, Pampadumpara, Sirsi and Mudigere during 2006 in 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.

Among the varieties Panniyur-1 recorded maximum disease incidence at Pampadumpara centre. The disease index for Panniyur-1 ranged from 6.24 to 22.50 and for IISR-Shakthi from 3.96 to 14.23 and for IISR-Thevam from 3.25 to 15.23 (Table 7). 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.

At Pechiparai and Sirsi planting materials of black pepper were put for further multiplication by serpentine method to produce sufficient cuttings for each treatment along with check variety Panniyur-1 in nursery.

Table 7. Management of *Phytophthora* foot rot of black pepper in new plantation at Pampadumpara

Treatment	Disease index		
	Panniyur-1	IISR-Shakthi	IISR-Thevam
Potassium phosphonate (0.3%) + <i>Trichoderma harzianum</i> (50 g/vine)	10.12	6.23	7.42
Bordeaux mixture (1% spray) – COC (0.2 % drench)	12.23	8.34	9.24
Consortium of bacteria (50 g/vine)	10.42	4.24	5.44
<i>Trichoderma harzianum</i> + Consortium of bacteria (50 g/vine)	6.24	3.96	3.25
Control	22.56	14.23	15.23
CD (P=0.05)	0.43	0.34	0.57

1 6 Pest Management Trial

1 6 1 Management of scale insects in black pepper with organic products (Mudigere, Pampadumpara)

The efficacy of insecticides was evaluated at Mudigere during 2007. The treatments with three organic insecticides viz., neem oil, econeem and fish oil rosin soap were compared with monocrotophos and an untreated control. In the pretreatment mussel scale population ranged from 6.99 to 8.05 on leaves and 54.95 to 70.25 on twigs. The population of mussel scales was lowest with fish oil (2.97 and 16.02) treatment followed by neem oil (3.50 and 15.80) (Table 8).

At Pampadumpara, the experiment was conducted in a farmer's field at Kattapana (20 acre) during February to March 2008. 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 cm² leaf area and 2.5 cm twig and are presented in Table 9.

The population of mussel scale, *Lepidosaphes piperis* on black pepper was found to be 39.5 per cm² on leaf and 52.7 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 37.3 to 11.2 on dimethoate-treated plants after the first spray on leaves. Scale population on vines treated with fish oil (23.5) and neem oil (23.1) were found at par. After the second/fourth spray, population of scale insects was reduced to 3.2 on dimethoate-treated vines followed by vines treated with thiamethoxam (8.1). 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. The population reduced from 51.9 to 11.9 in dimethoate-treated vines after the first spray. Scale population on neem oil (30.0) and fish oil-treated vines (30.4) were found to be non-significant and inferior compared to that of vines treated with thiamethoxam (18.0) and neem gold (22.9). After second/fourth spray, vines treated with dimethoate resulted in least population of scale insects (4.4) followed by thiamethoxam-treated vines (9.4). 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%).

Table 8. Management of pepper mussel scale with organic products at Mudigere.

Treatment	Dosage %	Mean number of population per leaf or twig at different days interval									
		Pretreatment		30		60		90		Mean	
		Leaf	Twig	Leaf	Twig	Leaf	Twig	Leaf	Twig	Leaf	Twig
Neem oil	0.5	8.05	59.83	2.10	17.05	2.20	14.50	6.20	15.85	3.50	15.80
Eco-neem	0.5	7.49	54.95	5.30	49.05	5.15	33.10	8.00	27.90	6.15	36.68
Fish oil	0.3	7.66	64.50	2.45	16.95	2.00	17.90	4.45	13.20	2.97	16.02
Monocrotophos	0.05	6.99	70.25	1.05	37.90	1.75	12.15	2.90	9.80	1.90	19.95
Control	-	7.53	55.60	9.15	79.80	7.05	43.25	12.10	32.15	9.43	51.73
CD (P=0.05)		1.76	17.20	1.57	30.55	0.78	5.65	2.72	4.29		

Table 9. Effect of organic products on scale insects of black pepper at Pampadumpara

Treatment	Scale population					
	Leaf			Twig		
	Initial count per cm ²	I* / II# spray	II* / IV# spray	Initial count per 2.5 cm	I* / II# spray	II* / IV# spray
Neem oil (0.5%)#	39.0(8.09)	23.1(6.58)	13.0(5.32)	52.2(9.07)	30.0(7.39)	19.3(6.15)
Neem Gold (0.5%)#	39.5(8.15)	17.9(5.97)	10.1(4.83)	52.5(9.07)	22.9(6.35)	12.0(5.16)
Fosco (3%)#	38.3(8.05)	23.5(6.61)	13.7(5.39)	51.7(9.04)	30.4(7.42)	19.5(6.18)
Thiamethoxam (0.013%)*	38.3(8.22)	15.2(5.61)	8.1(4.45)	52.7(9.11)	18.0(6.00)	9.4(4.70)
Dimethoate (0.05%)*	37.3(7.72)	11.2(5.00)	3.2(3.29)	51.9(9.05)	11.9(5.32)	4.4(3.47)
Control	39.5(8.22)	35.5(7.77)	33.5(7.59)	52.5(9.09)	50.7(8.77)	48.7(7.43)
CD (P=0.05)	NS	0.19	0.42	NS	0.15	0.23

Values in parentheses are square root transformed

2. Cardamom

2.1. Genetic Resources

2.1.1 Germplasm collection, characterization, evaluation and conservation (Mudigere, Pampadumpara)

A total of 152 germplasm were maintained at Mudigere centre. Out of 32 cardamom germplasm evaluated for yield and its attributing traits during 2007, D-141 was the tallest (290 cm). Pothamedu was found superior for number of bearing suckers (14), and panicle number (22). Longest panicle length was observed in Pothamedu and PDP-7. Pothamedu recorded high green capsule yield (198 kg/ha) followed by D-141 and CI-730. The cardamom germplasm maintained at different AICRPS centres are given in Table 10.

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. Yield (fresh and dry) of top ten germplasm accessions were recorded during 2007-08. The highest fresh yield of capsules (7807 g/plant) and dry yield (1695 g/plant) of capsules was recorded in S-1 followed by CR-9 with 7243 g/plant and 1425 g/plant of fresh and dry yield, respectively. CR-9 recorded maximum 100 capsule volume (239.2) and weight (108.7g) followed by PS-44 (225.4 and 106.1 g). Five accessions namely, PS-1 (24.4), PS-44 (22), PS-7 (21.8), Sam-10 and NS-50 (21) registered more than 20 seeds per capsule. CR-9 registered very minimum number of seeds per capsule (18.8). Driage percentage of PS-44 was found to be highest (22.5%) confirming its superiority in recovery percentage. PS-44 was also found to be tolerant to *azhukal* disease (2.86%). Thrips infestation was low in NS-50 (3.54%) and high in S-1 (9.43%). CR-9 was found to be highly susceptible to *azhukal* disease (21.0%) whereas least capsule borer damage was recorded in the same accession.

Table 10. Cardamom germplasm collections of AICRPS centres

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

2.2 Hybridization and Selection

2.2.1 Evaluation of OP progenies under intensive management (Mudigere)

Thirty open pollinated progenies, planted in Mudigere centre during 2002-03, were evaluated. The progeny 23C₈ yielded highest (215.10 kg/ha) followed by 22C₈ (212.50 kg/ha) and 21C₈ (210.21). M-2 was tallest (315.33 cm), 22C₈ and 23C₈ had maximum number of bearing suckers (13.33 and 13.66), 6C₈ had longest panicle

(68.74 cm) and number of capsules/plant (62.00) was maximum in 4C₈. A crossing block involving 5 elite clones M-1, M-2, HS-1, Njallani Gold and CL-726 was established at a closer spacing of 6 x 3' during 2005-06 at Mudigere centre in order to generate all possible cross pollinations through both random open pollination and hand pollination. All the clones were good general combiners and belong to Malabar type, while Njallani green gold is a Vazuka type.

2.2.2 CVT 2000-Series IV (Mudigere, Sakleshpur)

A CVT comprising of 12 cardamom clones planted in 2001-02 was evaluated at Mudigere centre. Three clones were found superior for dry capsule yield and were significantly superior over check (M-2). MHC-10 yielded highest (337 kg/ha) followed by S-1 (289.80 kg/ha) and CL-692 (274.40 kg/ha). Number of bearing suckers (18.10), panicle number (42.01) and number of capsules (51.4) was maximum in MHC-10. Entry S-1 had longest panicle (54.10 cm) (Table 11).

Plant height was significantly more in PS-44 (277 cm) followed by MHC-10 (246 cm) at Sakleshpur centre. Bearing tillers and panicles were significantly more in SKP-170 followed by MHC-10. Yield was significantly more in SKP-170 (785 kg/ha) followed by SKP-165 (625 kg/ha) and in MHC-10 (607 kg/ha) (Table 12). Maximum percentage of bold capsules (capsules retained in 8 mm sieve) was found in CL-692 (51.6%) followed by ICRI-3 (50.9%).

Table 11. Performance of cardamom clones in CVT- 2000 at Mudigere

Clone	Plant height (cm)	Suckers /plant	Bearing suckers /plant	Panicles /plant	Panicle length (cm)	Capsules /panicle	Internodes /panicle	Dry capsule yield (kg/ha)
MHC-10	288.42	38.01	18.10	42.01	52.80	51.40	18.90	337.00
S-1	302.00	26.01	13.02	40.02	54.10	47.04	18.01	289.80
CL-692	266.41	38.90	18.00	42.00	46.40	38.90	17.89	274.40
MCC-200	262.08	31.80	16.00	33.00	39.97	44.00	17.00	233.50
MHC-18	276.85	28.00	15.01	32.00	42.90	39.00	16.00	219.50
APG-284	200.15	26.00	10.90	23.01	40.80	37.00	15.60	205.00
PS-44	276.07	19.01	10.40	20.00	43.57	47.00	16.90	202.90
M-2	296.72	28.00	14.00	39.00	51.68	42.00	15.70	202.40
APG-293	257.08	26.00	13.00	26.90	50.77	47.00	16.00	199.50
SKP-165	251.80	29.00	13.00	25.70	39.41	35.00	14.00	188.40
SKP-170	279.42	24.00	12.00	27.00	42.20	40.00	15.00	182.90
MHC-13	254.30	30.00	11.00	27.00	38.43	31.00	15.00	168.40
Mean	267.61	27.92	13.27	28.14	45.25	41.71	16.33	225.36
CD ($P=0.05$)	7.55	3.06	1.93	3.36	2.53	2.73	1.70	36.70
CV %	3.33	12.93	17.19	14.12	6.61	7.14	12.33	19.24

Table 12. Yield and yield attributing characters of CVT 2000 cardamom at Sakleshpur

Genotype	Racemes /panicle	Capsules /raceme	Yield (kg/ha)	Increase over released variety (ICRI 3) (%)
Control	17.9	2.9	416.0	-
APG-310	19.8	3.0	464.6	-
APG-306	18.8	3.1	545.3	-
APG-298	16.8	2.9	413.3	-
SKP-165	19.0	3.1	624.7	14.0
SKP-170	20.4	3.2	785.3	43.3
MCC-200	16.7	2.9	373.7	-
MHC-10	16.7	3.1	607.0	10.7
MHC-13	14.7	3.2	404.7	-
MHC-18	16.5	3.1	481.0	-
PS-44	20.7	3.1	451.3	-
S-1	19.8	3.0	472.3	-
CL-692	17.7	2.9	508.0	-
ICRI-3	19.3	3.1	549.0	-
CD (P=0.05)	4.8	0.2	198.2	

2.2.3 CVT - 2005 - Series V (Mudigere, Pampadumpara)

A CVT comprising of 8 clones was initiated in 2005-06 at Mudigere center. CL-722 was found superior for dry capsule yield (337.96 kg/ha) and significantly superior over checks (M-2 and M-1). Other entries which recorded high dry capsule yield were PS-27, MCC-309 and MCC-246. MCC-246 had maximum height (281.96 cm), panicle number (65.33), longest panicle (52.33 cm) and maximum number of capsules (20.40) (Table 13).

Among the seven accessions evaluated at Pampadumpara PS-27 (208.77cm) registered maximum plant height followed by MCC-73 (201.67cm), PS-27 (208.77cm) and MCC-73 (201.67 cm) were found to be taller than the check *Greengold* (198.43cm). Number of tillers ranged from 24.66 (MCC-309) to 32.33 (PS-27). Three accessions namely, PS-27 (32.33), MHC-26 (31.66) MCC-73 (29.11) were found to have more number of tillers than the check *Greengold* (28.77). The highest fresh yield of capsules (550.2 g/plant) and dry yield (125.3 g/plant) of capsules was recorded in PS-27 followed by MHC-26 with 534.1 g/plant and 110.2 g/plant of fresh and dry yield, respectively (Table 14).

Table 13. Performance of cardamom clones in CVT 2005 at Mudigere

Clone	Plant height (cm)	Suckers /plant	Bearing suckers /plant	Panicle /plant	Panicle length (cm)	Capsules /panicle	Internodes /panicle	Dry capsule yield (kg/ha)
MCC-73	235.03	17.33	8.25	44.48	34.30	5.75	9.00	193.59
VCC-246	281.96	19.44	13.00	65.33	52.33	20.40	18.77	286.35
MCC-309	243.59	19.42	12.44	60.11	46.82	16.25	16.44	290.17
V-C-26	236.18	17.78	11.11	58.40	43.27	18.63	16.33	279.99
PS-27	239.74	19.89	13.78	53.19	41.72	17.45	18.67	298.5
CL-722	219.96	20.89	11.00	58.85	50.08	18.55	19.11	337.96
M-1	208.26	18.44	9.55	41.33	35.36	14.85	15.33	175.76
M-2	257.70	18.65	9.92	48.59	41.43	15.81	16.33	199.58
Mean	240.30	18.89	11.13	53.78	43.17	17.21	16.25	257.69
CD (P=0.05)	22.07	2.08	2.93	5.17	2.37	2.49	2.31	50.57
CV %	8.56	10.22	20.56	8.97	13.33	13.49	13.30	25.54

Table 14. Plant growth characters of CVT-2005 cardamom at Pampadumpara

Accession	Plant height	Tiller number	Fresh weight (g/plant)	Dry weight (g/plant)
CL-722	170.41	25.22	395.1	79.0
PS-27	208.77	32.33	550.2	125.3
MCC-246	186.87	26.57	401.5	82.3
MCC-309	188.31	24.66	384.3	76.5
MCC-73	201.67	29.11	423.2	86.23
MHC-26	182.38	31.66	534.1	110.2
Green gold	198.43	28.77	423.2	85.2
Mean	191.62	28.79	441.1	91.9
CD (P=0.05)	7.15	2.43	5.23	3.17

2.2.4 CVT 2007 Series VI

(Mudigere, Pampadumpara, Sakleshpur)

Trial has been laid out in a randomized block design during July 2008 at Mudigere and Pampadumpara centres with thirteen accessions namely, IC-349545, IC-349651, IC-547167, IC-547185 (Appangala), CL-726 and CL-691 (RARS, Mudigere), MCC-346 (ICRI, Myladumpara), PI No. 14 and CR-6 (CRS, Pampadumpara) and *Green Gold* & PV-2 (checks). At Sakleshpur SKP-104 and SKP-164 are being multiplied for distribution to other centers and the trial would be initiated during June 2008.

2.3 Varietal Evaluation Trial

2.3.1 Initial evaluation trial (IET-I)
(Mudigere)

Fifteen open pollinated progenies were evaluated at Mudigere centre. 2-4-D-11 yielded highest (220.14 kg/ha) followed by 2-5-D-11 (195.40 kg/ha) and 7-24-D-11 (189.00 kg/ha). 2-4-17 D-10 was superior for number of bearing suckers (19.67) and number of panicles/plant (35). 2-5-D-11 had longest panicle length (59.44 cm) and number of capsule/panicle (65.44).

2.3.2 Initial evaluation trial (IET-II)
(Mudigere)

In the IET with 13 entries at Mudigere centre, CL-692 yielded highest (332.50 kg/ha) followed by Sel-800 (308.2 kg/ha) and CL-722 (307.50 kg/ha). CL-722 was tallest (301.33 cm) and had maximum bearing suckers (20.00), HS-1 was found superior for number of panicles (42.67), Sel-800 for panicle length (61.80 cm) and CL-691 for number of capsules (50.11).

2.4 Nutrient Management Trial

2.4.1 Effect of biofertilizer *Azospirillum* on cardamom (Final report)
(Mudigere)

The results obtained at Mudigere indicate that the application of inorganic P alone or with P-solubilizer performed significantly superior over other treatments (Table 15 & 16). Application of FYM with or without bioorganism yielded less.

Table 15 Effect of *Azospirillum* on yield parameters of cardamom at Mudigere

Treatment	Bearing suckers	Panicle number	Panicle length (cm)	Capsules /panicle	Nodes /panicle
Inorganic N (100%) + <i>Azospirillum</i> (50 g) + FYM (5 kg)	23.87	41.00	65.71	23.60	16.64
Inorganic N (75%) + <i>Azospirillum</i> (50 g) + FYM (5 kg)	20.80	38.07	65.87	22.75	15.72
Inorganic N (50%) + <i>Azospirillum</i> (50 g) + FYM (5 kg)	19.33	34.73	64.20	21.49	14.45
FYM (5 kg) + <i>Azospirillum</i> (50 g)	16.93	30.40	62.87	16.79	13.45
FYM (5 kg)	19.67	31.47	63.29	17.79	14.01
FYM (10 kg) + <i>Azospirillum</i> (50 g)	18.33	30.47	64.62	17.64	13.15
FYM (10 kg)	17.60	29.53	63.87	17.32	15.08
Inorganic N (100%)	23.73	39.40	67.71	23.21	16.64
Inorganic N (75%)	20.00	38.87	66.20	22.89	16.11
SEm ±	0.58	0.81	1.14	0.46	0.41
CD (P=0.05)	1.74	2.43	NS	1.38	1.23
CV (%)	15.06	14.05	13.05	13.91	14.69

Table 16 Effect of *Azospirillum* on yield of cardamom at Mudigere

Treatment	2004	2005	2006	2007	Mean	CB Ratio
Inorganic N (100%) + <i>Azospirillum</i> (50 g) + FYM (5 kg)	101.78	213.24	220.76	210.14	186.48	1:1.98
Inorganic N (75%) + <i>Azospirillum</i> (50 g) + FYM (5 kg)	79.40	176.52	208.58	189.62	163.56	1:1.77
Inorganic N (50%) + <i>Azospirillum</i> (50 g) + FYM (5 kg)	77.74	161.58	169.16	156.30	141.06	1:1.35
FYM (5 kg) + <i>Azospirillum</i> (50 g)	58.85	140.10	150.16	137.10	121.55	1:1.34
FYM (5 kg)	59.50	130.54	152.36	136.52	119.73	1:1.33
FYM (10 kg) + <i>Azospirillum</i> (50 g)	65.42	121.28	153.59	124.27	116.13	1:1.41
FYM (10 kg)	58.91	114.82	145.29	116.00	108.77	1:1.40
Inorganic N (100%)	101.50	198.74	210.79	190.62	175.25	1:1.92
Inorganic N (75%)	81.44	159.44	194.37	150.11	146.34	1:1.50
S.E.m =	1.44	0.91	4.98	3.25		
CD (P=0.05)	4.32	2.63	14.93	7.21		
CV (%)	10.14	13.57	14.83	12.81		

2.4.2 Effect of biofertilizer P-solubilizers on cardamom (Final report) (Mudigere)

At Mudigere, application of P-solubilizer along with 100% recommended inorganic P (50 g/plant) was significantly superior over all other treatments (Table 17). It also recorded the highest cost benefit ratio, and showed significant improvement in soil available P. This was closely followed by the application of 75% inorganic P + P-solubilizer. However, this was on par with the application of 100% inorganic P-alone. Application of FYM with or without bioorganism recorded low yield. The supporting yield parameters also had similar tendency as that of yield obtained.

Table 17. Effect of P-solubilizer in INM on yield of cardamom at Mudigere

Treatment	2004	2005	2006	2007	Mean	CB Ratio
Inorganic P (100%) + P-solubilizer (50 g) + 5 kg FYM	118.94	220.32	233.22	235.32	201.94	1:1.99
Inorganic P (75%) + P-solubilizer (50 g) + FYM (5 kg)	97.44	211.58	193.28	218.58	180.22	1:1.77

Inorganic P (50%) -- P-solubilizer (50 g) -- FYM (5 kg)	88.32	167.24	173.49	160.23	147.32	1:1.35
FYM (5 kg) -- P-solubilizer	63.43	126.61	130.03	125.11	112.29	1:1.34
FYM (5 kg)	74.37	118.70	136.49	117.30	111.71	1:1.33
FYM (10 kg) -- P-solubilizer (50 g)	75.51	137.52	138.56	136.73	122.08	1:1.41
FYM (10 kg)	71.31	126.92	151.10	125.91	118.81	1:1.40
Inorganic P (100%) -- FYM	98.00	216.72	212.70	210.00	182.93	1:1.92
Inorganic P (75%) + FYM	96.35	165.70	177.91	160.15	150.02	1:1.50
SEm±	5.36	0.80	5.27	3.47		
CD (P=0.05)	16.08	2.43	15.80	10.31		
CV(%)	12.91	12.59	15.31	12.51		

2.4.3 Effect of neem cake on the productivity, pest and disease incidence in cardamom (Mudigere)

At Mudigere, application of neem cake 0.5 or 1 kg/plant was found to be significantly superior over control (Table 18). The maximum dry capsules yield was obtained with the application of neem cake (1.0 kg/plant during May). But high shoot borer damage was noticed. Application of neem cake 0.5 kg/plant during May recorded the highest cost benefit ratio (1:1.86).

Table 18. Effect the neem cake on the productivity, pest and disease incidence on cardamom at Mudigere

Treatment	2005	2006	2007	Mean	CB ratio
Neem cake 0.5 kg/clump (once in May)	233.74	158.51	230.54	207.59	1:1.86
Neem cake 0.5 kg/clump (twice in May/September)	225.56	161.72	223.46	203.58	1:1.58
Neem cake 1.0 kg/clump (once in May)	246.48	161.75	240.48	216.23	1:1.62
Neem cake 1.0 kg/clump (twice in May/September)	222.48	166.40	220.33	203.07	1:1.03
Without neem cake	209.30	152.25	195.44	175.66	1:1.80
SEm±	2.62	4.06	3.85		
C D (P=0.05)	7.08	12.50	10.27		
C V (%)	12.30	15.08	11.98		

2.5 Pest Management Trial

2.5.1 Bioecology of natural enemies of major pests of cardamom (Mudigere)

Observations on natural enemies of the major pests of cardamom with special reference to cardamom thrips and capsule borer at Mudigere indicated that the general predators like spiders in the cardamom ecosystem, larvae of *Chrysoperla* sp. and certain predatory mites were found preying on thrips, more often

weather factors (rainfall) playing a vital role in minimizing thrips population. The larvae of *Conogethes punctiferalis* were found being parasitized by *Xanthopimpla* sp., *Ropalidia* sp. and an unidentified species of *Ichneumonid*. No microbes were found infecting these pests during the study period.

2.5.2 Estimation of quantitative and qualitative losses due to thrips damage in cardamom (Mudigere)

At Mudigere centre, thrips damage was assessed based on the per cent scabbed surface areas of the capsules. Capsules harvested and dried were graded in to four groups as 0 = no damage, 1 = up to 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.

2.5.3 Management of shoot fly in cardamom (Mudigere)

The efficacy of four insecticides viz., phorate, fipronil, thiamethaxam and imidacloprid and three organic insecticides viz., neem cake, fish oil rosin soap and neem seed kernel extract (NSKE) were compared for the management of shoot fly in newly planted cardamom plantation at Mudigere centre during 2007-08. The population of shoot fly was significantly low in all the treatments compared to NSKE and untreated control. However, the treatments phorate, imidacloprid, thiamethaxam and neem cake were found superior in recording lowest number of dead hearts per clump compared to other chemical treatments (fipronil and fish oil rosin soap) (Table 19).

Table 19 Bioefficacy of insecticides against shoot fly in cardamom at Mudigere

Treatment	Dosage	No of dead hearts at different DAT				
		Pretreatment	30	60	75	Mean
Phorate	10 g	7.00	2.00	1.00	1.67	2.34
Neem cake	½ kg	6.66	3.33	1.67	2.00	2.33
Fipronil	1.5 ml	7.33	4.67	4.33	3.00	4.00
Fish oil rosin soap	4 g	7.67	4.33	5.00	3.67	4.33
NSKE	4%	7.00	5.33	5.78	5.00	5.37
Thiamethaxam	0.5 g	10.33	2.33	2.39	1.00	1.90
Imidacloprid	0.5 ml	9.00	1.33	2.33	1.67	1.77
Control		9.00	5.00	6.00	5.33	5.44
CD (P= 0.05)		3.01	1.23	1.10	1.50	

2.5.4 Management of cardamom root grub through entomopathogenic nematodes (Pampadumpara)

A field experiment was conducted at CRS, Pampadumpara to evaluate the efficacy of two 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 2008 and the field was adequately moistened before release of EPN. Initial population of the root grub was assessed as 25.4 in 30 cm³ 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 (60.7%). The cardamom root grub population ranged from 3.3 to 13.4 in 30 cm³ of soil after the application of EPN. Significant reduction (82.7%) 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.

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 and 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 into 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.

2.5.5 Trial on management of panicle rot and clump rot diseases of cardamom in existing plantation (Mudigere Pampadumpara)

At Mudigere all the treatments were found effective in reducing the incidence as compared to control. The minimum of 3.7% blotch was recorded in copper oxychloride (COC) drenching which was followed by potassium phosphonate spray and drench as compared to control (5.1%). Application of COC (0.3%) drenching gave significantly higher dry capsule yield (253.5 kg/ha) followed by potassium phosphonate (0.3%) spray and drench.

Biocontrol agents and fungicides were evaluated against capsule rot and clump rot diseases of cardamom at Pampadumpara. Least disease incidence on tillers, panicles and capsules was recorded in the plots treated with *Trichoderma harzianum* and consortium of bacteria @ 50 g/plant, followed by consortium of bacteria @ 50 g/plant. Tiller infection due to clump rot disease ranged from 3.12% to 17.25% for all the treatments (Table 20). Minimum panicle infection (3.54%) and capsule infection (4.61%) due to capsule rot was recorded in the plots treated with *T. harzianum* and consortium of bacteria @ 50 g/plant and maximum infection on panicles (16.31%) and capsules (16.92%) was observed in control plots.

Table 20 Management of panicle rot and clump rot diseases of cardamom in existing plantation at Pampadumpara

Treatment	Tiller infection (%)	Panicle infection (%)	Capsule infection (%)
<i>Trichoderma harzianum</i> (50 g/vine)	6.92	6.92	6.21
Consortium of bacteria (50 g/vine)	5.31	5.21	4.92
<i>Trichoderma harzianum</i> + consortium of bacteria (50 g/vine)	3.12	3.54	4.61
COC (0.1%) drenching	7.24	8.24	9.21
Potassium phosphonate (0.3%) spray and drench	7.39	7.81	8.65
Control	17.25	16.31	16.92
CD (P=0.05)	0.92	0.82	0.93

2.5.6 Trial on management of panicle rot and clump rot diseases of cardamom in new plantation (Mudigere, Pampadumpara)

The maximum number of suckers (2.54/hill) was produced in T_3 (combined application of *T. harzianum* and consortium of bacteria) as compared to other treatments at Mudigere. The minimum tiller infection (1.16/hill) was recorded in T_5 (0.3% potassium phosphonate spray and drench) as compared to other treatments. All the treatments were non-significant in reducing the incidence of leaf spot and leaf blotch. More number of suckers (2.54/hill) and low incidence of sucker infection, leaf spot and leaf blotch were recorded in V_3 (Nellani gold) as compared to V_1 (Mudigere-1) and V_2 (IISR-Avinash).

Pre and post monsoon treatments were imposed during 2007 at Pampadumpara. Three varieties of cardamom namely *Green gold*, PV-2 and IISR-Avinash were planted for evolving a management strategy for capsule rot and clump rot diseases of cardamom. Maximum disease incidence was noticed in *Green gold* followed by PV-2. The incidence was not noticed in IISR-Avinash. The infection for the varieties is given in Table 21. Plots treated with *T. harzianum* and consortium of bacteria in combination @ 50 g/plant was found effective in the management of disease followed by consortium of bacteria alone @ 50 g/plant.

Table 21 Management of panicle rot and clump rot diseases of cardamom in new plantation at Pampadumpara

Treatment	PV-2			Green Gold		
	Tiller infection (%)	Panicle infection (%)	Capsule infection (%)	Tiller infection (%)	Panicle infection (%)	Capsule infection (%)
<i>Trichoderma harzianum</i> (50 g/vine)	5.91	7.92	6.21	6.32	7.72	7.31
Consortium of (50 g/vine)	4.32	6.21	4.92	5.42	7.41	5.21
<i>Trichoderma harzianum</i> + consortium of bacteria (50 g/vine)	2.12	4.54	4.61	3.32	5.44	4.12
COC (0.1%) drenching	6.25	9.24	9.21	7.42	10.21	10.41
Potassium phosphonate (0.3%) spray and drench	6.33	8.81	8.65	7.43	9.11	9.23
Control	15.32	17.31	17.92	16.42	18.34	18.79
CD (P=0.05)	0.92	0.82	0.93	0.92	0.82	0.93

3. Ginger

3.1 Genetic Resources

3.1.1 Germplasm collection, characterization, evaluation and conservation

(Chintapalle, Dholi, Kumarganj, Pottangi, Pundibari, Raigarh, Solan)

At Chintapalle centre, among 6 collections, Varnugedda, recorded the highest fresh rhizome yield of 11.5 t/ha, followed by Bilukinchangi (11.0 t/ha).

Among 47 germplasm lines evaluated at Dholi, nine germplasm accessions (RG-43, RG-39, RG-29, RG-28, RG-25, RG-15, RG-13, RG-7 and RG-3) registered high yield. RG-43 recorded the maximum yield 9.0 kg/3m² followed by RG-39 (8.5 kg/3m²).

At Kumarganj, maximum yield of 351.20 q/ha was recorded in genotype NDG-55 followed by NDG-28 (140 q/ha), NDG-9 (123 q/ha), NDG-27 and NDG-6 (121 q/ha) over control.

Out of total 177 ginger accessions collected at Pottangi, 143 accessions were evaluated and only 34 accessions yielded more than 8 kg/3 m², the range of yield being 3.0 kg to 12.5 kg/3m². The highest fresh rhizome yield was recorded by No-13 (12.5 kg/3m²), Zo-22 (12.0 kg/3m²), followed by KG-42 (11.5 kg/3m²) and PGS-8 (11.0 kg/3m²).

Twenty nine germplasm of ginger were evaluated at Pundibari centre. Highest rhizome yield/plant was recorded in GCP-31 (263.50 g) followed by GCP-32 (260.50 g), GCP-21 (59.00 g) and GCP-04 (247.33 g). Lowest rhizome yield/plant was recorded in GCP-7 and GCP-22 (148.33 g for both), which was followed by GCP-24 (153.66 g).

Out of the thirty three germplasm accessions were evaluated at Raigarh, maximum yield was obtained in genotype IG-5-10 (3.01 t/ha).

Two hundred and seventy nine collections maintained at Solan were evaluated under field conditions for different horticultural characters. The yield per plot (3 m²) of ten promising lines varied from 4.40 to 8.0 kg. Only two collections viz SG-1142 and SG-27/04 gave yield more than the check Himgiri. Maximum dry matter (21%), essential oil (2%) and oleoresin (6%) were recorded in SG-1142, SG-45/04 and SG-026, respectively. The crude fiber content was minimum (3.0-4.0%) in SG-1026, SG-1116 and SG-17/04. The disease incidence varied from 1.0% (SG-1116) to 3.0% (SG-1704). The germplasm conserved at various AICRPS centers are given in Table 22.

Table 22 Ginger germplasm collection of AICRPS centres

Centre	Indigenous	Exotic	Total
Chintapalle	06	-	06
Dholi	47	-	47
Kumarganj	58	-	58
Pottangi	174	3	177
Pundibari	48	-	48
Raigarh	44	-	44
Solan	279		279
Total	656	3	659

3.2 Coordinated Varietal Trial (CVT)

3.2.1 CVT 2000 Series V (Pottangi, Raigarh)

There was significant difference among the cultivars for fresh rhizome yield at Pottangi centre. Highest fresh rhizome yield was recorded by V_1E_4-5 (29.21 t/ha) followed by V_2E_5-2 (28.29 t/ha) with 32.29% and 28.12% higher yield over national check Suprabha.

The trial was initiated in Raigarh during 2001-02 and is in the fifth year of progress. Seven entries were evaluated during 2007-08. The highest yield was obtained in IG-1 (9.7) t/ha.

3.2.2 CVT 2005 Series VI (Solan)

The entries did not perform well during the period.

3.2.3 CVT 2006 (Kumarganj, Pundibari, Raigarh)

Maximum fresh rhizome yield of 52.33 q/ha was obtained in Suprabha (check) followed by 50.33 q/ha in entry V_2E_5-2 at Kumarganj centre.

Analysis of data at Pundibari centre revealed that the genotype GCP-05 (61.88 cm) had highest plant height followed by GCP-31 (61.74 cm). Highest tiller number was recorded in genotype PGS-8 (9.25) whereas lowest value was recorded in IG-1 (6.42). GCP-31 showed the highest yield per plot (2.48 kg) followed by GCP-05 (2.22 kg) and IG-1 recorded lowest yield (1.14 kg). The lowest disease incidence was recorded in GCP-05 (51.53%) followed by GCP-31 (53.33%) and highest in PGS-8 (62.96%). Highest rhizome yield was recorded in GCP-31 (5.00 t/ha) followed by GCP-05 (4.48 t/ha).

At Raigarh centre, maximum yield was obtained in IG-1 (8.44 t/ha).

3.3 Comparative Yield Trial (Pottangi)

There was significant difference among the cultivars for fresh rhizome yield at Pottangi centre. Highest fresh rhizome yield was recorded by 20.2 (27.52 t/ha) followed by V_1S_1-2 (27.37 t/ha).

3.4 Initial evaluation trial (IET) (Dholi, Pottangi, Raigarh, Solan)

Significant difference among the cultivars was recorded among the entries tested at Pottangi for fresh rhizome yield. Highest fresh rhizome yield was recorded by V₁E₄-5 (28.92 t/ha) followed by PGS-9 (28.46 t/ha) with 33.76% and 31.63% increase over the check variety Suprabha.

Ten entries were evaluated in IET during 2007-08 at Raigarh centre and maximum yield was obtained in IG-1 and IG-5-24 (3.81) followed by IG-5-2 (3.61 t/ha).

Entries showed significant differences for quality and yield per plot at Solan centre (Table 23). Yield varied from 4.0 kg to 6.2 kg per plot. Only two collections (SG-680 and SG-857) gave yield more than check (Himgiri). SG-906 was found superior for quality attributes with 17% dry matter, 2.0% essential oil and low fiber content (4.5%). Between two high yielding collections, SG-680 was found superior for all quality attributes. The disease incidence varied from 5% (SG-857) to 4.5% (V1C1-4).

The experiment failed at Dholi centre due to heavy rain during September 2007

Table 23. Yield, disease incidence and quality attributes of IET ginger at Solan

Entry	Yield/plot (kg)	Converted yield (t/ha)	Disease incidence %	Dry matter (%)	Essential oil (%)	Oleoresin (%)	Crude fibre (%)
SG-970	4.0	8.04	2.5	15.0	1.00	3.5	6.0
SG-1105	4.2	8.44	1.5	14.5	1.00	4.0	6.5
SG-03/04	4.2	8.44	1.0	15.0	0.75	3.0	6.8
SG-680	6.2	12.46	0.5	16.0	1.86	5.5	5.0
SG-825	5.2	10.45	1.0	15.0	1.80	6.5	6.0
PLS-4	5.2	10.45	3.5	16.5	1.80	6.5	6.0
SG-885	5.7	11.45	2.5	17.0	1.75	5.0	5.0
SG-906	5.5	11.05	1.5	17.0	2.00	6.5	4.5
SG-857	6.2	12.46	0.5	18.0	1.50	6.0	7.0
SG-1103	5.6	11.25	1.5	16.5	1.00	5.0	6.0
V1C1-4	5.5	11.25	4.5	16.0	1.00	4.0	5.8
SG-1007	4.9	9.85	2.5	15.0	1.50	6.5	3.5
SG-991	4.7	9.44	2.5	15.5	2.00	6.0	3.5
SG-933	4.5	9.04	2.0	13.5	1.00	4.0	5.0
Himgiri	6.0	120.60	2.0	17.5	1.50	5.0	5.5
CD (P= 0.05)	1.4	-	-	0.9	0.3	0.7	1.0

3.5 Quality Evaluation Trial

3.5.1 Evaluation of ginger germplasm for quality (Solan)

At Solan, among the 41 accessions analyzed for different quality attributes viz., dry matter, essential oil, oleoresin and fiber content during 2008, 23 were found to be superior for quality attributes and had significantly high dry matter content than Himgiri, with more than 1.5 per cent essential oil and more than 4.5 percent oleoresin. Fibre content in these collections was recorded to be less than 6.0 per cent. Dry matter content

ranged from 15.00 to 24.16%. Essential oil and oleoresin contents varied from 0.5 to 2.0 and 4.0 to 6.7 per cent, respectively. Among these 41 collections SG-49/04, 27/04 followed by SG-1030, SG-17/04, SG-603, SG-856, SG-713, 14/04 and SG-4 were found significantly superior for dry matter content in comparison to check Himgiri. The essential oil contents in 59/04, SG-062, SG-4, SG-983, SG-780, SG-861, SG-995 and SG-7/04 were found to be significantly higher than Himgiri. However, significantly less fibre content was recorded in SG-702, 48/04, and SG-030 in comparison to check Himgiri. SG-27/04, SG-45/04 and SG-896 were identified as high quality and high yielding (> 5 kg/plot) accessions. However, other collections like SG-1030, SG-856, SG-49/04, etc. also exhibited superior quality attributes but recorded lesser yield.

3.6 Nutrient Management Trial

3.6.1 Effect of micronutrients on ginger (Kumarganj, Pottangi, Raigarh)

At Kumarganj maximum fresh ginger rhizome yield of 55.53 q/ha was observed in T₂₇ treatment (foliar spray of zinc @ 0.5% + Bo @ 0.2% + Fe @ 1.0% after 60 and 90 days of planting) followed by T₉ with an yield of 49.96 q/ha. Four years pooled data also showed similar findings.

Significant difference was observed among various treatments at Pottangi centre. Highest fresh rhizome yield was obtained in T-14 (25 kg/ha of Zn, Fe, Bo as soil application) with 26.36 t/ha followed by T-15 (Zn and Bo 25 kg/ha as soil application and Fe as 0.5% foliar spray) which recorded an yield 19.21 t/ha (Table 24).

At Raigarh, application of zinc sulphate resulted in appreciable improvement in fresh rhizome yield of ginger. Increasing levels of zinc sulphate also increased the rhizome yield of ginger significantly. Maximum yield of fresh rhizome (10.57 t/ha) was recorded with applications of 0.5% zinc sulphate as foliar spray (60 and 90 DAP). The minimum yield of 8.46 t/ha was recorded without zinc application. Increasing level of boron also increased the yield of ginger significantly. Application of 0.2% foliar spray of borax (60 and 90 DAP) produced maximum yield of 10.89 t/ha. The minimum yield of 7.70 t/ha was recorded without application of borax. Application of ferrous did not increase the yield of ginger significantly. Maximum yield of 9.4 t/ha was recorded with application of 1.0% ferrous sulphate (60 and 90 DAP) as foliar spray. The interaction effect between Zn, Bo and Fe was not found significant, but the yield was appreciably higher at higher levels of Zn, Bo and Fe. The maximum rhizome yield of 12.98 t/ha was recorded with foliar spray of 0.05% zinc sulphate (60 and 90 DAP), 0.2% of borax (60 and 90 DAP) and 1.0% of ferrous sulphate (60 and 90 DAP).

Table 24 Effect of micronutrients on yield of ginger at Pottangi

Treatment		Plot yield (kg/3m ²)			Average yield (kg/3 m ²)	Yield tons/ha
		2005	2006	2007		
T-1	Zn0 Bo0Fe0	6.73	6.6	6.0	6.50	14.95
T-2	Zn0 BO0Fe25	6.60	7.0	7.1	6.90	15.87
T-3	Zn0 BO0 Fe0.5	6.73	6.6	6.8	6.71	15.43
T-4	Zn0 B25Fe0	6.57	6.7	7.2	6.82	15.69
T-5	Zn0 B25Fe25	6.63	7.4	7.3	7.11	16.35
T-6	Zn0 B25 Fe0.5	6.60	7.2	7.1	6.96	16.02
T-7	Zn0 B0.5 Fe0	6.53	6.7	6.6	6.61	15.20
T-8	Zn0 B0.5 Fe 25	6.63	7.2	7.0	6.94	15.96
T-9	Zn0 B0.5 Fe0.5	6.50	7.0	6.8	6.76	15.56

T-10	Zn25 B0 Fe0	6 86	7 4	7 1	7 12	16 37
T-11	Zn25 B0 Fe25	7 27	7 7	7 2	7 39	16 99
T-12	Zn25B0 Fe 0 5	6 83	7 1	6 9	6 94	15 96
T-13	Zn25 B25 Fe0	7 63	7 6	6 0	7 31	16 81
T-14	Zn25 B25 Fe25	8 06	9 4	9 1	8 50	26 36
T-15	Zn 25 B25 Fe0 5	7 76	8 6	8 0	8 35	19 21
T-16	Zn25 B0 5 Fe0	8 00	7 5	6 6	7 36	16 94
T-17	Zn25 B0 5 Fe25	7 50	8 2	7 2	7 50	17 25
T-18	Zn25 B0 5 Fe0 5	7 30	8 0	7 4	7 40	17 15
T-19	Zn0 5 B0 Fe0	6 80	7 0	6 8	6 86	15 79
T-20	Zn0 5 B0 Fe25	6 80	7 1	7 4	7 10	16 33
T-21	Zn 0 5 B0 Fe 0 5	6 63	7 1	6 9	6 87	15 81
T-22	Zn 0 5 B25 Fe0	6 47	7 0	7 0	6 82	15 69
T-23	Zn0 5 B25 Fe25	7 43	8 2	7 4	7 67	17 65
T-24	Zn 0 5 B 25 Fe0 5	7 63	7 3	6 8	7 24	16 65
T-25	Zn0 5 B0 5 Fe0	6 08	6 7	6 8	6 52	15 01
T-26	Zn0 5 B0 5 Fe25	6 63	7 6	7 1	7 11	16 35
T-27	Zn0 5B0 5Fe0 5	6 33	7 4	6 0	6 81	15 66
CD (P=0 05)		NS	1 2	1 0		

3 6 2 Organic farming in ginger (2006) (Dholi, Kumarganj, Pottangi, Pundibari, Solan)

The experimental plots were severely affected by rhizome rot disease and the yield was very poor at Kumarganj centre. Maximum fresh rhizome yield of 68 8 q/ha was obtained by the application of 50% recommended dose of fertilizer (60 40 40 NPK) + 50% FYM @ 10 t/ha + Azospirillum (5 kg/ha) + seed treatment and soil application of *P fluorescence* and *Trichoderma* @ 50 g/3 m² followed by fresh rhizome yield of 54 19 q/ha by application of 100% FYM (20 t/ha) by seed treatment and soil application of *P fluorescence* and *Trichoderma* @ 50 g/3 m².

There was no significant difference among different treatments for fresh rhizome yield at Pottangi centre. Highest cost benefit ratio 1 1 79 and highest yield (20 24 t/ha) was recorded in fully inorganic treatment.

At Pundibari, application of integrated nutrients on ginger produced highest clump weight of 126 g and highest yield of 2 91 kg/plot and highest oleoresin of 3 7% in the rhizomes followed by application of organic nutrients on ginger with a clump weight of 101 g and yield of 2 13 kg per plot.

At Solan, yield of ginger was significantly high in fully organic in comparison with the treatments. Maximum yield of 4 90 kg was obtained in fully organic treatment followed by integrated treatment.

The experiment failed at Dholi centre due to heavy rain.

3 7 Disease Management Trial

3 7 1 Disease surveillance and etiology of rhizome rot in ginger (Solan)

The disease-affected rhizomes of ginger were collected from Bilaspur, Sirmour and Solan districts of the state and disease analysis report reveals the association of all the major pathogens (Table 25).

Table 25. Disease surveillance on rhizome rot of ginger

Location	District	Plant part affected	Associated pathogen
Sohari	Bilaspur	Rhizome	<i>Pythium, Ralstonia</i>
Sohari	-do-	-do-	<i>Ralstonia, Meloidogyne</i>
Binola	-do-	-do-	<i>Ralstonia</i>
Soshan	-do-	-do-	<i>Pythium, Ralstonia</i>
Rohin	-do-	-do-	<i>Ralstonia, Meloidogyne</i>
Kotlu Brahamna	-do-	-do-	<i>Ralstonia</i>
Kotlu Brahamna	-do-	-do-	<i>Ralstonia</i>
Gaura Hinnar	Sirmour	-do-	<i>Ralstonia, Fusarium</i>
Nauni	Solan	-do-	<i>Pythium, Meloidogyne, Fusarium</i>

3.7.2 Biocontrol studies on rhizome rot of ginger (final report) (Kumarganj, Pottangi)

At Kumarganj, minimum incidence (24%) of rhizome rot and maximum rhizome yield of 45.55 q/ha was observed in the treatment T_6 (seed treatment of rhizome with hot water at 51°C for 30 minutes and *T. harzianum* for 30 minutes mixed with neem cake) followed by 34.66% in treatment T_2 (seed treatment with hot water at 51°C for 30 min). In four years pooled data, T_6 recorded minimum rhizome rot incidence (40.2%) and increase in yield by 120.73% over control.

At Pottangi, highest rhizome yield of 20.54 t/ha was obtained in seed treated with mancozeb 3 g/l + carbendazim 1g/l + chloropyriphos 2ml/l for 30 min and soil application of thimath (10G) 1kg a.i./ha with 44.59% increase over control (Table 26).

Table 26. Effect of biocontrol agent, fungicide and hot water treatment on incidence of rhizome rot disease in ginger at Pottangi

Treatment	Germination (%)	Rhizome rot (%)	Rhizome yield (kg/3m ²)				Projected yield (t/ha)	Increase over control (%)
			2005	2006	2007	Mean		
No seed treatment	72	38	4.6	6.6	6.3	5.83	13.41	
Seed treatment with hot water 51°C for 10 minutes	76	31	5.2	7.8	7.0	6.60	15.33	
Seed treatment with mancozeb 3 g/l + carbendazim 1g/l + chloropyriphos 2ml/l for 30 min and soil application of thimath (10G) 1kg a.i./ha	86	16	6.6	10.4	9.8	8.93	20.54	44.59
Seed treatment with <i>Trichoderma</i> 2.5 g/l for 30 min for 1 kg seed	74	24	5.2	8.2	8.3	7.23	16.63	
Hot water seed treatment + T_3	76	29	6.3	9.6	9.4	8.43	19.39	30.94
Seed treatment with hot water + <i>Trichoderma</i> , FYM, neem cake soil application	76	25	6.2	8.6	8.1	7.63	17.56	
Soil application with only <i>Trichoderma</i> @ 10 kg/ha	72	30	5.2	7.2	7.6	6.66	15.38	
Soil application with neem cake @ 1t/ha during planting	74	31	5.4	7.4	7.8	6.86	15.79	
CD (P= 0.05)			NS	1.3	1.6			

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

(Kumarganj, Pundibari, Raigarh, Solan)

At Kumarganj, treatment of seed rhizomes with mancozeb (3 g/l) for 30 minutes recorded a low of 1.7% rhizome rot disease incidence and maximum fresh rhizome yield of 35.30 q/ha. Four years pooled data also showed lowest incidence of rhizome rot disease (40.12%) with highest yield of 22.9 q/ha. Seed treatment of rhizomes with mancozeb (3 g/l) for 30 minutes with maximum disease control of 62.2 per cent and rhizome yield of 71.44 per cent (45% increase over control).

At Pundibari, during 2003 – 2004 seed treatment with *T. harzianum* (T_2) was the best in reducing the disease incidence at different phases of crop growth. This treatment reduced 44%, 36.69% and 30.41% disease over control. In 2004 – 2005 and 2005 – 2006 the best treatment was found to be seed treatment with hot water at 51°C for 30 minutes (T_4). This treatment reduced 53.31% and 67.50% disease over control. In 2006 – 2007 and 2007 – 2008, the best treatment was seed treatment with Ridomil Mancozeb (T_5) (100 ppm metalaxyl). This treatment reduced 75.31% and 76.44% disease over control in respective years. However, except in 2003 – 2004, there is no significant difference between T_2 , T_4 and T_5 regarding disease incidence in all the other 4 years. Cost benefit ratio was highest (1.285) with *T. harzianum* – neem cake application followed by 0.1% Metalaxyl (1.271). Regarding yield all the best treatments produced highest yield in respective years. In pooled data analysis (Table 27), it was found that seed treatment with *T. harzianum* (T_2) was the best treatment in reducing the disease over control. T_2 is followed by T_5 (66.07% disease reduction) and T_4 (64.45% disease reduction). These three treatments are statistically at par with each other. Regarding fresh rhizome yield, the maximum yield was obtained from T_2 (5.29 kg/plot) followed by T_5 and T_4 with their yields of 4.68 kg and 4.67 kg/plot respectively. In case of yield there is significant difference between T_2 and all other treatments but T_4 and T_5 are statistically at par with each other. Cost Benefit ratio was also found highest in T_2 (1.190), which was followed by T_4 (1.177) and T_5 (1.175).

At Raigarh, application of Ridomil Mancozeb (100 ppm) reported minimum disease incidence (21.15) and maximum yield 9.8 t/ha. Maximum disease incidence (48.55) and minimum yield t/ha (4.9) was found in control plot (Table 28).

Among the disease management treatments assessed at Solan centre, rhizome solarization, hot water treatment and mancozeb treatments decreased the incidence of rhizome rot diseases to 5.05, 6.13 and 6.86 per cent, respectively due to *Pythium*, *Fusarium* and *Ralstonia* infection significantly over other treatments. These treatments were at par with each other in minimizing the disease over the years 2002 to 2007. Besides the yield of ginger significantly increased (7.287, 7.122 and 6.326 kg/3 m² respectively). Rhizome solarization for 45 min (11 am to 11.45 am) was economically a superior treatment followed by mancozeb (0.3%) and hot water rhizome treatments with benefit cost ratio of 1.991, 1.402 and 1.143 respectively, in increasing the yield and decreasing the incidence of diseases.

Table 27. Pooled data of integrated management of *Pythium*, *Fusarium* and *Ralstonia* in ginger at Pundibari

Treatment	Germination (%)	Disease incidence (%) (150 DAS)	Percent reduction over control	Yield (kg/plot)	Projected yield (t/ha)	C : B Ratio
T-1 Mancozeb (0.3%) seed treatment	85.30	13.40 (21.47)	46.89	3.69	7.44	1:1.39
T-2 Seed treatment with <i>T. harzianum</i> @ 4 g/kg	89.26	7.95 (16.38)	68.49	5.29	10.66	1:1.90
T-3 Rhizome solarization in polybags for 2 h before sowing	84.74	11.87 (20.15)	52.95	4.22	8.51	1:1.58
T-4 Seed treatment with hot water treatment (51°C for 30 minutes)	89.22	8.97 (17.43)	64.45	4.67	9.41	1:1.77
T-5 Ridomil Mancozeb (100 ppm Metalaxyl)	89.52	8.56 (17.01)	66.07	4.68	9.43	1:1.75
T-6 Control	73.30	25.23 (30.15)		2.27	4.58	1:0.92
SEm ±	-	1.479	-	0.161	-	-
CD (P= 0.05)	-	4.167	-	0.455	-	-

(Figures in parenthesis are angular transformed value)

Table 28. Integrated management of *Pythium*, *Fusarium* and *Ralstonia* of ginger at Raigarh.

Treatment	Average sprouting in rhizome	Survival of rhizome	Percent disease incidence (%)	Average plot yield (kg)	Projected yield (t/ha)
Mancozeb (0.3%) seed treatment	90.0	58.1	35.44	3.3	6.7
Seed treatment with <i>T. harzianum</i> @ 4 g/kg	90.5	69.5	23.07	3.9	7.7
Rhizome solarization (Solarization of Rhizome solarization in polybags for 2 h before sowing)	91.3	66.5	27.55	3.1	6.3
Ridomil Mancozeb (100 ppm metalaxyl)	95.0	74.9	21.15	4.6	9.8
Seed treatment with hot water treatment (51°C for 30 minutes)	89.4	65.9	26.28	3.3	6.6
Control	90.0	46.3	48.55	2.4	4.9
CD (P=0.05)	-	6.04	1.35	0.1	0.8

3.7.4 Survey and monitoring of disease in ginger (final report)

(Pundibari, Raigarh)

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 Bhaish and Nangrey. Disease incidences at different locations were determined during July to 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. *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%).

Surveys were conducted in Armuda Village of Raigarh district for rhizome rot disease and 42.9% disease incidence was noticed during October. Maximum disease incidence was reported in Padigao village of Pusour developmental block and minimum disease incidence in Samabaijuri village of Raigarh developmental block.

3.8 Management of rhizome rot in ginger

(Chintapalle, Sirsi)

The observations on management of rhizome rot in ginger at Chintapalle centre revealed that highest germination (90.13%), more number of tillers (9.91), low disease incidence (6.34 PDI) and highest yield of 2.68 kg per bed when seed material were solarized in polyethylene bags for 30 min and treated with Mancozeb (@ 0.25%) before planting as seed treatment and soil application as drench. The next best treatment was solarization of seed material in polyethylene bags for 30 min and seed treatment and soil application of *T. harzianum* 50 g/l, where in highest germination (83.18%), more number of tillers (9.24), low disease incidence (8.71 PDI) and highest yield of 2.16 kg per bed were recorded. Ginger beds were severely affected by soft rot disease with low germination (56.08%), less number of tillers (6.56), high disease incidence (43.71 PDI) and low yield of 0.56 kg per bed when non solarized and unprotected rhizomes were used for sowing.

Rhizome rot was not noticed under Sirsi conditions in any of the treatments both in solarized and non solarized rhizomes. *T. harzianum* was effective in improving the germination of solarized rhizomes (76.02%) whereas 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%) 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. Solarized rhizomes when treated with combination of bioagents viz., *T. harzianum* and bacterial consortium recorded an 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).

4. Turmeric

4.1 Genetic Resources

4.1.1 Germplasm collection, characterization and conservation

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

To the existing germplasm of 258 genotypes maintained at Coimbatore, four *Curcuma* species viz , *C. zedoara*, *C. amada*, *C. aromatica* and *C. caesia* (collected from IISR Calicut), *C. zedoara*, Blue zedoara and *C. amada* (collected from Kerala Agricultural University, Trivandrum) and two accessions (from Agricultural Research Station, Bhavanisagar) were added during 2007-08. Two hundred and sixty seven accessions were evaluated for yield during the year and the yield ranged from 7 to 22 kg/3m² with a mean of 13.01 kg. The coefficient of variability for yield in the population was 20.20%. The highest yield of 22 kg/3m² was recorded by the accession CL-9. The germplasm maintained at various AICRPS centres are given in Table 29.

Out of ninety germplasm, only fourteen accession namely, RH-7, RH-9/90, RH-12, RH-13/90, RH-14, RH-16, RH-17, RH-24, RH-50, RH-80, RH-403, RH-406, RH-407 and RH-411 gave the maximum yield as compared to check RH-5 and Rajendra Sonia at Dholi centre. Among the fourteen promising accession, RH-80 produced maximum yield (15.63 kg/3m²) which was closely followed by RG-50 (15 kg/3m²).

At present, 273 germplasm collections are being maintained at RARS, Jagtial. Lot of variability was observed for growth and yield characters. Variability was also observed for diseases like rhizome rot, *Colletotrichum* and *Taphrina* leaf blotch. Among all the germplasm lines tested, JTS-10 has given high fresh rhizome yield (29.6 t/ha) followed by CLI-38 (28.7 t/ha).

Kumarganj centre holds 128 accessions of turmeric germplasm. Maximum fresh rhizome yield of 331.0 q/ha was obtained in NDH-79 followed by NDH-49 (321 q/ha), among the 31 early maturing genotypes. Out of 61 medium maturing genotypes, NDH-14 produced maximum fresh rhizome yield of 365 q/ha followed by NDH-18 (340 q/ha). Among 36 late maturing genotypes evaluated for yield NDH 9 recorded highest yield (363.0 q/ha) followed by NDH 8 (331.0 q/ha).

Out of the total 197 turmeric accessions available at Pottangi centre, 173 were evaluated during the year, which consisted of 155 *Curcuma longa*, 20 *C. aromatic* and 4 *C. amada*. Fresh rhizome yield/3 m² ranged from 5.3 kg/3m² to 14.6 kg/3m² in *C. longa* and 32 accessions gave more than 10 kg/3m² yield. Tu No-6 (14.6 kg/3m²), PTS-41 (14.0 kg/3 m²), PTS-4 (13.5 kg/3m²), PTS-51 (13.0 kg/3m²) were identified as higher yielders. In *C. aromatica* the range in fresh rhizome yield varied from 4.0 kg/3m² to 11.4 kg/3m² and 7 accessions gave more than 7.0 kg/3m² yield and *Chaya pasupu-II* (11.4 kg/3m²) was identified as a high yielder. In *C. amada* types, the yield ranged from 8.60 kg/3m² to 13.0 kg/3m².

Hundred and sixteen germplasm accessions of turmeric were screened for suitable characterization under genetic resource programme at Pundibari centre. Germplasm were evaluated systematically and it was found that rhizome yield of individual plant (clump weight) was maximum in TCP-66 (670.67 g) followed by TCP-90 (652.33 g), TCP-11 (523.33 g), TCP-18 (466.00 g), TCP-12 (451.33 g), TCP-34 (430.67 g), TCP-71 (417.00 g), TCP-46 (416.00 g) and TCP-135 (395.67 g). With respect to rhizome yield, a total of 16 genotypes out yielded the local check TCP-2 (32.26 t/ha). TCP-66 (54.43 tons/ha), TCP-90 (47.58 tons/ha each), TCP-49 (42.34 tons/ha) and TCP-67 (41.93 tons/ha), TCP-47 (41.13 tons/ha), TCP-153 (39.92 tons/ha), TCP-93 (39.51 tons/ha), TCP-41 and TCP-135 (36.29 tons/ha) recorded significantly higher rhizome yield.

Forty-two germplasm lines were evaluated at Raigarh centre and IT-24 recorded highest yield (15.27 t/ha).

Table 29 Turmeric germplasm collections in AICRPS centres

Centre	Indigenous		Total
	Cultivated	Wild and related sp	
Coimbatore	265	-	265
Dholi	90	2	92
Jagtial	273	-	273
Kumarganj	128	-	128
Pottangi	197	-	197
Pundibari	156	14	170
Raigarh	42	-	42
Solan	145	-	145
Total	1296	16	1312

4.2 Coordinated Varietal Trial (CVT)

4.2.1 CVT 2000-Series V (Jagtial, Raigarh)

Out of thirty cultures tested at Jagtial, PTS-15 recorded maximum fresh rhizome yield (25.0 t/ha) followed by IT-1 (24.2 t/ha) in comparison to Duggirala Red check variety (25.5 t/ha). At Raigarh centre TCP-2 recorded the maximum yield (15.85 t/ha).

4.2.2 CVT-2004 – series VI (Chintapalle, Coimbatore, Kumarganj, Pottangi, Pundibari, Raigarh)

Among 13 varieties evaluated at Chintapalle, variety PTS-39 recorded the highest fresh rhizome yield of 19.7 t/ha followed by NDH-9 (16.5 t/ha) whereas IT-2 recorded the lowest fresh rhizome yield of (7.9 t/ha).

Among the twelve accessions evaluated in CVT 2004 series at Coimbatore, the yield ranged from 8.0 kg/plot to 15.0 kg/plot (3m²). Highest yield of 15.0 kg/plot was registered by NDH-9 followed by CL-101 (14.0 kg/plot).

At Kumarganj, highest yield of 316.97 q/ha of fresh rhizome yield was observed in NDH-9 followed by NDH-1 (4312.17 q/ha). In the pooled analysis NDH-9 recorded maximum fresh rhizome yield (31.11 t/ha) followed by NDH-18 (30.54 t/ha) and IT-3 (30.14 t/ha) [Table 30].

There was significant difference in fresh rhizomes yield among cultivars which were evaluated at Pottangi centre. Highest fresh rhizome yield was recorded by PTS-39 (27.39 t/ha) followed by PTS-4 (27.29 t/ha) with 33.80% increase over check Roma.

In the trial at Pundibari, highest rhizome yield was obtained in IT-2 (32.26 t/ha) followed by PTS-39 (31.71 t/ha) and IT-1 (31.51 t/ha) during 2007-08. Lowest yield was recorded in CL-147 (16.47 t/ha). From pooled data analysis of 2005 – 06, 2006 – 2007 and 2007 – 2008, it was found that the genotype IT-2 showed the highest rhizome yield (27.82 t/ha), followed by TCP-56 (27.73 t/ha), IT-1 (26.48 t/ha) and TCP-11 (25.36 t/ha). But there was no significant difference between these four germplasm regarding fresh rhizome yield.

In the CVT at Raigarh centre, TCP-11 recorded maximum yield (17.48 t/ha).

Table 30. Pooled yield of CVT turmeric at Kumarganj

Entry	2004-05	2005-06	2006-07	2007-08	Mean (t/ha)
IT-1	20.55	16.10	19.96	20.44	19.26
IT-2	17.33	30.51	30.73	21.66	27.39
PTS-34	13.55	26.10	25.53	22.99	22.68
PTS-39	13.88	26.60	26.16	31.66	23.32
TCP-56	12.21	21.07	21.16	32.21	19.02
TCP-82	12.88	19.97	20.16	20.44	18.36
NDH-18	30.66	29.43	30.86	31.00	30.54
TCP-11	26.88	24.43	23.00	22.33	24.32
NDH-9	29.22	31.63	31.96	165.53	31.11
IT-3	27.88	21.63	21.83	30.99	30.41
CL-101	13.44	30.50	30.60	25.55	26.38
CL-147	12.77	15.81	16.06	26.66	15.29
NDH-14	26.66	26.08	25.76	29.88	26.15
RH-9/90	-	04.33	12.76	20.22	12.43
RH-13/90	-	08.87	14.10	19.77	14.24
Prabha (Check)	28.33	27.77	29.40	26.09	28.84
SEm ±	-	4.43	1.26		
CD (P=0.05)	2.60	12.51	4.47		
CV%	7.58	32.02	9.21		

4.3 Varietal Evaluation Trial

4.3.1 Comparative yield trial (Jagtrial, Pottangi)

Out of 10 promising turmeric cultures tested during 2007-08 at Jagtrial, JTS-401 and JTS-402 have recorded high fresh rhizome yield (29.7 t/ha.) followed by JTS-406 (25.1 t/ha), Duggirala Red (24.0 t/ha). The check variety PCT-13 recorded fresh rhizome yield (23.1 t/ha).

There was significant difference in fresh rhizomes yield among cultivars evaluated at Pottangi centre. Highest fresh rhizome yield was recorded by PTS-47 (26.75 t/ha) and PTS-39 (26.68 t/ha).

4.3.2 Initial evaluation trial

(Kumarganj, Pottangi, Pundibari)

Out of 9 promising genotypes tested at Kumarganj, NDH-18 produced maximum fresh rhizome yield of 374.9 q/ha followed by NDH-79 (348.8 q/ha). The yield was comparatively higher than Prabha (319.4 q/ha) used as a check.

There was significant difference among the cultivars for fresh rhizome yield at Pottangi centre. Highest fresh rhizome yield was recorded by VK 9 (26.39 t/ha), followed by PTS-3 (25.90 t/ha).

At Pundibari, highest mean values for clump weight/plant was recorded by TCP-57 (437.13 g) while TCP-128-1 showed the lowest values for that trait (181.87 g). In respect to plot yield (kg/3m²) and the projected yield (t/ha), TCP-70 recorded the highest mean values (18.00 kg and 36.29 t/ha, respectively), closely followed by TCP-129 (17.17 kg and 34.61 t/ha, respectively), both the genotypes out yielded TCP-2, the local check.

4.4 Quality Evaluation Trial

4.4.1 Quality evaluation of germplasm

(Coimbatore)

Twenty six high yielding accessions identified from the trials conducted during 2005-06 and 2006-07 at Coimbatore were evaluated for quality parameters like curcumin content, oleoresin and essential oil. Among the 26 accessions, the curcumin content ranged from 3.0 to 3.5%. The highest curcumin content of 3.5% was recorded by the accession CL-57. Oleoresin content varied from 8.5 to 12.5%. The highest oleoresin content (12.5%) was recorded by CL-219. The essential oil content varied from 2.0 to 4.5% among the accessions. The highest essential oil content (4.5%) was recorded in CL-20.

4.4.2 Impact of environment on quality of turmeric (final report)

(Coimbatore)

The trial was laid out with six promising accessions viz., CL-131 (Suguna), CL-40 (JTS 2), CL-133 (Roma), CL-141 (Rajendra sonia), CL-2 (BSR-2) and Acc 360 (IISR Prabha) during 2002-03 to study the role of environmental factors on yield and quality of turmeric. During 2006-07 the yield of various accessions ranged from 8.8 kg/plot (3m²) to 15.4 kg/plot. The highest yield of 15.4 kg/plot was registered in Acc 133 (Roma) followed by BSR-2 (12.2 kg/plot). The curcumin content ranged from 3.2 to 5.2% and highest curcumin content of 5.2% was recorded by Acc 131 (Suguna). Oleoresin content ranged from 8.0 to 10.5% and Acc 131 (Suguna) registered the highest oleoresin content (10.5%). The essential oil content ranged from 3.0 to 3.4% and the highest essential oil content of 3.4% was registered in Acc 151 (IISR Prabha) (Table 31).

Based on the pooled analysis of the data on yield and curcumin content of the six genotypes the results revealed that the yield varied from 21.1 t/ha to 28.9 t/ha. The highest yield of 28.9 t/ha was obtained by the cv BSR 2. Regarding the curcumin content it varied from 4.0 to 4.9%. The highest curcumin content of 4.9% was recorded by the cv IISR Prabha (Table 32).

Table 31 Impact of environment on quality of turmeric (2006-07) at Coimbatore

Accession	Rhizome weight (g)			Yield/plot (kg/3m ²)	Curcumin (%)	Oleoresin (%)	Essential oil (%)
	Mother	Primary	Secondary				
Acc 131 (Suguna)	9.0	108.9	141.67	9.0	5.2	10.5	3.3
Acc 360 (IISR Prabha)	8.8	72.8	101.1	8.8	4.0	8.3	3.4
Acc 141 (Rajendra sonia)	11.8	103.9	161.91	11.8	3.5	9.6	3.2
Acc 140 (JTS-2)	11.2	140.0	125.57	11.2	4.3	9.5	3.0
Acc 2 (BSR 2)	12.2	106.1	220.57	12.2	3.2	8.0	3.0
Acc 133 (Roma)	15.4	106.1	178.90	15.4	5.0	8.5	3.2
CD (P = 0.05)	40.1	16.0	2.32	1.7	0.1	1.3	0.5

Table 32 Pooled data on yield and curcumin content of the genotypes at Coimbatore

Accession	Yield (t/ha)	Curcumin content (%)
Acc 131 (Suguna)	28.3	4.5
Acc 360 (IISR Prabha)	21.1	4.9
Acc 141 (Rajendra sonia)	23.3	4.0
Acc 140 (JTS 2)	28.3	4.5
Acc 2 (BSR 2)	28.9	4.2
Acc 133 (Roma)	28.0	4.5

4.5 Nutrient Management Trial

4.5.1 Effect of biofertilizer, *Azospirillum* on turmeric (Dholi, Kumarganj)

Soil application of inorganic nitrogen (100%) – *Azospirillum* – 5 t/ha FYM and inorganic nitrogen (75%) – *Azospirillum* – 5 t/ha FYM were significant regarding number of tillers per plant, number of leaves per plant and yield per plant (kg/3m²) as compared to control and other treatments of *Azospirillum* at Dholi centre. Soil application of inorganic nitrogen (100%) – *Azospirillum* – 5 t/ha FYM gave maximum number of tillers per plant (6.04), number of leaves per tiller (13.50) and yield (18.88 kg/3m² or 62.92 t/ha) followed by inorganic nitrogen (75%) + *Azospirillum* – 5 t/ha FYM.

Application of 50% recommended dose of inorganic fertilizer (60-40-40 kg NPK/ha) + 50% FYM (10 t/ha) + application of 5 kg/ha of *Azospirillum* – seed treatment and soil application of *P. fluorescens* – *Trichoderma* @ 50 g/3m² produced 347.29 q/ha of fresh rhizome at Kumarganj.

4 5 2 Organic farming in turmeric (new) (Coimbatore, Dholi, Jagtial, Pottangi, Pundibari)

Trial on organic farming in turmeric was laid out for the second year during 2007-08 at Coimbatore. The treatment T₃ (fully inorganic) recorded the highest yield of 15.0 kg/3m² plot followed by T₂ (integrated), which recorded a yield of 11.44 kg/3m² plot. The treatment T₁ (fully organic) recorded a yield of 7.2 kg/3m² plot.

At Dholi, integrated fertilizer management (T₂) (FYM-20t/ha - ½ N, P, K - P-solubilising bacteria, *P. fluorescens* and *Trichoderma* as seed treatment and soil application (50 g/3m²) with spray of indofil M-45 (0.2%) and malathion (0.1%) for controlling of disease and pest produced the maximum plant height (121.61 cm), number of leaves (10.16) and yield per plot (15.80 kg/3m²) or yield (52.67 t/ha) followed by fully organic treatment.

At Jagtial, during 2007-08 among the three treatments, integrated treatment recorded highest rhizome yield (24.8 t/ha) followed by inorganic (22.9 t/ha) whereas, organic treatment recorded 21.2 t/ha.

There was no significant difference among different treatments at Pottangi. Highest fresh rhizome yield was obtained T-3 (27.37 t/ha) followed by T-2 (21.18 t/ha).

Application of integrated nutrients on turmeric at Pundibari produced highest clump weight of 301.42 g and highest yield of 9.36 kg per plot. The highest oleoresin of 10.8% was produced in turmeric by application of organic nutrients on turmeric.

4 5 3 Effect of organic farming on turmeric (Adaptive Research) (Dholi)

Soil application of inorganic nitrogen (100%) + *Azospirillum* - 5 t/ha FYM (T₁) and inorganic nitrogen (75%) - *Azospirillum* - 5 t/ha, FYM (T₂) were found significantly better performance regarding number of tillers per plant, number of leaves per plant and yield per plant or tones per hectare as compared to control (T₀). Soil application of inorganic nitrogen (100%) - *Azospirillum* - 5 t/ha FYM (T₁) gave the maximum number of tillers per plant (6.04), number of leaves per tiller (13.50) and yield (18.88 kg/3m² and 62.92 t/ha) followed by inorganic nitrogen (75%) - *Azospirillum* - 5 t/ha FYM (T₂).

4 5 4 Efficacy of biocontrol agents for control of rhizome rot of turmeric (Pottangi)

There was no significant difference among different treatments. Highest fresh rhizome yield was obtained in chemical treatment (22.84 t/ha) followed by the treatment with both bio-control agents as soil and seed treatment (21.18 t/ha).

4 5 5 Effect of micronutrients on turmeric (Pottangi, Raigarh)

The effect of micronutrients was evaluated at Raigarh and Pottangi centres. At Raigarh centre, application of zinc sulphate resulted in appreciable improvement in fresh rhizome yield of turmeric. Increasing levels of zinc sulphate also increased the rhizome yield of ginger significantly. Maximum yield of fresh rhizome (22.47 t/ha) was recorded with applications of 0.5% of foliar spray (60 & 90 DAP). The minimum yield of 22.47 t/ha was recorded without zinc application.

Increasing level of boron also increased the yield of turmeric significantly. Application of 0.2% foliar spray of borax (60 & 90 DAP) produced maximum yield of 24.06 t/ha. The minimum yield of 24.06 t/ha was recorded without application of Borax.

Application of iron increased the yield of turmeric significantly. Maximum yield was found (24.95 t/ha) which spray of ferrous sulphate 1% foliar spray (60 & 90 DAP) of per spray.

The interaction effect between Zn, B and Fe was found significant and maximum yield was found in treatment combinations zinc sulphate spray 0.1% 60 and 90 DAP boron 10 kg/ha at the time of planting and spray ferrous sulphate 0.5% (60 & 90 DAP) (27.91 t/ha) and zinc sulphate spray 0.1% 60 and 90 DAP spray of boron 0.2% at the time of planting and spray ferrous sulphate 0.5% (60 & 90 DAP) (27.51 t/ha) and both the treatments are statistically at par.

At Pottangi there was no significant difference among different treatments. Highest fresh rhizome yield was obtained on application of 25 kg/ha of zinc sulphate and borax as soil dressing and 0.5% foliar spray of iron sulphate at 45 & 60 DAP (23.97t/ha) followed by 25 kg/ha each of zinc sulphate, borax and iron sulphate (23.80 t/ha) as soil dressing.

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)

The disease survey was conducted in turmeric growing areas of Coimbatore and Erode district to determine the extent of turmeric diseases during 2007-08. In Coimbatore district, leaf spot intensity was maximum at Boluvampatty (56 PDI); the leaf blotch intensity was maximum at Mathampattii (72 PDI) and the rhizome rot was maximum at Boluvampatty (12.00%). In Erode district, leaf spot intensity was maximum at Uonjalur (48 PDI), leaf blotch at Bhavanisagar (68 PDI) and rhizome rot at Uonjalur (12%). Out of the 265 turmeric germplasm accessions screened for resistance against leaf spot and leaf blotch diseases, the turmeric germplasm accessions viz., CL-1, 2, 3, 6, 14, 22, 25, 31, 32, 33, 53, 54, 148, 153, 230 were resistant to leaf spot (8-10 PDI) and the accessions viz., CL- 8, 9, 139, 153, 160 and 161 were resistant (10 PDI) for leaf blotch.

Survey were conducted by Pundibari centre in 2 blocks of Coochbehar and one block of Dinahata of Coochbehar district. Three major diseases were found to be prevalent in this area, namely, leaf blotch of turmeric (*Taphrina* spp.), leaf spot of turmeric (*Colletotrichum* spp.) and rhizome rot. Another leaf spot disease (*Helminthosporium* sp.) was found in the survey. It was observed that leaf blotch disease severity was highest in Coochbehar II block (average 31.92%) followed by Dinahata II block (26.67%) and followed by Coochbehar I block (24.13%). Regarding leaf spot of turmeric it was found that disease severity is highest in Coochbehar II block (average 38.17%) which is followed by Dinahata II block (average 28.33%) and it is followed by Coochbehar I block (average 26.4%). It was also observed that leaf spot disease severity was higher in all the blocks than leaf blotch disease in 2007-08. Among the germplasm TCP-3, 4, 5, 9, 19, 35, 48, 54, 55, 74, 79, 90, 95, 100, 121, 122, 125, 132, were tolerant to leaf blotch disease and TCP-49, 93, 104, 162, 194, were tolerant to leaf spot disease.

At Raigarh centre, TCP-11 was found resistance against *Colletotrichum* leaf spot and *Taphrina* leaf spot. TCP-56 was found resistant to *Colletotrichum* leaf spot. TCP-1, TCP-11, TCP-82, ACC-126, ACC-584, IT-1, IT-2, IT-3 was found resistant to *Taphrina* leaf spot.

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

Investigation on rhizome/soft rot disease was not observed during 2004-07 and maximum fresh rhizome yield of 346.68 q/ha was observed by application of recommended dose of NPK (120:80:80) + 10 t/ha of FYM + seed treatment of *Trichoderma viridae* and *Pseudomonas floescens* @ 4 g/kg and soil treatment of *T. viridae* and *P. floescens* @ 12.5 and 25 kg/ha as basal and top dressing. Similar trend was observed in four years mean pooled data with an increase in 34.34% fresh rhizome yield over control.

5. Tree Spices

5.1 Genetic Resources

5.1.1 Germplasm collection, characterization, evaluation and conservation of clove, nutmeg and cinnamon (Dapoli, Pechiparai, Yercaud)

Clove, nutmeg, cinnamon and cassia are the germplasm of tree spices conserved at various AICRPS centres and the details are given in Table 33.

Clove

At Dapoli, 2 accessions of clove have been maintained and are being evaluated for growth and yield performance. The flowering and fruiting was observed on both the genotypes. IISR Calicut type recorded vigorous growth with maximum plant height of 5.23 m, girth 22.53 cm and dry bud yield of 212.14 g/plant and was found to be promising when compared to the Kallar type. The trial was initiated during 1992 with an objective to collect, maintain, characterize and catalogue the germplasm of clove at Pechiparai. Morphological characteristics, yield and yield attributing traits are being evaluated to identify promising accessions. Among the 14 accessions, SA-13 registered the highest yield of 9.08 kg buds per tree and from the pooled mean of three years yield accessions SA-1, SA-3, SA-12 and SA 13 were identified as promising accessions. These accessions can be forwarded to CVT

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 were recorded in 22 accessions and selections, Sel.1, Sel. 4 and Sel. 6 were identified as the promising entries. The germplasm of nutmeg, consisting of 97 accessions have been maintained and are being evaluated for growth and yield characters at Dapoli. Evaluation of, eight accessions of nutmeg planted during 1996-97 at Dapoli, showed variations in bearing, nut size and yield. The growth parameters did not differ significantly among the different genotypes. The plant height ranged from 4 to 5 m, the girth 22.44-32.56 cm and the spread 5.61 - 8.94 m. Tree no. 56 of Acc. A-4/22 (250 fruits), tree no. 65 of Acc. 4/12 (145 fruits), tree no. 38 of Acc. bulk (260 fruits) and tree no. 26 of Acc. 9/4 (70 fruits) were found to be promising. Acc.A-9/4 produced large sized fruits.

Cinnamon

This trial was initiated during 1992 with an objective to collect, maintain, characterize and catalogue the germplasm of cinnamon at Pechiparai. Morphological characteristics, yield and yield attributing traits are being evaluated to identify promising accessions. Among the accessions, Sel.65 performed well and gave the bark yield of 469 g of dried bark/tree and leaf yield of 6.3 kg/tree (Table 34). A local collection from Pechiparai recorded a leaf yield of 6.2 kg/tree and bark yield of 464.5 g/tree. The growth parameters did not vary significantly among different genotypes at Dapoli centre. The plant height ranged from 3.36-3.99 m, girth 38.22-47.78 cm, spread 2.03 -3.62 m and the regenerated shoots from 5.00-7.11

Cassia

At Dapoli, the germplasm of cassia consisting of 6 accessions have been maintained and are being evaluated for growth and yield performance. The growth parameters did not vary significantly among different genotypes at Dapoli centre. The plant height ranged from 3.36-3.99 m, girth 10.00-17.25 cm, spread 0.61-1.86 m.

Table 33. Tree spices germplasm collections at AICRPS centres

Crop/Centre	Indigenous/cultivated
Clove	
Dapoli	2
Pechiparai	23
Yercaud	13
Total	38
Nutmeg	
Dapoli	97
Pechiparai	22
Total	119
Cinnamon	
Dapoli	11
Pechiparai	12
Yercaud	16
Cassia	
Dapoli	06
Pechiparai	04
Total	49

Table 34. Growth and yield performance of cinnamon at Pechiparai.

Accession	Tree height(cm)	Rejuvenation growth (120 days)	Stem girth(cm)	Leaf yield (kg/plant)	Bark yield (g/plant)
Sel.5	2.41	0.95	15.3	3.2	208.3
Sel.44	2.42	1.02	14.8	3.5	325.5
Sel.53	2.43	0.98	11.2	3.8	96.4
Sel.63	2.40	1.03	13.6	4.4	232.7
Sel.65	3.32	1.25	23.4	6.3	469.0
Sel.139	2.36	1.18	16.2	3.9	386.3
Sel.203	2.68	1.02	18.5	4.6	162.4
Sel.310	2.72	1.06	16.3	3.8	296.8
Sel.312	2.67	1.19	16.4	4.9	352.3
Konka	2.70	1.17	12.9	4.5	205.4
Bhavani	2.32	1.16	14.2	4.3	242.1
Pechiparai local (CV 12)	2.35	1.10	21.6	6.2	464.5
CV (%)	7.14	7.42	9.64	12.20	10.25
SED	0.15	0.12	1.56	0.87	22.45
CD (P=0.05)	0.30	0.20	2.63	1.58	50.93

5.2 Coordinated Varietal Trial (CVT)

5.2.1 CVT-1992 - clove (Pechiparai/Yercaud)

Nine genotypes collected from IISR, Calicut were evaluated at Pechiparai for growth and yield parameters. Among the genotypes SA-3 was found to be promising in terms of yield characters (4.36 kg/tree) (Table 35).

Table 35. Performance of CVT clove accessions at Pechiparai

Accession	Yield/tree				Yield (kg/ha)	Per cent increase over check
	2005	2006	2007	Pooled mean		
SA-3	0.073	5.10	7.92	4.36	1207.72	58.49
SA-4	0.117	4.32	4.08	2.84	786.68	36.25
SA-5	0.077	4.98	5.60	3.55	983.35	49.03
SA-6	0.098	1.20	4.64	1.98	548.46	8.57
SA-7	0.159	3.8	4.58	2.85	789.45	36.50
SA-8	0.170	3.37	4.27	2.60	720.20	30.41
SA-9	0.140	3.15	6.15	3.15	872.55	42.57
SA-10	0.122	4.0	5.70	3.27	905.79	44.72
SA-11	0.018	1.80	3.74	1.85	512.45	2.14
SA-12	0.025	3.75	4.32	2.70	747.90	32.93
SED	0.170	1.25	2.32	-	-	-
CD(P=0.05)	0.340	2.45	4.95	-	-	-

5.2.2 CVT 2001- nutmeg (Dapoli, Pechiparai)

The trial on nutmeg was planted during the year 2003-04 at Dapoli centre. There was no significant difference in height, number of branches and spread among the genotypes. The plant height ranged from 0.68 to 1.52 m, girth from 4.83 to 7.83 cm., and the spread from 0.30 to 0.93 m. Six accessions collected from IISR, Calicut were evaluated along with a local check at Pechiparai center. Among the accessions A9/150 recorded highest plant height (91.71 cm).

5.2.3. CVT 2001 - cassia (Pechiparai)

Among the four selections, D3 was found to be promising with a dry leaf yield of 349.8 g/tree at Pechiparai centre.

5.3 Propagation/Multiplication Trial

5.3.1 Soft wood grafting in clove (Dapoli)

The propagation trial on softwood grafting of clove on different species of jamun rootstock did not show any success. This might be due to incompatibility of rootstock.

5.4 Disease Management Trial

5.4.1 Survey for disease incidence in tree spices (final report) (Dapoli, Pechiparai)

Nutmeg

The shot hole disease (*Colletotrichum gloeosporioides*) was observed in all the orchards visited. Incidence of shot hole was trace to low (up to 10%). The incidence of fruit rot (*Botriodiplodia theobromae*) recorded in few orchards was at low level. Dieback or sudden wilt of branches was observed in all the orchards visited. The incidence of the disease was at low level except in Ratnagiri district.

Cinnamon

In all the seven orchards visited low incidence (<10%) of leaf blight, leaf spot and pink disease were recorded during 2001-2002 to 2006-07. Low incidence (<10%) of leaf blight, leaf spot was recorded in Raigad, Ratnagiri and Sindhudurg districts. Low incidence of pink disease was recorded in Raigad, Ratnagiri whereas in Sindhudurg no incidence of pink disease was observed during 2001-2002 to 2006-07.

Clove

In all five orchards visited, leaf rot, leaf spot and dieback of branches were found to be the most common diseases. Among these diseases, leaf rot disease was moderate in Raigad, Ratnagiri and Sindhudurg districts whereas leaf spot and dieback were at low level. Incidence of leaf rot was moderate (11 to 30 %) throughout the period of survey.

At Pechiparai, the disease incidence was found to be high during October to November. The key factors influencing the spread of the disease were found to be the well-distributed rainfall with RH 89-92% and a temperature of 22.53°C – 30.50°C. Among the different plant products evaluated, *Lawsonia* leaf extract (5.0%) was effective and recorded 60% reduction of leafspot. The effective bioagents *P. fluorescens* (Pf_{ppg}) and Pf₁ were tested for their efficacy under *in vitro* conditions. Among them *P. fluorescens* (Pf_{ppg}) was effective and recorded a inhibition zone of 27.00 mm. The combination of Pf_{ppg} with *Lawsonia* sp. extract recorded lowest disease incidence of 13.38 per cent and a cost benefit ratio of 1:2.97 (Table 36).

Table 36. Biocontrol efficacy of antagonists and plant extracts in controlling leaf spot disease of clove

Treatment	2005		2006		Yield/ Plant (kg)	Cost benefit ratio
	Disease incidence (%)	Reduction over control (%)	Disease incidence (%)	Reduction over control (%)		
<i>Pseudomonas fluorescens</i> (Pf _{ppg})	12.80 ^{bc}	51.31	14.57 ^{bc}	45.31	2.20	1: 2.42
<i>P. fluorescens</i> (Pf _{ppg}) + <i>Lawsonia</i> sp.	11.75 ^b	55.31	13.38 ^{ab}	49.77	2.70	1: 2.97
<i>P. fluorescens</i> (Pf _{ppg}) + <i>Ocimum sanctum</i>	12.29 ^{bc}	53.25	14.18 ^{abc}	46.77	2.30	1: 2.53
<i>P. fluorescens</i> (Pf ₁)	15.67 ^e	40.40	17.35 ^d	34.87	2.10	1: 2.32
<i>P. fluorescens</i> (Pf ₁) + <i>Lawsonia</i> sp.	13.92 ^{cd}	47.05	15.43 ^{bcd}	42.08	2.14	1: 2.35
<i>P. fluorescens</i> (Pf ₁) + <i>Ocimum sanctum</i>	14.20 ^d	45.99	15.98 ^{cd}	40.02	2.14	1: 2.35
Mancozeb (0.2%)	9.86 ^a	62.50	12.26 ^a	53.98	2.00	1: 2.10
Control	26.29 ^f	-	26.64 ^e	-	1.80	1: 1.99
CD (P=0.05)	0.98	-	1.82	-	-	-

6. Coriander

6.1 Genetic Resources

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

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

At Coimbatore centre, 274 accessions of coriander germplasm were screened for productivity and incidence to powdery mildew. Powdery mildew was noticed in all the accessions. The PDI ranged from 16 to 64 and six accessions (CS-63, CS-75, CS-142, CS-205, CS-211 and CS-233) recorded a minimum intensity of 16 PDI with a yield of 950 kg/ha. Sixteen accessions (CS-52, CS-58, CS-71, CS-73, CS-107, CS-115, CS-174, CS-184, CS-199, CS-224, CS-225, CS-231, CS-237, CS-253, CS-256 and CS-266) recorded a disease intensity of 18 PDI with a yield of 850 kg/ha. Accessions CS-45, CS-52 and CS-58 registered a yield of 2.3 kg, 2.2 kg and 2.1 kg/20m² respectively and a disease intensity of 18 PDI for powdery mildew.

Among one hundred germplasm evaluated at Dholi centre, twelve accessions namely, RD-151, DH-115, JCO-125, JCO-102, JCO-360, JCR-340, ICS-2, RD-366, RD-380, RD-385, JCO-130 and UD-73 gave the maximum yield as compared to check variety, Rajendra Swati and Pant Haritima. Among the promising accession RD-154 produced maximum yield 1.10 kg/4.8 m² followed by DH-115 and JCO-125 (1.05 kg/4.8 m²).

One hundred and twenty six entries were evaluated at Guntur centre. Among the entries evaluated, LCC-201 recorded highest yield (single plant yield-3.26 g) followed by LCC-210 (3.16 g), LCC-149 (3.07 g) and LCC-138 (3.03 g) which was significantly superior to checks Sindhu (1.97 g), Sadhana (2.1 g), Swathi (1.54 g), Sudha (1.62 g) and Local (1.64 g). Sixty-three germplasm lines were collected during the period.

Among the 148 accessions of coriander evaluated at Hisar centre, using Hisar Anand, Narnaul Selection and Pant Haritima as checks the mean seed ranged from 180 g (DH-350) to 560 g (DH-224). Forty-two lines gave higher seed yield than the highest yielding check, Hisar Anand. The most promising lines for seed yield were DH-221, DH-222, DH-224, DH-228, DH-229, DH-236, DH-239, DH-278, DH-284, DH-285, DH-335 and DH-346.

During the year 96 entries were raised and evaluated with GCori-1 and GCori-2 as checks for different yield attributes at Jagudan centre. Among them seven entries namely, JCr-372, EC-363574, 363971, Lam-45, Egyptian, Lam-23 and Lam-73 were dwarf types (<68 cm plant height) and six entries viz. JCr-392, 342, 256, EC-363980, JCr-372 and JCr-308 had good branches (>6 branches per plant). Twelve entries (JCr-392, EC-350691, Lam-4, UD-290, Russian, EC-363974, JCr-393, EC-363980, Lam-5, EC-350690, JCr-375 and JCr-342) had > than 21 umbels per plant and seven entries (JCr-333, 377, UD-51, JCr-379, 340, 344 and JCr-342) recorded equal or more than 7 umbellate per umbel. Nine entries namely, JCr-360, Lam-87, EC-363980, JCr-381, Lam-6, JCr-387, 402, Australian and EC-363972 were identified as early maturing types (d" 110 days) Entries Lam-4, JCr-392, 401, Dhana-98, EC-343370, JCr-350, 690, Russian were identified as high yielders with

more than 2330 kg/ha grain yield. During the year 41 (39 + 2) entries were screened for the resistance against powdery mildew disease (PM) under natural condition at Jagudan. The incidence of PM ranged from 15 to 50%. None of the entries were found resistant against the disease. The minimum incidence was noticed in JCr-403 (15%) followed by GCr-1 (20%).

Out of 213 accessions, 25 accessions yielded better than best check variety, RCr-41 at Jobner. Some of the promising accessions identified on the basis of yield per plant were UD-374-2, Merigold-6, DH-38-I, UD-21-I, UD-82, Dipchar, UD-21-III, UD-73, UD-417, UD-406, Peempoda, UD-744, Jhola-2-2, UD-91 and UD-340. Twenty three entries which were short listed for powdery mildew from previous year's at Jobner were screened against powdery mildew disease under natural condition. The disease incidence ranged from 30 to 60%. None of the entries was found resistant to the disease. The minimum incidence was noticed in JCr-328, JCr-360, UD-290, DH-227, DH-231 and NDCor-29 (30%) and followed by DH-228 and DH-239 (35%).

Maximum yield of 17.5 q/ha was obtained with NDCor-2 over check of K.sel (16.2 q/ha) and Hisar Anand (11.2 q/ha) at Kumarganj. The germplasm of coriander conserved at various AICRPS centres are presented in Table 37.

Table 37. Coriander germplasm collection at AICRPS centres

Centre	Indigenous		Total
	Cultivated	Wild and related sp.	
Coimbatore	274	-	274
Dholi	97	3	100
Guntur	248	-	248
Hisar	251	-	251
Jagudan	86	22 (Exotic)	108
Jobner	753	102	855
Kumarganj	75	-	75
Total	1784	127	1911

6.2 Coordinated Varietal Trial

6.2.1 CVT 2001 Series V (final report) (Coimbatore,)

Nineteen accessions collected from various coordinating centres along with the local check CO-3 and CO (CR)-4 were evaluated for the growth and yield characters during 2007-08 at Coimbatore centre. These accessions were obtained from Hisar (UD-206, UD-242, Hissar Anand), Kumarganj (K.sel, ND Cor-2, ND Cor-30), Jagudan (J.Cori-340, J.Cori-375) and Jobner (LCC, UD and RG series). The highest grain yield of 650 kg/ha was recorded by ND Cor-3, UD-728 and UD-797. This was on par with the yield of the local check CO (CR)-4. The pooled mean of the three years 2005-06 to 2007-08 revealed that the cultivar LCC-170 and UD-206 recorded the highest yield of 928.33 kg/ha and 923.33 kg/ha respectively (Table 38).

Table 38. Pooled data on growth and yield performance of CVT coriander

Cultivar/variety	Yield /ha(kg)			
	2005-06	2006-07	2007-08	Mean
K. sel	535	450	600	528.33
NDCor-2	435	600	550	528.33
NDCor- 30	715	450	650	605.00
J.Cor-340	665	450	600	571.66
J.Cor-375	915	600	600	705.00
DH -206	800	1420	550	923.33
DH -242	515	300	450	421.66
Hisar Anand	515	360	600	491.66
LCC-212	465	600	500	521.66
LCC-170	1135	1050	600	928.33
UD-728	535	700	650	628.33
UD-796	565	600	400	521.66
UD-797	600	450	650	566.66
RG-20	400	450	600	483.33
RG-435	500	600	450	516.66
RG-684	535	300	550	461.66
RG-41	500	600	550	550.00
RG-436	685	300	550	511.66
SED				28.07
C D (P=0.05)				56.94

6.2.2 CVT 2004 - Production of leafy type coriander during off-season (final report)
(Coimbatore, Guntur, Hisar)

At Coimbatore, seven leafy type coriander received from various coordinating centres viz., Hisar (DH-202, DH-228), Guntur (LCC-232, LCC-234) and NRCSS, Ajmer (ACr-250, ACr-256) along with the two varieties of Tamil Nadu Agricultural University (CO-2 and CO-4) were evaluated with the national check Pant Haritma to find its suitability for Tamil Nadu condition. The results of the evaluation conducted during 2005-06 revealed that among the ten types three genotypes viz., DH-228, CO-2 and LCC-234 registered the maximum leaf yield of 3.40, 3.32 and 3.30 t/ha respectively. The evaluation of the genotypes during 2006-07 revealed that the yield varied from 1.96 t/ha to 3.40 t/ha. The highest leaf yield of 3.4 t/ha was obtained in DH-202. The leaf yield/ha varied from 2.60 to 3.35 t/ha during 2007-08. The highest leaf yield was recorded by the accession DH-202 (3.35 t/ha). The pooled analysis of the nine genotypes along with the check revealed that the leaf yield varied from 2.44 t/ha to 3.18 t/ha. The highest leaf yield of 3.18 t/ha was registered by the cultivar DH-202 followed by the check Pant Haritma (3.15 t/ha) and LCC- 234 (3.10 t/ha) (Table 39).

During 2007-08, fourteen entries were evaluated for their performance for leaf yield at Guntur centre. Highest greens yield was recorded in LCC-244 (18.9 t/ha) followed by LCC-233 (18.5 t/ha) and LCC-234 (18.0 t/ha), which were significantly superior to check Local (9.07 t/ha)

At Hisar, significant differences among entries were recorded for days taken to flowering as well as total leaf yield. The variety DH-228 was late in flowering and gave maximum mean leaf yield (3889 kg/ha), which was 72.23% higher over check variety Pant Haritima followed by DH-202 (2775 kg/ha). The entries CO-2, CO-4, LCC-232 and LCC-234 were the earliest and took about 22 to 25 days to flowering/bolting, therefore, did not produce green leaf yield (Table 40).

Table 39. Yield performance of leafy type coriander during off-season at Coimbatore (Pooled analysis 2005 - 2008)

Cultivar/variety	Yield/ha (kg)			
	2005-06	2006-07	2007-08	Mean
DH-202	2.80	3.40	3.35	3.18
DH-228	3.40	2.60	2.60	2.87
Acr-250	2.50	2.90	2.80	2.73
Acr-256	2.40	1.96	2.95	2.44
LCC- 234	3.30	2.90	3.10	3.10
LCC- 232	2.40	3.04	3.15	2.86
Pant Haritima	2.70	3.70	3.05	3.15
CO-2	3.20	2.50	3.10	2.93
CO-4	2.90	2.72	3.25	2.96
SED	0.15	0.18	0.19	0.18
CD (P=0.05)	0.03	0.40	0.40	0.38

Table 40. Performance of leafy type coriander during off-season at Hisar.

Entry	Average days to bolting /flowering	Leaf yield (kg/ha)				Increase /decrease over check (%)
		2005	2006	2007	Mean	
ACr-250	30	915	1002	1080	999	-55.76
ACr-256	32	1650	1337	1250	1412	-37.47
DH-202	46	2775	2505	3044	2775	22.90
DH-228	49	3450	4008	4210	3889	72.23
JCO-377	34	1650	1837	1760	1749	-22.54
JCO-384	30	1350	1503	1408	1420	-37.11
Pant Haritima	36	2100	2254	2420	2258	-
C D (P=0.05)	-	185	150	192	-	-

6.2.3 CVT 2005

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

Among the entries evaluated at Dholi, none of entries and national check was found significantly superior over local check regarding number of branches per plant, number of umbels per plant, number of umbellets per umbel and yield per plot or yield per hectare. However, COR-15, COR-2, COR-14 and COR-43 produced significantly more grain per umbel (42.33, 41.07, 37.47 and 37.27 respectively) as compared to local check Rajendra Swati while entries, COR-4, COR-10, COR-11, COR-12, COR-13, COR-14 and COR-15 were found significantly early maturing as compared to local check.

At Guntur, COR-12 (667 kg/ha), COR-10 (659 kg/ha), and COR-11 (643 kg/ha) recorded high yield, which are significantly superior to checks Sudha (554 kg/ha) Sadhana (413 kg/ha) and local coriander (285 kg/ha)

Significant difference was obtained for all the parameters studied at Hisar centre. Plant height ranged from 75.8 to 115.0, number of branches 7.0 to 10.9, umbels per plant 40.0 to 60.6 and seeds per umbel 23.3 to 43.5. Maximum seed yield (1913 kg/ha) was recorded in COR-5 followed by COR-4 (1825 kg/ha) and COR-2 (1670 kg/ha) (Table 41)

Table 41 Performance of CVT coriander at Hisar

Entry	Plant height (cm)	Branches/ plant	Umbels/ plant	Umbellets/ umbel	Seeds/ umbellet	Seeds/ umbel	Seed yield (kg/ha)
COR-1	91.3	9.8	48.7	6.0	5.3	30.5	1554
COR-2	87.6	8.7	58.8	5.9	5.4	35.5	1670
COR-3	115.0	8.7	44.0	6.0	6.8	37.3	1457
COR-4	113.1	10.9	60.0	6.3	7.5	43.5	1825
COR-5	126.5	9.3	60.6	6.2	6.1	36.4	1913
COR-6	81.3	9.5	47.3	5.7	5.5	31.3	1507
COR-7	110.4	8.9	45.3	5.8	6.1	35.4	1563
COR-8	92.0	7.4	44.8	5.2	4.9	25.2	1458
COR-9	78.3	7.7	41.1	4.9	5.1	24.7	1298
COR-10	75.8	7.4	43.4	5.0	5.0	23.3	1057
COR-11	75.8	7.0	40.0	5.0	4.9	24.1	1034
COR-12	80.7	9.5	52.1	5.7	5.5	29.9	1590
COR-17	120.6	10.4	58.7	6.4	5.5	37.2	1650
C.D = (P=0.05)	03.4	0.4	3.3	0.4	0.6	3.7	112

Though the yield differences among the entries were significant at Jagudan centre, none of the entries were superior over check. COR-11 gave the highest yield (1408 kg/ha), which was 16.99% higher over check GCori-2 and was on par with the check.

At Jobner, significant differences were observed for all the characters including seed yield. The seed yield ranged from 208.33 to 1078.70 kg/ha. Of the twenty one entries evaluated, COR-1 recorded maximum seed yield of 1078.70 kg/ha followed by COR-9 (1023.70 kg/ha), RD-154 (907.41 kg/ha), COR-15 and COR-8 (875.00 kg/ha) and COR-2 (847.22 kg/ha), while lowest seed yield of 208.33 kg/ha was recorded in COR-11.

Maximum seed yield in coriander was observed in COR-9 (19.90 a/ha) followed by 19.37 a/ha seed yield in Cor- 8 at Kumarganj.

At Raigarh, COR-3 (8.78 a/ha), COR-5 and COR-2 (8.54 a/ha) were identified as high yielders.

6.3 Coordinated Varietal Trial

6.3.1 Initial evaluation trial

(Guntur, Hisar, Jagudan, Jobner, Kumarganj)

Among the twelve entries tested LCC-240 recorded highest yield of 691 kg/ha followed by LCC-237 with 681 kg/ha at Guntur. LCC-240 recorded 25.2% increase in yield over check where as LCC-237 recorded 23.3% increase in yield over check indicating the superiority of these lines. The three years pooled analysis indicated that LCC-237 (791 kg/ha) and LCC-236 (773 kg/ha) recorded significantly higher yield than the check Sadhana (617 kg/ha). Both the entries had higher oil content (LCC-237 (0.39%) and LCC-236 (0.35%) than the check Sadhana (Table 42). These entries may be promoted to coordinated varietal trials for multilocation testing.

Table 42. Yield and quality performance of IET (pooled data) coriander at Guntur

Entry	No. of umbellets / umbel	Days to maturity	Test weight (g)	Oil (%)	Oil yield (l/ha)	Yield /ha (kg)	Increase /decrease over check (%)
LCC-134	5.1	85.0	15.53	0.32	2.41	666	7.9
LCC-214	5.2	85.8	15.79	0.42	3.25	678	9.9
LCC-220	5.0	91.0	14.69	0.40	2.63	607	-1.6
LCC-228	5.5	87.1	16.32	0.43	2.85	697	13.0
LCC-229	5.2	89.7	15.79	0.32	2.04	588	-4.7
LCC-234	4.8	89.2	14.29	0.37	1.85	525	-14.8
LCC-236	5.2	88.7	16.86	0.35	2.65	773	25.4
LCC-237	5.3	86.9	15.51	0.39	3.11	791	28.3
LCC-240	5.3	87.2	15.89	0.38	2.58	695	12.7
LCC-243	5.1	91.2	13.96	0.35	1.74	500	-19.0
Sadhana (C)	5.0	88.1	13.43	0.33	2.06	617	-
Swathi (C)	4.7	85.0	15.62	0.25	1.53	586	-5.1
CD (P=0.05)	NS	1.9	1.73	-	-	136	
CV (%)	8.7	1.3	6.68	-	-	12	

At Hisar, DH-220 and DH-233 gave significantly better yield over check with 27.67 and 32.05% increase in yield, respectively. Hence, both these lines would be included in coordinated varietal trial for further evaluation.

Yield for the entries tested at Jagudan were non significant. However, an entry JCr-383 gave 1430 kg/ha yield, which was 10.57 per cent higher over check. The pooled data for three years showed nonsignificant difference for yield. However, an entry JCr-383 gave high yield (1439 kg/ha), which was 12.95% higher over check.

At Jobner, ten entries were evaluated and the analysis of variance revealed significant differences among the entries for all the traits including seed yield. The seed yield ranged from 333.33 to 930.56 kg/ha. Of the ten entries evaluated, UD-475 recorded maximum seed yield of 930.56 kg/ha followed by UD-20-130-278 (784.72 kg/ha), RCr-435 check (625 kg/ha), RCr-436 check (604.17 kg/ha), UD-600 (506.27 kg/ha) and Merigold-6 (493.06 kg/ha), while lowest yield of 333.33 kg/ha was recorded in local check. Mean performance of the entries evaluated in IET over 2004-05 to 2006-07 revealed superior performance of UD-475 yielding 1249.23 kg/ha followed by UD-20-130-278 (1158.95 kg/ha), RCr 435 check (967.59 kg/ha), Merigold-6 (853.40 kg/ha) and RCr-436 check (846.07 kg/ha), while lowest mean yield of 618.05 kg/ha was recorded in local check (Table 43).

Highest seed yield of 17.7 q/ha was observed in NDCor-2 out of ten entries tested at Kumarganj, followed by seed yield of 17.1-17.2 q/ha produced by NDCor-30 and NDCor-49 during the year 2007-08.

Table 43 Yield performance of IET coriander entries at Jobner

Entry	Seed yield (kg/ha)				Increase/ decrease over check (%)
	2004-05	2005-06	2006-07	Mean	
UD-475	1576.39	1240.74	930.56	1249.23	29.11
UD-20-130-278	1645.83	1046.30	784.72	1158.95	19.78
RCr-435 Check	1444.44	833.33	625.00	967.59	Best check
Merigold-6	1409.72	657.41	493.06	853.40	-11.80
RCr-436 Check	1128.47	805.56	604.17	846.07	-12.56
UD-630	1434.03	611.11	458.33	834.49	-13.76
UD-600	1239.58	675.00	506.25	806.94	-16.60
UD-627	1256.94	490.74	368.06	705.25	-27.11
UD-707	1017.36	527.78	395.83	646.99	-33.13
Local Check	1076.39	444.44	333.33	618.05	-36.12
CD (P=0.05)	178.70	174.11	130.58		
CV (%)	7.88	13.85	13.85		

6.4 Quality evaluation trial

6.4.1 Quality evaluation in coriander (Jobner)

Twenty one entries of coriander under CVT were tested for volatile oil content during Rabi 2006-07. The volatile oil content in the entries of CVT ranged from 0.20% to 0.43%. The maximum volatile oil of 0.43% was observed in COR-3 and COR-2 followed by 0.40% in RCr-435 check, RCr-436 check, RD-154, RD-366, COR-17, COR-12, CO-1, COR-4, COR-5, COR-6, COR-8 and COR-9 while minimum of 0.20% in COR-16. The entry COR-1 ranked first in terms of volatile oil yield (4.31 l/ha) followed by COR 9 (4.09 l/ha), COR-2 (3.67 l/ha), RD-154 (3.63 l/ha) and COR-8 (3.50 l/ha). While lowest volatile oil yield of 0.69 l/ha was recorded in COR-11. Ten entries of coriander under IET were tested for volatile oil content during Rabi 2006-07.

The volatile oil content in the entries of IET ranged from 0.20 to 0.40%. The maximum volatile oil of 0.40% was observed in UD-475, Merigold-6 and UD-20-130-278 followed by 0.37% in RCr-435 check and minimum

of 0.20% in UD-627 and UD-630. Highest volatile oil yield was recorded in UD-475 (3.72 l/ha) followed by UD-20-130-278 (3.14 l/ha) and RCr-435 check (2.31 l/ha) and minimum was recorded in UD-627 (0.74 l/ha). On the basis of three years data (2004-05, 2005-06 and 2006-07) (Table 44), the highest mean volatile oil content of 0.43% was recorded in UD-475 and Merigold-6 followed by 0.42% in UD-20-130-278 and 0.39% in RCr-435 check, whereas minimum 0.31% was recorded in UD-630. The maximum mean volatile oil yield in terms of litre per ha was observed in UD-475 (5.37 l/ha) followed by UD-20-130-278 (4.87 l/ha) and RCr-135 check (3.77 l/ha) and minimum in local (2.04 l/ha).

Table 44. Volatile oil content of IET coriander (2004-05 to 2006-07)

Entry	Mean seed yield (kg/ha)	Volatile oil (%)				Mean volatile oil yield (l/ha)
		2004-05	2005-06	2006-07	Mean	
UD-475	1249.23	0.43	0.47	0.40	0.43	5.37
UD-600	806.94	0.33	0.40	0.30	0.34	2.74
UD-627	705.25	0.35	0.40	0.20	0.32	2.26
UD-630	834.49	0.33	0.40	0.20	0.31	2.59
UD-707	646.99	0.40	0.33	0.22	0.32	2.07
Merigold-6	853.40	0.47	0.43	0.40	0.43	3.67
UD-20-130-278	1158.95	0.43	0.43	0.40	0.42	4.87
RCr-435 Check	967.59	0.37	0.43	0.37	0.39	3.77
RCr-436 Check	846.07	0.30	0.40	0.33	0.34	2.88
Local Check	618.05	0.25	0.37	0.37	0.33	2.04
CD ($P=0.05$)		0.08	0.08	0.04		
CV (%)		13.23	1.15	7.59		

6.5 Nutrient Management Trial

6.5.1 Effect of biofertilizer, *Azospirillum* on coriander (Dholi)

No significant effect was found regarding height of the plant, number of branches per plant and number of umbellets per umbel at Dholi centre. Application of inorganic nitrogen 100% + *Azospirillum* + 5 t/ha FYM (T_1), inorganic nitrogen 75% + *Azospirillum* + 5 t/ha FYM (T_2) and inorganic nitrogen 50% + *Azospirillum* + 5 t/ha FYM (T_3) gave significantly more number of umbels per plant (70.13, 68.33 & 66.80 respectively) as compared to control (49.93). Application of inorganic nitrogen 100% + *Azospirillum* + 5 t/ha FYM (T_1), inorganic nitrogen 75% + *Azospirillum* + 5 t/ha FYM (T_2), inorganic nitrogen 50% + *Azospirillum* + 5 t/ha FYM (T_3), FYM-10 t/ha + *Azospirillum* and FYM-10 t/ha alone (T_7) produced significantly more yield (2.05, 1.92, 1.88, 1.83 & 1.81 t/ha respectively) as compared to control (1.35 t/ha) while inorganic nitrogen 100% + *Azospirillum* + 5 t/ha FYM (T_1), inorganic nitrogen 75% + *Azospirillum* + 5 t/ha FYM (T_2), inorganic nitrogen 50% + *Azospirillum* + 5 t/ha FYM (T_3) and 100% inorganic nitrogen (T_6) gave significantly more number of grain per umbel (45.00, 41.33, 39.53 & 37.93 respectively) as compared to control (29.47). Among the treatment inorganic nitrogen 100% + *Azospirillum* + 5 t/ha FYM produced maximum number of umbels per plant (70.13), number of grains per umbel (45.00) and yield per plot (0.98 kg/4.8 m²) or yield (2.05 t/ha) followed by inorganic nitrogen 75% + *Azospirillum* + 5 t/ha FYM.

6.5.2 Effect of bioregulators on coriander (Jobner)

At Jobner the experiment consisting of thirteen treatment 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 DAS) two (40 and 60 DAS) and three (40, 60 and 80 DAS) along with one absolute control. On the basis of three years data application of NAA 50 ppm resulted in significantly higher seed yield of coriander and net returns but it was at par with triacontanol 1.0 ml/l (Table 45). 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 and net returns also showed increasing trend but the significant response was observed only up to 2 sprays i.e. at 40 and 60 DAS. Two foliar sprays of 50 ppm NAA or 1.0 ml/l triacontanol at 40 and 60 DAS could be recommended for obtaining higher seed yield as well as net returns from coriander crop.

Table 45 Effect of bioregulators on seed yield of coriander at Jobner

Treatment	Seed yield (kg/ha)				Net Returns (Rs/ha)	B C ratio
	2004-05	2005-06	2006-07	Mean		
Bioregulators						
Triacontanol @ 0.5 ml/l	1475	1379	1007	1287	17205	1.15
Triacontanol @ 1.0 ml/l	1694	1562	1074	1443	20955	1.39
NAA @ 50 ppm	1728	1585	1104	1472	21804	1.45
Water spray	1409	1246	901	1185	14805	1.00
CD (P = 0.05)	79	77	117	51	857	0.07
Sprays						
One (40 DAS)	1460	1358	920	1246	16412	1.11
Two (40 & 60 DAS)	1603	1470	1063	1379	19498	1.30
Three (40, 60 & 80 DAS)	1668	1501	1081	1417	20210	1.33
CD (P = 0.05)	68	67	102	44	742	0.06
Control v/s Rest						
Control	1264	1160	815	1080	12500	0.86
Rest	1577	1443	1021	1347	18698	1.25
CD (P = 0.05)	101	94	144	63	1050	0.09

Common cost of cultivation Rs 14500/ha. Cost of coriander seed Rs 25/kg. Cost of triacontanol Rs 300/litre, Cost of NAA Rs 350/100 g, Cost of one spray Rs 160/ha.

6.5.3 Role of rhizobacteria in growth promotion of coriander (Coimbatore, Guntur, Hisar, Jagudan)

At Coimbatore, an experiment with two types of rhizobacteria (FK-14 & FL-18) and different methods of their application was tested on coriander to evaluate the effect on growth promotion of coriander. Among the eight treatments, treatment T₃ (rhizobacteria FL-18 as seed-treatment) recorded maximum yield (500 kg/ha) followed by treatment T₂ (rhizobacteria FK-14 (seed treatment + soil application)) that recorded a yield of 450 kg/ha.

Among the treatments evaluated at Guntur, T 6 (seed treatment + soil application with FK-14 + FL 18) recorded maximum yield (583 kg/ha) followed by T 2 (seed treatment + soil application with FK-14) (570 kg/ha) which was on par and significantly superior to control (402 kg/ha)

At Hisar, among the treatments, maximum seed yield (1779 kg/ha) was recorded with the application of rhizobacteria FL 18 (seed treatment + soil application) followed by *Trichoderma* MTCC 5179 (1611 kg/ha) (Table 46)

At Jagudan, the effect of rhizobacteria was found to be non significant on ancillary characters yield as well as quality of coriander. However, seed inoculation of FL-18 was found beneficial for improving yield

Table 46 Effect of rhizobacteria on growth and seed yield of coriander at Hisar

Treatment	Plant height (cm)	Branches /plant	Umbels /plant	Umbellets /umbel	Seeds/ umbel	Seed yield (kg/ha)
Rhizobacteria FK-14 (seed treatment)	65.0	6.5	35.5	4.5	28.4	1395
Rhizobacteria FK-14 (seed treatment + soil application)	65.9	6.4	35.7	5.0	32.3	1564
Rhizobacteria FL-18 (seed treatment)	68.2	6.5	39.6	5.2	29.1	1427
Rhizobacteria FL-18 (seed treatment + soil application)	69.5	6.8	45.9	5.7	35.0	1779
Rhizobacteria FK-14 + FL-18 (seed treatment)	69.8	6.9	36.4	5.4	31.1	1511
Rhizobacteria FK-14 + FL-18 (seed + soil treatment)	72.2	6.8	40.3	5.1	31.9	1604
<i>Trichoderma</i> MTCC 5179 (Recommended dose)	70.1	6.6	39.3	5.0	34.1	1611
Control	61.5	6.0	39.4	5.0	29.3	1493
C.D (P=0.05)	4.5	0.5	2.8	0.5	3.5	186

6.5.4 Identification of drought and alkalinity tolerance source in coriander (Coimbatore, Guntur, Kumarganj)

A study on identification of drought tolerance source in coriander was conducted during 2007-08 at Coimbatore. Among the fifty high yielding genotypes evaluated for drought tolerance, the genotype CS-127 recorded the highest yield of 305.90 g and 270.7 g of grain yield /plot (5 m²) when they were subjected to drought during the vegetative phase and flowering stage respectively. The same genotypes recorded a highest grain yield of 454.70 g/plot under control.

Among the entries evaluated for drought tolerance at Guntur, LCC-200 (529 kg/ha) followed by LCC-187 (515 kg/ha) recorded significantly higher yields over best check Sadhana (414 kg/ha). The data on physiological parameters indicated that LCC-187 (75.5), LCC-184 (74.9) recorded high RWC %, where as LCC-219 and LCC-229 has high SLW (3.85) LCC-134 (53.5) and LCC-143 (50.3) recorded high CSI. LCC-200 (383) and LCC-187 (344) registered high SLA.

At Jobner, twenty entries of coriander were evaluated under normal and limited moisture condition during Rabi 2006-07. Stress susceptible index (SSI) for seed yield of coriander genotypes revealed that thirteen genotype viz., local, RCr-480, Hisar Anand, ICS-1, UD-728, K-Selection, NDCor-2, RD-154, RCr-20, JCor-375, RCr-684, DH-206 and LCC-17 had SSI value < 1 and may be termed as tolerant genotypes, while rest of the genotypes had SSI value > 1 and termed as susceptible genotype. Thus, on the basis of mean performance of SSI values genotype viz., UD-728, RCr-480 and RCr-435 were tolerant to limited moisture condition. On the basis of values of stress tolerance (TOL) and stress tolerance index (STI), genotype RCr-480 and Hisar Anand were ranked as genotype which were tolerant to limited moisture condition.

6.6 Disease Management Trial

6.6.1 Management of powdery mildew and stem gall in coriander (Coimbatore, Dholi, Jagudan, Jobner, Kumarganj, Raigarh)

A field experiment was conducted during 2007-08 at Coimbatore, to test the efficacy of bacterial biocontrol agents and *Trichoderma* along with chemical check as talc based and liquid formulation against stem gall and powdery mildew diseases. The results revealed that seed treatment with *Pseudomonas fluorescens* (ISR-6) at the rate of 10 g/kg of seed followed by foliar application at 10^8 cfu on 60 days after sowing recorded the minimum powdery mildew incidence of 30.00 PDI when compared to the untreated control (60.00 PDI). The next best treatment was soil application of *Bacillus subtilis* @ 10^8 cfu + spray with *B. subtilis* @ 10^8 cfu after 60 days which recorded the disease incidence of 32 PDI. Among the nine treatments, *P. fluorescens* (ISR-6) applied plots recorded the maximum yield of 690 kg/ha with maximum cost benefit ratio of 1:2.3 as against control (480 kg/ha with 1:1.6). There was no stem gall disease symptom in the entire experimental plots. The pooled mean analysis (2005-06 to 2007-08) revealed that seed treatment with *Pseudomonas* (ISR-6 isolate) + foliar spraying at 60 DAS was found to be effective in reducing the powdery mildew intensity (24 PDI) and recorded the maximum yield of 724.44 kg/ha with CB ratio of 1:2.4. This treatment was on par with *B. subtilis* applied plots.

In the experiment on management of stem gall and powdery mildew at Dholi centre, the lowest incidence of stem gall disease (16.74%), highest yield (1.40 t/ha), decrease in disease incidence over control (78.60%), increase in yield over control (97.18%) were recorded in treatment (T_1) i.e., soil solarization + soil application of *Trichoderma* (1 kg/plot) + spray with tridemorph (Calixin) 0.1% after 60 days of sowing. Second highest yield (1.30 t/ha) and consequently increase in yield over control (83.10%) was in treatment (T_4) i.e., seed treatment, soil drench with tridemorph (Calixin) 0.1% + spray with Calixin 0.1% after 60 days whereas, second highest decrease in PDI over control (53.02%) was noted in treatment (T_5) i.e., carbendazim as soil drench and spray (0.1%). Treatment T_1 proved to be the best treatment with respect to all the recorded parameters. No incidence of powdery mildew was recorded at any stage of the crop.

At Jobner among the eight treatments tested, minimum powdery mildew (25.83%) with maximum seed yield of 668 kg/ha was recorded in the treatment soil solarisation + soil application of *Trichoderma* + spray with calixin which was closely followed by seed treatment, soil drench + spray with calixin (27.50% with seed yield 648 kg/ha) and spray with wettable sulphur (49.17% with seed yield 639 kg/ha). Maximum disease incidence (85.0%) was observed in control. Stem gall disease was not observed in any of the treatments.

At Kumarganj, maximum control of stem gall disease (69.35%) was possible by drenching the soil + foliar spray of carbendazim (0.2 %) after 60 DAS (T₅). Lowest incidence of powdery mildew disease was observed in the treatment foliar spray of wettable sulphur (T₆) over control during the year 2007-08 and maximum yield in T₆ treatment. Study of four years pooled data also showed similar observation in disease control. Maximum seed yield was registered in the treatment soil application of *B. subtilis* 10⁸ CFU and spray with *B. subtilis* after 60 DAS, showing 45.77% increase in yield over control.

At Raigarh, minimum disease intensity of powdery (19.1%) were observed in treatment T5 (carbendazim (0.1%) as soil drench and spray) followed by T6 (spray with wettable sulphur 0.2%) (19.76%). Maximum yield q/ha was found in same treatment (8.0 q/ha) and 8.1 q/ha respectively. Both the treatments were statistically at par regarding disease intensity and yield. Maximum disease intensity (72.16%) and minimum plot yield/kg (3.1) was found in control plant. Minimum disease intensity (10.7%) was observed in treatment T4 (seed treatment, soil drench tridemorph 0.1% + spray with calixin 0.1% after 60 days) followed by treatment T1 (soil solarization + soil application of *Trichoderma* (1 kg/plot) + spray with tridemorph (calixin) 0.1% after 60 days of sowing) (10.77%) and treatment T5 (11.7%) with a maximum yield of 8.5, 7.7, and 7.2 q/ha respectively. Maximum disease intensity (43.72) and minimum yield 3.9 q/ha was in control.

7. Cumin

7.1 Genetic Resources

7.1.1 Germplasm collection, characterization, evaluation, conservation and screening against diseases (Jagudan, Jobner)

Two hundred and fourteen genotypes of cumin were compared with three checks i.e. GC-1, GC-2, GC-3 and GC-4 during rabi season 2007-08. Among them seven entries were identified as tall type. Four entries recorded more than 6 umbellates/umbel. Eight entries were identified for the traits more seeds per umbel i.e. e" 36 seed per umbel. Five entries observed more or less early maturity (d" 101 days). Ten entries isolated as high yielders recorded more than 2257 kg/ha grain yield (yield kg/ha is calculated on basis of per plant yield). The details on quantitative characters are presented in Table 47. Forty three entries were screened for the resistance against blight disease. None of the entries was found free from blight disease incidence. The minimum incidence was noticed in GC-2 (check) & GC-4 (check) (60%) followed by RZ-19 (65%). The blight incidence ranged from 60 to 95%. All other entries were highly susceptible. The incidence of powdery mildew ranged from 10 to 75%. Two hundred and eighty one indigenous and 20 exotic germplasm of cumin are maintained at Jobner centre. The germplasm of cumin maintained at Jobner and Jagudan centres are given in Table 48.

Table 47. Promising accessions of cumin germplasm at Jagudan

Character	Range	GC-4 (Check)	Desirable values	No. of entries	Promising accessions
Plant height (cm) (Tall)*	25.7-46	32.7	>42	7	JC-2002-4, 96-42, 95-75, 99-39, 9936, 99-31, 95-136
Number of branches/plant (More branches)*	3-7.7	5.7	>5.5	9	JC-96-40, 99-39, 96-36, GC-4, JC-2002-37, 2000- 27, 99-43, 99-38, 96-37
Number of umbels/plant (More umbels)*	4-17.3	16.3	>16	6	JC-95-120, 95-100, GC-4, JC-2000-21, 99-3, 96-40
Number of umbellates/umbel (More umbellates)*	4-7	6	>6	4	JC-96-36, 96-53, 95-116, White flower
Number of seeds/ umbel (More seeds)*	15.3-42.7	34	>36	8	GC-2, JC-96-27, 99-43, 99-1, 95-71, 2000-27, GC-1, JC-95-120

Maturity days 2002-36, 94-61 (Early maturity)*	99-117	117	>101	5	JC-94-70, 94-262, 96-54,
Grain yield (g plant ⁻¹) (High yield)*	0.17-3.23	2.07	>2.1	10	JC-2002-31, 2000-66, 2002-37, 99-3, 95-125, GC-1, JC-95-75, 2002-24, 2000-62, 96-40
Grain yield (kg/ha) (High yield)*	179-3475	2221	>2257	10	... As above....

* Trait for which selected

Table 48. Cumin germplasm collection under AICRPS centres

Centre	Indigenous	Exotic	Total
Jagudan	218	7	225
Jobner	281	20	301
Total	499	27	526

7.2 Coordinated Varietal Trial

7.2.2 CVT 2005

(Jagudan, Jobner)

Due to adverse weather conditions and severe disease incidence at Jobner and poor germination at Jagudan the trials could not be completed at both the places.

Among the ten entries of cumin evaluated at Jobner in CVT and tested against wilt, blight and powdery mildew, CUM-3, CUM-6 and RZ-19 (check) recorded minimum disease incidence of wilt (3.33, 3.33 and 5.0%) and blight (26.67, 20.0 and 33.33%, respectively). CUM-2, CUM-3, CUM-4 and RZ-209 recorded minimum powdery mildew incidence (25%).

7.3 Varietal Evaluation Trial

7.3.1 Initial evaluation trial 2005

(Jagudan, Jobner)

The yield differences among the entries evaluated at Jagudan were non-significant. However, the entries JC-2002-41, JC-2002-32 and JC-2002-21 gave higher yield (i.e. 1139, 1129, 1124 kg/ha, respectively), than check GC-4 which was 11.54, 10.60 and 10.07 per cent higher over check, respectively. The pooled data for two years was also non significant for yield characters. However, the entry JC-2002-41 gave higher yield (1340 kg/ha), which was 12.79 per cent higher over check GC-4.

At Jobner ten entries were evaluated but due to adverse weather conditions during reproductive period and severe disease incidence of blight and wilt, the trial could not be completed. Out of ten entries in IET tested against wilt, blight and powdery mildew, UC-331 and UC-225 was found resistant against wilt, blight and powdery mildew.

7.4 Identification of drought tolerance (Jobner)

The trial could not be completed due to severe disease incidence and adverse weather conditions during reproductive period.

7.5 Role of rhizobacteria on growth and yield of cumin (Jagudan)

At Jagudan, two different types of rhizobacteria and their methods of application with recommended dose of fertilizer were tested on cumin cv. GC-4. The trial was laid out with an objective to study the effect of rhizobacteria on growth, yield and quality of seed. The effect of rhizobacteria were found to be non significant on ancillary characters, yield as well as quality of cumin.

7.6 Disease Management Trial

7.6.1 Management of wilt and blight disease in cumin (Jagudan, Jobner)

Minimum incidence of blight was found in the treatment spray with mancozeb @ 0.25% at 40, 50, 60 & 70 DAS (7.67%) and it was on par with the treatment of soil solarization + soil application of *Trichoderma harzianum* + spray with mancozeb @ 0.25% at 60 DAS and followed by the treatment of vermicompost + soil application of *T. harzianum* + mancozeb spray @ 0.25% at 60 DAS and neem cake + soil application of *T. harzianum* + mancozeb spray @ 0.25% at 60 DAS. The treatments, *Pseudomonas fluorescens* (IISR-6) @ 10^8 cfu as seed treatment + soil application of *T. harzianum* + *P. fluorescens* as spray and the control treatment showed maximum incidence of blight (27.33%). The minimum incidence of wilt was found in *P. fluorescens* (IISR-6) @ 10^8 cfu as seed treatment and spray at 60 DAS (10.00%) and it was on par with the treatment *P. fluorescens* (IISR-6) 10^8 cfu as seed treatment + soil application of *T. harzianum* + *P. fluorescens* as spray. The maximum yield was found in spray of mancozeb @ 0.25% at 40, 50, 60 & 70 DAS (497 kg/ha) followed by the treatment of vermicompost + soil application of *T. harzianum* + mancozeb spray @ 0.25% at 60 DAS (305 kg/ha).

At Jobner the experiment on management of wilt and blight in cumin revealed that out of eleven treatments, the minimum wilt incidence (5.67%) and blight incidence (4.67%) was recorded in the treatment where soil solarization and soil application of *Trichoderma* + FYM and spray with mancozeb @ 0.25%. It was closely followed by vermicompost + soil application of *Trichoderma* and spray with mancozeb @ 0.25% wilt (7.0%) and blight (5.30%) with a seed yield of 244 kg/ha. Maximum disease incidence wilt (20.0%) and blight (55.33%) with lowest yield (156 kg/ha) was observed in control (Table 49).

Table 49. Management of wilt and blight in cumin at Jobner.

Treatment	Wilt (%)	Blight (%)	Seed yield (kg/ha)
Soil solarization + soil application of <i>Trichoderma</i> + FYM (5 t/ha) + spray with mancozeb 0.25% (60 DAS)	5.67	4.67	294
<i>Trichoderma</i> + FYM + spray with mancozeb 0.25% (60 DAS)	8.00	5.33	230
Vermicompost (2 t/ha) + <i>Trichoderma</i> + spray with mancozeb 0.25% (60 DAS)	7.00	5.30	235

Neem cake (2 t/ha) + <i>Trichoderma</i> + spray with mancozeb 0.25% (60 DAS)	8.43	6.00	226
Soil drench with carbendazim 0.1% + spray with mancozeb 0.25% (60 DAS)	7.26	5.67	234
<i>Pseudomonas fluorescens</i> (ISR-6) 10^8 cfu as seed treatment and spray (60 DAS)	12.93	28.67	214
<i>Bacillus subtilis</i> as soil application and foliar spray (60 DAS)	14.79	30.00	208
<i>Pseudomonas fluorescens</i> + <i>Trichoderma</i> as soil application + <i>Pseudomonas fluorescens</i> (ISR-6) 10^8 cfu as spray (60 DAS)	12.26	30.67	212
<i>Bacillus subtilis</i> + <i>Trichoderma</i> as soil application + <i>Pseudomonas fluorescens</i> (ISR-6) 10^8 cfu as spray (60 DAS)	12.38	33.33	212
Seed treatment + spray with neem seed kernel extract 5%	10.23	8.00	219
Control	20.09	55.33	156
CD (P = 0.05)	1.88	4.46	43.32
CV (%)	10.44	13.83	13.02

8. Fennel

8.1 Genetic Resources

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

{Dholi, Hisar, Jagudan, Jobner, Kumarganj}

Among the thirty seven accessions evaluated at Dholi centre, six accessions, namely RF-58, RF-27, RF-28, RF-9, RF-57 and J.F-332 gave maximum yield as compared to Rajendra Saurabh check variety. Among the promising accessions, RF-58 and RF-27 produced maximum yield (0.90 kg/7.2 m²) followed by RF-28 (0.85 kg/7.2 m²).

One hundred and twenty two accessions of fennel were evaluated using PF-35, GF-1 and local as checks at Hisar centre. The mean seed yield of the germplasm ranged from 520 g (HF-201) to 1025 g (HF-125) per plot and the promising lines identified for high yield were HF-107, HF-116, HF-118, HF-119, HF-123, HF-125, HF-129, HF-132, HF-139, HF-149, HF-158, HF-200 and HF-212

At Jagudan, 66 and 52 entries were screened for blight disease during kharif and rabi season respectively and no disease was reported.

Out of 78 entries evaluated at Jobner, 10 entries namely, NS-61, NS-1, JF-25, SPS, NS-7, NS-5, NS-50, NS-65, NS-15, and NS-21 yielded better than best check variety RF-125 and were identified as promising.

Maximum seed yield of fennel (3.4 q/ha) was recorded in NDF-34 followed by 1.32 q/ha in NDF-1, 16, 23, 38 at Kumarganj out of 44 entries screened during 2007-08. The germplasm maintained at various centres are given in Table 50.

Table 50. Fennel germplasm collections maintained at various AICRPS centres

Centre	Indigenous	Exotic	Total
Dholi	39	-	39
Hisar	122	-	122
Jagudan	135	4	139
Jobner	261	20	281
Kumarganj	44	-	44
Total	601	24	625

8.2 Coordinated Varietal Trial

8.2.1 CVT-2004

(Dholi, Hisar, Jagudan, Jobner and Kumarganj)

At Dholi centre none of the entries were found significantly superior over local check variety Rajendra Saurabh regarding number of umbellets per umbel, number of grains per umbellet, yield per plot and yield per hectare. However, Rajendra Saurabh was found significantly early maturing as compared to all other entries and national check GF-2.

Significant differences were obtained for all the parameters at Hisar centre (Table 51). Plant height ranged from 108.7 to 129.3, number of branches 7.1 to 8.8, umbels per plant 31.9 to 47.0, umbellets per umbel 23.8 to 30.9 and seeds per umbel 235.5 to 342.3. Maximum seed yield was recorded as 2150 kg/ha in FNL-19, which was statistically at par with FNL-15, FNL-12 and FNL-18.

At Jagudan yield differences among the entries were found significant. But none of the entries was significantly superior over check. However, maximum yield was recorded in FNL-14 (2091 kg/ha), which was 7.35% higher, over check GF-11.

The analysis of variance revealed significant differences among the entries for all the traits including seed yield at Jobner centre. The seed yield ranged from 1075.56 to 1880.00 kg/ha. Of the fourteen entries evaluated, entry FNL-16 recorded maximum seed yield of 1880 kg/ha followed by FNL-15 (1822.22 kg/ha), FNL-14 (1782.22 kg/ha), RF-125 check (1613.33 kg/ha) and FNL-12 (1573.33 kg/ha), while lowest seed yield of 1075.56 kg/ha was recorded in FNL-20.

Among ten entries (FNL-2 to 11) tested at Kumarganj, FNL-6 showed maximum seed yield of 0.68 q/ha followed by 0.61 q/ha in FNL-6. FNL-19 showed maximum seed yield of 2.37 q/ha followed by FNL-23 out of twelve entries (FNL-12 to FNL-23).

Table 51. Performance of CVT fennel at Hisar

Entry	Plant height(cm)	Branches /plant	Umbels /plant	Umbellets /umbel	Seeds /umbel	Seed yield(kg/ha)
FNL -12	113.3	7.9	42.7	30.4	307.3	2000
FNL -13	116.3	7.1	34.0	26.9	273.4	1750
FNL -14	117.5	7.4	39.6	28.6	289.3	1900
FNL -15	108.9	7.9	42.2	30.6	327.3	2050
FNL -16	118.0	7.1	37.4	27.3	300.0	1850
FNL -17	112.4	7.4	39.2	29.5	306.1	1900
FNL -18	113.5	7.9	40.5	30.2	319.7	2000
FNL -19	126.9	8.8	47.0	30.9	342.3	2150
FNL -20	118.3	7.7	31.9	25.9	257.1	1650
FNL -21	115.5	7.2	31.9	23.8	235.5	1627
FNL -22	108.7	8.6	39.2	30.1	313.1	1930
FNL -23	117.1	8.2	37.2	30.0	295.3	1850
Local (C)	129.3	7.6	35.2	28.5	267.6	1827
HF-33 (SC)	123.1	8.6	39.6	30.3	311.5	1973
CD (P=0.05)	11.9	0.7	4.0	3.3	26.6	158

8 2 2 CVT- Transplant early rabt (2006) (Jagudan)

Significant yield differences were observed among entries at Jagudan centre during 2007-08. An entry FNL-3 was found significantly superior for yield (2754 kg/ha) was followed by FNL-2 (2537 kg/ha) and FNL-4 (2516 kg/ha) than check GF-11, which were 20.79, 11.26 and 10.34 per cent higher over check, respectively. Significant difference was obtained in yield in the pooled two year data. But none of the entries were found significantly superior for yield over check. However, the entries FNL-2 and FNL-3 gave higher yield (2679 & 2671 kg/ha) which were 13.83 and 13.71 per cent higher over check GF-2, respectively.

8 2 3 CVT 2007 (Jagudan)

At Jagudan, nonsignificant yield differences were observed among entries. However, the entry FNL-29 gave significantly higher yield (2223 kg/ha) than check GF 2, which was 10.19 per cent higher over check GF-11 (Table 52).

Table 52 Yield performance of CVT 2007 fennel at Jagudan

Treatment	Yield (kg/ha)		Mean	Per cent increase over control
	2006-07	2007-08		
FNL-1	1998	2352	2175	-
FNL-2	2820	2537	2679	13.83
FNL-3	2587	2754	2671	13.49
FNL-4	2219	2516	2368	0.62
FNL-5	1877	1817	1847	-
FNL-6	1641	1685	1663	-
FNL-7	2136	1846	1991	-
FNL-8	2090	1400	1745	-
FNL-9	1663	942	1303	-
FNL-10	1696	1612	1654	-
FNL-11	1507	1201	1354	-
GF-2 (Check)	2425	2280	2353	-
SEm ±	96	82	171	-
CD (P=0.05)	282	240	531	-
CV%	8.09	7.41	7.79	-

8 3 Varietal Evaluation Trial

8 3 1 Initial evaluation trial (Hisar, Jagudan, Jobner, Kumarganj)

At Hisar, IET in fennel was conducted with ten accessions along with GF-2 (check) and the results indicated that HF-131 and HF-143 gave better yield over GF-2 showing 21.3 and 24.3% increase in yield, respectively. Hence, both these lines have been included in coordinated varietal trial for further evaluation.

At Jagudan, significant yield differences were observed among entries but none of the entries was significantly superior over check GF-11. However, the entries JF-586-5 and JF-596 recorded higher yield (2289 and 2256 kg/ha), which was 11.53 and 9.91 per cent higher than check GF-11, respectively.

The analysis of variance revealed significant differences among the entries for all the traits including seed yield at Jobner. The mean days to flowering ranged from 105.0 (NS-3 & local check) to 109.33 days (NS-32), plant height from 90.00 (RF-125 check) to 130.27 cm (NS-11), branches per plant 4.47 (local check) to 6.93 (NS-32), umbels per plant from 9.73 (NS-45) to 14.07 (NS-63), umbellets per umbel from 15.93 (local check) to 23.67 (NS-45), seeds per umbel from 222.13 (NS-3) to 388.87 (NS-63) and test weight from 6.73 (NS-45) to 9.41 g (NS-10). The seed yield ranged from 907.41 to 1962.96 kg/ha. Of the twelve entries evaluated, entry NS-63 recorded maximum seed yield of 1962.96 kg/ha followed by NS-46 (1694.44 kg/ha), RF-125 check (1629.63 kg/ha) and RF-101 check-1 (1333.33 kg/ha), while lowest seed yield of 907.41 kg/ha was recorded in NS-37. Mean performance of the entries evaluated in IET over 2005-06 and 2006-07 revealed superior performance of NS-63 yielding 1935.19 kg/ha followed by NS-46 (1763.52 kg/ha), RF-125 check (1694.44 kg/ha) and RF-101 check (1504.63 kg/ha), while lowest seed yield of 981.48 kg/ha was recorded in NS-37 (Table 53).

In the IET conducted at Kumarganj center with 10 promising lines, NDF-16 and NDF-24 gave maximum seed yield of 0.64 q/ha followed by seed yield of 0.57 q/ha in NDF-6.

Table 53 Yield performance of IET fennel at Jobner

Entry	Yield (kg/ha)		
	2005-06	2006-07	Mean
NS-3	1351.85	1055.56	1203.71
NS-10	1398.15	1259.26	1328.71
NS-11	833.33	1212.96	1023.15
NS-32	1518.52	907.41	1212.97
NS-37	1055.56	907.41	981.49
NS-41	1555.56	1166.67	1361.12
NS-45	1074.07	972.22	1023.15
NS-46	1842.59	1694.44	1768.52
NS-63	1907.41	1962.96	1935.19
RF-101 Check	1675.93	1333.33	1504.63
RF-125 check	1759.26	1629.63	1694.45
Local Check	1157.41	1074.07	1115.74
CD (P=0.05)	251.43	272.76	
CV (%)	10.40	12.74	

8.4 Quality Evaluation Trial

8.4.1 Quality evaluation in fennel (Jobner)

CVT fennel

Fourteen entries of fennel under CVT were tested for volatile oil content during Rabi 2006-07 at Jobner. The volatile oil content in the entries of CVT ranged from 1.60% to 2.47%. The maximum volatile oil of 2.47% was

observed in FNL-17 followed by 2.27% in FNL-15 and FNL-20, while, minimum of 1.60% in FNL-14. FNL-15 was identified as a superior entry in terms of volatile oil yield (41.36 l/ha) followed by FNL-16 (40.04 l/ha), RF-125 check (34.36 l/ha), FNL-17 (32.93 l/ha) and FNL-14 (28.52 l/ha). While lowest volatile oil yield of 20.07 l/ha was recorded in FNL-23 (Table 54).

IET fennel

Twelve entries of fennel under IET at Jobner, were tested for volatile oil content during 2006-07 and the oil ranged from 1.80% to 2.47%. The maximum volatile oil of 2.47% was recorded in NS-46 followed by 2.40% in NS-63, 2.27% in NS-45 and RF-101 check, whereas minimum of 1.80% in NS-41. 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. On the basis of two years data (2005-06 & 2006-07), the highest mean volatile oil content of 2.64% was recorded in NS-46 followed by 2.60% in NS-63, 2.50% in NS-45 & 2.49% in RF-101 check, whereas minimum 2.05% was recorded in local check. The maximum mean volatile oil yield in terms of litre per ha was observed in NS-63 (50.31 l/ha) followed by NS-46 (46.60 l/ha), RF-125 check (41.01 l/ha), and RF-101 check (37.39 l/ha) and minimum in NS-37 (22.43 l/ha) (Table 55).

Table 54. Volatile oil content of entries of fennel (IET) in 2006-2007

Entry	Seed yield (kg/ha)	Volatile oil (%)	Volatile oil yield (l/ha)
NS-3	1055.56	1.80	19.00
NS-10	1259.26	2.20	27.70
NS-11	1212.96	2.13	25.84
NS-32	907.41	2.20	19.96
NS-37	907.41	2.00	18.15
NS-41	1166.67	1.80	21.00
NS-45	972.22	2.27	22.07
NS-46	1694.44	2.47	41.85
NS-63	1962.96	2.40	47.11
RF-101 Check	1333.33	2.27	30.27
RF-125 check	1629.63	2.07	33.73
Local Check	1074.07	1.93	20.73
CD (P=0.05)	272.76	0.18	
CV (%)	12.74	1.80	

Table 55. Mean volatile oil content of fennel (IET) 2005-06 and 2006-07

Entry	Mean seed yield (kg/ha)	Volatile oil (%)			Mean volatile oil yield (l/ha)
		2005-06	2006-07	Mean	
NS-3	1203.71	2.37	1.80	2.09	25.10
NS-10	1328.71	2.23	2.20	2.22	29.43
NS-11	1023.15	2.37	2.13	2.25	23.02
NS-32	1212.97	2.23	2.20	2.22	26.87
NS-37	981.49	2.57	2.00	2.29	22.43

NS-41	1361.12	2.77	1.80	2.29	31.10
NS-45	1023.15	2.73	2.27	2.50	25.58
NS-46	1768.52	2.80	2.47	2.64	46.60
NS-63	1935.19	2.80	2.40	2.60	50.31
RF-101 Check	1504.63	2.70	2.27	2.49	37.39
RF-125 check	1694.45	2.77	2.07	2.42	41.01
Local Check	1115.74	2.17	1.93	2.05	22.87
CD (P=0.05)		0.09	0.18		
CV (%)		2.14	4.89		

8.5 Nutrient Management Trial

8.5.1 Effect of biofertilizer, *Azospirillum* on fennel (Dholi)

At Dholi centre, application of inorganic nitrogen (100%) + FYM 5 t/ha + *Azospirillum* (T₁), inorganic nitrogen (75%) + *Azospirillum* + FYM 5t/ha (T₂) and inorganic nitrogen (50%) + *Azospirillum* + FYM-5 t/ha (T₃) and inorganic nitrogen (50%) + *Azospirillum* + FYM 5t/ha (T₃) were found significantly superior as compared to control regarding number of umbels per plant, number of umbellet per umbel, number of grains per umbellet and grain yield per plot or per hectare. Among the treatments, application of inorganic nitrogen (100%) + FYM 5t/ha + *Azospirillum* (T₁) produced maximum number of branches per plant (9.67), number of umbellet per umbel (65.00), number of grains per umbellet (41.00) and yield per plot (1.18 kg/7.2m²) or yield (1.64 t/ha) followed by application of inorganic nitrogen (75%) + *Azospirillum* + FYM 5 t/ha).

8.5.2 Role of rhizobacteria on growth and yield of fennel (Jagudan)

A new experiment was initiated during 2007-08 to evaluate the influence of two different types of rhizobacteria and their methods of application with recommended dose of fertilizer on fennel cv. GF-11 on growth, yield and quality of seed. The effect of rhizobacteria was found non significant on ancillary characters, yield as well as quality of fennel except number of umbels per plants. However, beneficial effect of seed and soil inoculation of FL-18 was observed.

8.6 Identification of drought/alkalinity tolerance source in fennel (Kumarganj)

During 2007-08, ten genotypes of fennel was tested with four levels of ESP and found that the highest yield of 52.25 and 49.25 g/plant was recorded under 10 and 20 ESP levels respectively in NDF-12.

9. Fenugreek

9.1 Genetic Resources

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

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

Among one hundred and seven collection of fenugreek germplasm evaluated at Dholi, only sixteen accession namely, RM-18, RM-28, H.M.-376, NDM-19, RM-70, RM-188, RM-192, UM-69, UM-127, RM-189, RM-190, RM-185, RM-15, HM-350, UM-37 & UM-31 gave maximum yield as compared to high yielding variety Rajendra Kanti. Among the promising accessions, RM-18, RM-28, HM-376 & NDM-19 gave maximum yield (0.95 kg/4.5 m²) followed by RM-70, RM-188, RM-192, UM-69 & UM-127 (0.90 kg/4.5 m²).

Among the fifty-eight accessions evaluated at Guntur, LFC-103 recorded highest yield (single plant yield) of 1.59 g followed by LFC-99 (1.42 g) which was significantly superior to checks Lam Selection-1 (0.74 g), Hisar Anand (0.92 g), PEB (0.69 g) and Local (0.80 g).

At Hisar, the mean seed yield ranged from 850 kg/ha (IC-397994) to 1950 kg/ha (Hisar Sonali)

Seventy six entries including GM-1 and GM-2 as checks were evaluated for different characters at Jagudan and among them nine entries were found promising for yield (> 3400 kg/ha). Forty seven (45+2) entries were screened against powdery mildew disease under natural condition. The disease incidence ranged from 1 to 85%. None of the entries were found free from disease incidence. The minimum incidence was found in JFg-246 (1%) followed by JFg-255 (3%), UM-305 (6%), JFg-242 (8%) and FGK-8, JFg-228, JFg-245 and GM-2 (check) registered 10% incidence. Twenty entries short-listed during the previous year were again screened against powdery mildew disease under natural condition. The disease incidence ranged from 0 to 5 %. The entry JFg-256-1 was found absolutely free from disease followed by JFg-256-2 (0.5%).

Three hundred and sixty five germplasm accessions including 12 exotic collections are maintained at Jobner centre. The germplasm maintained by various AICRPS centres are given in Table 56.

Out of 80 genotypes screened at Kumarganj, NDF-24 produced maximum seed yield of 26.4 q/ha followed by NDM-18 (23 q/ha)

Table 56. Fenugreek germplasm collections under AICRPS centres

Centre	Indigenous	Exotic	Total
Dholi	107	-	107
Guntur	125	-	125
Hisar	240	-	240
Jagudan	64	-	64
Jobner	353	12	365
Kumarganj	77	-	77
Total	966	12	978

9.2 Coordinated Varietal Trial

9.2.1 CVT 2001 – Series V (final report) (Coimbatore)

A total of 25 fenugreek accessions were evaluated for their growth and yield performance during rabi season 2005-06. CO-2 fenugreek was used as local check. Among the 25 accessions, the accession, Rmt-303 recorded the highest yield of 1030 kg/ha followed by JF-244 which recorded an yield of 870 kg/ha. The accession HM-232 recorded the lowest yield of 225 kg/ha. All the accessions were screened for their resistance against powdery mildew disease. Rmt-303 and JF-270 recorded minimum disease incidence of 14.23% and 15.23% respectively.

The experiment conducted during 2006-07 revealed that among the 25 accessions evaluated the accession JF-270 recorded the highest yield of 525 kg/ha followed by RM-28, NDM-20, CM-145, Rmt-1 and NDM-19 (450 kg/ha). All the accessions were screened for resistance against powdery mildew disease. The results showed that none of the accessions were resistant to powdery mildew disease.

During 2007-08, NDM-20, CM-145 and Rmt-1 recorded the highest yield of 500 kg/ha.

The pooled analysis for three years revealed that the cultivar JF-270 recorded the highest yield of 573 kg/ha which was on par with Rmt-303 (543.33 kg/ha) (Table 57).

Table 57. Yield of CVT 2001 fenugreek at Coimbatore

Cultivar/ Variety	Yield /ha (t)			
	2005-06	2006-07	2007-08	Mean
HM-376	635	270	350	418.33
UM-363	880	270	300	483.33
HM-57	510	285	250	348.33
NDM-25	655	195	350	400.00
JFG-244	870	300	350	506.66
CO-2	235	270	350	285.00
RM-28	510	450	400	453.33
NDM-20	540	450	500	496.66
UM-392	530	270	350	383.33
CM-1	575	225	250	350.00
UM-351	580	375	400	451.66
RM-18	715	285	250	416.66
HM-65	490	360	350	400.00
Rmt-303	1030	300	300	543.33
UM-362	580	210	350	380.00
CM-145	495	450	500	481.66
UM-352	590	285	400	425.00
UM-1	675	365	300	446.66
Rmt-1	480	450	500	476.66
NDM-19	645	450	450	515.00
UM-361	590	285	350	408.33
JF-270	795	525	400	573.33
HM-292	520	270	250	346.66
HM-444	335	285	300	306.66
HM-232	225	255	350	276.66
SED				19.64
CD (P = 0.05)				39.49

9.2.2 CVT-2005 Series VI (Hisar, Jobner)

Out of 12 entries evaluated in coordinated varietal trial at Hisar, significant differences were obtained for all the parameters. Plant height ranged from 68.9 to 87.3, pods per plant 53.6 to 77.2, length of pods 8.1 to 9.0 and seeds per pod 16.1 to 17.3. Maximum seed yield (1967 kg/ha) was recorded in FGK-1 and FGK-11 followed by FGK-3 (1900 kg/ha) and local check (1860 kg/ha)

At Jobner, significant differences among the entries for all the traits including seed yield were registered. The seed yield ranged from 708.33 to 1550.93 kg/ha and FGK-1 recorded maximum seed yield of 1550.93 kg/ha followed by RM-70 (1537.04 kg/ha), RMT-351 check (1532.41 kg/ha), RMT-303 check (1513.90 kg/ha), FGK-2 (1245.37 kg/ha), RMT-1 check (1231.48 kg/ha), and FGK-3 (1203.70 kg/ha), while lowest yield of 708.33 kg/ha was recorded in FGK-10 (Table 58). Entries FGK-1, FGK-2 and RMT-351 (check) were found resistant for root rot, downy mildew and powdery mildew disease.

Table 58. Performance of CVT fenugreek at Jobner

Entry	Days to flowering	Plant height (cm)	Branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	Test wt. (g)	Seed yield (kg/ha)	Increase/decrease over check (%)
FGK-1	50.00	65.47	5.60	32.60	10.27	17.53	13.94	1550.93	+1.21
FGK-2	46.33	55.40	5.67	25.00	10.27	16.80	13.75	1245.37	-18.73
FGK-3	45.67	65.07	4.67	23.40	10.63	16.80	13.44	1203.70	-21.45
FGK-4	43.00	56.40	5.73	26.27	11.13	16.40	12.23	953.70	-37.76
FGK-5	51.00	58.67	5.27	27.60	11.13	16.93	12.24	1009.26	-34.14
FGK-6	46.33	55.87	5.80	26.67	10.77	14.80	12.05	1111.11	-27.49
FGK-7	48.67	59.73	6.07	35.27	11.07	16.93	12.63	1064.81	-30.51
FGK-8	46.00	50.53	6.07	30.27	11.47	16.60	11.09	1125.00	-26.59
FGK-9	44.33	56.27	5.73	26.53	10.70	15.73	12.87	1041.67	-32.02
FGK-10	47.67	44.00	5.27	24.33	10.80	16.27	11.58	708.33	-53.78
FGK-11	43.00	57.87	6.07	27.47	11.67	16.60	12.31	939.81	-38.67
RM-18	50.67	63.80	6.20	31.87	10.80	16.20	12.03	1143.52	-25.38
RM-28	51.33	59.27	5.53	29.47	11.40	17.53	11.38	884.26	-42.30
RM-70	52.67	54.67	6.27	29.60	10.73	17.73	11.85	1537.04	+0.30
FGK-12	47.33	56.80	5.47	26.60	11.20	16.20	12.68	995.37	-35.35
JFg-244	44.67	59.53	5.53	23.33	12.37	17.87	12.74	990.74	-35.35
RMT-1 C	51.67	62.00	5.07	24.73	10.23	16.73	11.99	1231.48	-19.64
RMT-303C	46.00	57.60	5.93	33.07	10.90	17.40	13.90	1513.89	-1.21
RMT-351 C	47.33	61.00	5.33	28.07	10.23	16.33	12.69	1532.41	Check
Local Check	54.33	62.13	4.60	24.20	10.33	16.33	10.13	851.85	-44.41
CD (P=0.05)	1.65	NS	0.77	4.26	0.98	1.08	1.07	176.53	
CV (%)	2.09	10.72	8.31	9.27	5.43	3.92	5.22	9.44	

9 2 3 CVT 2006

(Dholi, Guntur, Jagudan, Kumarganj)

At Dholi, all the entries recorded significantly higher plant height except FGK-10, FGK-12 and FGK-13 as compared to local check Rajendra Kanti. None of the entries were found significantly superior for number of branches per plant and pod length. However, all the entries were found significant with respect of delayed maturity as compared to local check Rajendra Kanti. FGK-14 produced significantly more yield (1 57 kg/7 2 m² or 2 18 t/ha) as compared to local check Rajendra Kanti with 19 12% increase over local check.

Among the fourteen genotypes evaluated at Guntur FGK-9 (679 kg/ha), FGK- 7 (519 kg/ha), FGK-11 (494 kg/ha) and FGK-10 (492 kg/ha) recorded significantly higher yield than the check LS-1 (305 kg/ha).

At Jagudan, significant yield differences were observed among the entries. FGK-6 was found significantly superior for yield (1 646 kg/ha) over check GM-2, which was at par with FGK-13 (1 447 kg/ha) and FGK-4 (1 429 kg/ha). They were 19 76, 5 32 and 3 97 per cent higher over check, respectively (Table 59).

Maximum seed yield of 18 7 q/ha was registered in entry FGK-12 followed by FGK-14 producing 15 23 q/ha at Kumarganj.

Table 59 Yield and ancillary characters of CVT fenugreek at Jagudan

Entry	50 % Flowe- ring	Maturity (DAS)	Plant height (cm)	Branches /plant	Pods /plant	Length of pod (cm)	Seeds /pod	Yield /plant (g)	Yield (kg/ha)	Increase over check (%)
FGK-1	48	122	59 6	5 2	25 1	9 6	16 5	4 12	1346	-
FGK-2	44	128	53 5	4 6	17 6	10 6	16 8	4 00	1308	-
FGK-3	46	124	57 9	5 0	23 2	10 0	16 2	3 83	1254	-
FGK-4	42	123	56 3	5 1	22 6	11 3	17 2	4 37	1429	3 97
FGK-5	46	129	58 6	5 2	26 5	10 5	16 0	3 86	1264	-
FGK-6	44	125	66 0	4 8	26 4	10 7	16 5	5 03	1646	19 76
FGK-7	48	121	60 5	5 0	23 9	10 7	16 4	4 18	1368	-
FGK-8	50	118	58 5	5 7	24 6	10 3	18 2	4 03	1320	-
FGK-9	47	120	58 4	5 5	23 2	10 2	17 4	3 70	1209	-
FGK-10	41	120	54 2	4 8	18 4	10 4	15 7	3 01	986	-
FGK-11	49	129	64 0	5 3	25 6	11 5	18 4	4 15	1358	-
FGK-12	49	127	58 2	4 9	25 9	10 5	17 9	3 54	1158	-
FGK-13	53	128	62 8	4 5	24 5	10 2	18 2	4 42	1447	5 32
FGK-14	45	112	54 5	4 9	27 9	10 4	17 0	3 96	1297	-
FGK-15	46	121	60 5	4 4	20 0	10 4	17 0	3 75	1227	-
FGK-16	43	127	60 9	5 0	23 7	10 8	17 1	4 02	1317	-
GM-1 (Check)	38	115	50 0	5 0	9 0	9 0	16 0	3 74	1093	-
GM-2 (Check)	41	123	62 0	6 0	38 0	11 0	17 0	4 20	1374	-
SEm ±								0 28	92	
CD (P=0 05)								0 81	265	
CV %								12 26	12 26	

9.3 Varietal Evaluation Trial

9.3.1 Initial evaluation trial

(Guntur, Hisar, Jagudan, Jobner, Kumarganj)

Among the entries tested during 2006-07 at Guntur, LFC-105 recorded the highest yield (623 kg/ha) followed by LFC-103 (577 kg/ha) which are significantly superior to check Lam Selection-1 (388 kg/ha). Three years pooled data indicated that LFC-105 and LFC-103 (905 kg/ha) recorded significantly superior yields over check Lam Selection-1 (692 kg/ha) (Table 60).

Table 60. Growth and yield attributes of IET fenugreek (Pooled) at Guntur

Entry	Plant height (cm)	No of branches	No. of days to 50% flowering	No. of days to maturity	No. of pods	Length of pod (cm)	Dios-genin (%)	Yield (kg/ha)	Increase /decrease over check (%)
LFC-85	37.6	3.8	43.2	79.7	23.1	9.8	0.51	690.0	-0.2
LFC-88	39.9	4.0	44.8	81.2	25.0	10.2	0.51	724.0	4.7
LFC-94	40.3	4.1	44.3	78.7	23.4	9.7	0.63	787.0	13.8
LFC-102	44.5	4.2	42.9	81.4	23.1	10.0	0.45	763.0	10.3
LFC-103	39.3	5.0	47.5	81.6	29.0	9.9	0.31	905.0	30.8
LFC-105	42.1	5.0	46.3	83.0	28.6	9.7	0.53	905.0	30.9
LFC-112	36.3	3.8	42.5	82.8	20.6	9.8	0.61	718.0	3.8
LFC-113	37.8	3.8	44.1	83.1	23.4	9.7	0.52	705.0	1.9
LFC-114	37.4	4.0	44.3	83.2	24.2	10.0	0.42	712.0	3.0
LFC-118	37.8	3.6	44.7	83.3	18.3	9.7	0.42	709.0	2.5
LS-1	35.8	3.5	43.8	83.3	20.6	9.3	0.47	692.0	-
PEB	35.0	3.4	44.8	84.3	20.8	9.0	0.43	618.0	-10.6
CD (P=0.05)	5.1	1.0	1.6	1.7	7.0	0.9	0.02	149.6	
CV%	7.8	14.6	2.2	1.2	17.7	5.5	0.51	11.9	

The initial evaluation trial in fenugreek at Hisar was conducted with ten accessions along with Hisar Sonali as check. The results indicated that maximum seed yield was recorded in HM-348 followed by HM-355 showing an increase of 24.6 and 17.7% respectively over Hisar Sonali (check). Entries HM-348 and HM-355 were identified for coordinated varietal trial for further evaluation.

At Jobner, the analysis of variance revealed significant differences among the entries for all the traits including seed yield. The seed yield ranged from 824.07 to 1500.00 kg/ha. UM-354 recorded maximum seed yield of 1500 kg/ha followed by UM-202 (1453.70 kg/ha), RMT-1 check (1314.81 kg/ha), RMT-303 check (1305.56 kg/ha) and UM-134 (1194.44 kg/ha), while lowest yield of 824.07 kg/ha was recorded in UM-189. Out of the ten entries evaluated in IET, UM-134, UM-354 and RMT-303 (check) were found resistant for root rot, downy mildew and powdery mildew disease.

In the IET at Jagudan, the entries JFg-255, JFg-253 and JFg-220 gave higher yield (i.e. 1829, 1806 and 1731 kg/ha respectively) than GM-1 which was 19.77, 18.20 and 13.28 per cent higher over GM-1, respectively. The pooled over three years data showed non significant yield differences among entries. However, the entries

JFg-255, JFg-220 and JFg-178 gave higher yield (i.e. 2388, 2244 and 2209 kg/ha respectively) than GM-1 which was 23.56, 16.07 and 14.30 per cent higher over GM-1, respectively (Table 61).

Among the 10 lines evaluated at Kumarganj NDM-25 recorded highest seed yield (24.2 q/ha) followed by NDM-19 (22.9 q/ha).

Table 61. Yield performance of IET fenugreek at Jagudan (Pooled analysis)

Treatment	Yield (kg/ha)			Mean	Increase over check (%)
	2005-06	2006-07	2007-08		
JFg-15	2370	1658	1407	1812	-
JFg-148	2448	1952	1132	1844	-
JFg-178	2681	2314	1633	2209	14.30
JFg-181	2461	1824	1378	1888	-
JFg-220	2572	2428	1731	2244	16.07
JFg-252	2565	2131	1289	1995	3.21
JFg-253	2146	2445	1806	2132	10.31
JFg-254	2330	1767	1633	1910	-
JFg-255	2363	2973	1829	2388	23.56
GM-1	2024	2247	1528	1933	-
(Check)					
SEm $\pm$	129	309	98	125	
CD (P=0.05)	NS	NS	291	NS	
CV%	9.30	24.59	10.99	17.11	

9.4 Nutrient Management Trial

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

At Dholi nine treatments of bio-fertilizers, *Azospirillum* and one control were tested during 2007-08 and no significant difference was observed for plant height, number of branches per plant, pod length and number of grains per pod. However, inorganic nitrogen 100% + *Azospirillum* + 5 t/ha FYM; inorganic nitrogen 75% + *Azospirillum* 5 t/ha FYM; inorganic nitrogen 50% + *Azospirillum* + 5 t/ha FYM;) and FYM-10 t/ha + *Azospirillum* produced significantly more number of pods per plant (71.73, 64.27, 59.87 and 53.20 respectively) as compared to control (39.80). Regarding yield, all treatments gave significantly more yield except *Azospirillum* @ 1.5 kg/ha as compared to control. Among the entries inorganic nitrogen 100% + *Azospirillum* + 5 t/ha FYM gave maximum number of pods per plant (71.73) and yield (0.98 kg/4.5 m² or 2.18 t/ha) followed by inorganic nitrogen 75% + *Azospirillum* + 5 t/ha FYM (0.90 kg/4.5 m² or 2.00 t/ha).

9.4.2 Identification of source of drought tolerance in fenugreek (Guntur, Jobner)

Among the fifty-eight germplasm lines evaluated at Guntur, biomass varied from 5.6 (LFC-97) to 14.74 (LFC-122) g/plant. The root length of the germplasm lines varied from 8.0 cm (Local) to 16.3 cm (LFC-91).

Shoot length varied from 26.9 cm (LFC-122) to 45.7 cm (LFC-77). The root-shoot ratio of the germplasm lines varied from 0.22 (Local) to 0.36 (LFC-121).

At Jobner, based on the values of Stress susceptibility index (SSI), Stress tolerance index (STI) and Stress tolerance (TOL) genotypes J.Fg.-244, NS-2006-7, NS-2006-3 were rated as good genotypes which were tolerant to limited moisture condition.

9.4.3 Effect of bioregulators on fenugreek (Coimbatore, Dholi, Jobner, Kumarganj)

The trial on effect of bioregulators on coriander was initiated during 2005-06 with the variety CO-(CR)-4. The experiment was conducted with four factors (triconanol 0.5ml/l, 1.0 ml/l, NAA 50 ppm and water spray) and with three levels each (one spray - 40 DAS, two sprays - 40 and 60 DAS and three sprays 40, 60 and 80 DAS). In 2005-06 evaluation revealed that the treatment T1 (spraying of triacontanol at 0.5 ml/l at 40 days after sowing resulted in the maximum grain yield of 813.3 kg/ha. The same trend was noticed in 2006-07 and 2007-08 evaluation with an yield of 853.3 kg/ha and 901.2 kg/ha respectively. The pooled analysis also revealed that the highest yield of 855.93 kg/ha was obtained by spraying triacontanol 0.5ml/l after 40 days of sowing (Table 62).

Studies conducted at Dholi indicated that application of bioregulators had significant effect on plant height, number of pods per plant and yield per plot and yield per hectare while non-significant effect was observed regarding number of branches per plant, pod length and number of grains per pod. However, spraying of GA @ 50 ppm has significantly increased, the plant height (85.28 cm), number of pods per plant (43.77) and yield per plot (1.47 kg/7.2 m² or 2.04 t/ha) as compared to water spray. Three sprays (25, 45 and 70 DAS) gave maximum plant height (86.23 cm), number of branches per plant (7.08), number of pods per plant (46.93) and yield (1.45 kg/7.2m² & 2.01 t/ha) followed by two sprays (25 & 45 DAS). Interaction effect was found non-significant regarding yield and yield attributing characters. However, three sprays (25,45 and 70 DAS) of bio-regulators GA @ 50 ppm gave the maximum plant height (89.67 cm), number of branches per plant (7.06), number of pods per plant (50.86), pod length (11.80 cm), number of grains per pod (18.20) and yield (1.56 kg/7.2m²) or (2.17 t/ha) followed by three sprays (25 & 45 & 70 DAS) of triacontanol @ 0.5 ml per liter of water.

Two year data of the experiment to evaluate the effect of bio-regulators on fenugreek at Jobner centre revealed that 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. 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.

At Kumarganj, maximum seed yield of 17.60 q/ha was recorded when crop was sprayed with triacontanol 1 ml/l of water after 30, 40 and 60 DAS. The next best treatment was spraying of NAA (50 ppm) after 40 days of sowing which recorded an yield of 16.21 q/ha.

Table 62. Effect of bioregulators on coriander at Coimbatore [Pooled analysis (2005-06 - 2007-08)]

Treatment	Root length (cm)	Shoot length (cm)	No. of branches	No. of flowers /plant	No. of umbels (5 m ²) g	Yield /plot	Yield /ha (kg)
T ₁ Triacontanol 0.5 ml/l at 40 DAS	6.73	27.26	4.63	59.67	14.07	427.97	855.93
T ₂ Triacontanol 0.5 ml/l at 40 & 60 DAS	7.23	31.43	5.50	45.40	14.20	372.89	745.77
T ₃ Triacontanol 0.5ml/l at 40, 60 & 80 DAS	6.17	35.07	5.47	61.57	21.57	355.17	710.33
T ₄ Triacontanol 1.0 ml/l at 40 DAS	6.97	31.78	4.27	58.30	15.97	389.50	779.00
T ₅ Triacontanol 0.5ml/l at 40 & 60 DAS	7.40	33.47	5.60	59.97	16.07	340.07	680.13
T ₆ Triacontanol 0.5ml/l at 40, 60 & 80 DAS	9.20	32.73	4.53	54.57	14.90	363.79	727.57
T ₇ NAA 50 ppm at 40 DAS	8.40	37.43	5.43	56.67	13.60	335.50	671.00
T ₈ NAA 50 ppm at 40 & 60 DAS	7.97	33.53	6.03	56.33	15.47	368.54	737.07
T ₉ NAA 50 ppm at 40, 60 & 80 DAS	6.70	33.43	5.33	48.83	12.77	372.73	745.47
T ₁₀ Water spray at 40 DAS	7.10	31.50	4.83	61.00	15.93	382.07	764.13
T ₁₁ Water spray at 40,60 DAS	7.90	31.00	4.77	80.37	18.73	376.17	752.33
T ₁₂ Water spray at 40, 60 & 80 DAS	8.13	31.27	5.10	70.17	15.97	359.44	718.90
SED	0.49	2.09	0.33	3.88	1.02	23.84	47.69
CD (P = 0.05)	1.02	4.34	0.68	8.06	2.11	49.46	98.92

9.4.4 Role of rhizobacteria in growth promotion of fenugreek.

(Dholi, Guntur, Hisar, Jagudan, Kumarganj)

A field trial was conducted to see the effect of rhizobacteria on growth promotion of fenugreek at Dholi centre. All the treatments were found to have significant effect on growth promotion of fenugreek. Highest number of branches/plant (7.03), pod length (12.00 cm), number of grains/pod (19.00), yield (1.17 t/ha) and increase in yield over control (64.79%) was found in treatment of seed with rhizobacterial strain FL-18. whereas highest plant height (77.60 cm), no. of pods/plant (50.53) were found in treatment of seed and soil application with rhizobacterial strain FK-14. The second best treatment was recorded in seed treatment and soil application with rhizobacterial strain FK-14 which recorded highest number of branches/plant (6.73), number of grains/pod (18.07), yield (1.12 t/ha) and consequently increase in yield over control (57.75%).

At Guntur, eight treatments with three rhizobacteria were evaluated for their effect on growth promotion of fenugreek. Among the treatments evaluated, seed treatment + soil application with FK-14 + FL-18 recorded maximum yield (392 kg/ha) followed by seed treatment + soil application with FK-14 (369 kg/ha) which are on par with each other and significantly superior to control (313 kg/ha). Maximum plant height (35.3 cm),

number of branches, number of pods per plant, pod length, and number of seeds were also recorded in seed treatment + soil application with FK-14 + FL-18 (10.2) .

Maximum seed yield (1705 kg/ha) was recorded with the application of rhizobacteria FL-14 + FL-18 (seed treatment + soil application) followed by *Trichoderma* MTCC- 5179 (1640kg/ha) at Hisar (Table 63).

At Jagudan the effect of rhizobacteria was found non significant on ancillary characters, yield as well as quality of fenugreek except length of pod. However, seed and soil inoculation of FL-18 was found beneficial for improving yield

At Kumarganj, seed treatment and soil application of rhizobacteria (FL-18 + FK-14) gave maximum growth in terms of maximum plant height (91.40), length of pod (11.53 cm), number of grains/pod (18.27) and seed yield of 11.43 q/ha.

Table 63 . Effect of rhizobacteria on growth and seed yield of fenugreek at Hisar

Treatment	Plant height (cm)	Branches /plant	Pods /plant	Pod length (cm)	Seeds /pod	Seed yield (kg/ha)
Rhizobacteria FK-14 (seed treatment)	59.9	6.0	40.3	8.7	16.7	1417
Rhizobacteria FK-14 (seed treatment + soil application)	71.8	6.2	47.7	8.7	18.1	1583
Rhizobacteria FL-18 (seed treatment)	65.1	5.4	43.8	8.2	15.5	1478
Rhizobacteria FL-18 (seed treatment + soil application)	65.1	5.5	40.5	8.3	16.5	1535
Rhizobacteria FK-14 + FL-18 (seed treatment)	65.8	5.8	41.9	8.4	16.9	1548
Rhizobacteria FK-14 + FL-18 (seed + soil treatment)	71.0	6.2	54.4	9.0	18.1	1705
<i>Trichoderma</i> MTCC 5179 (Recommended dose)	67.0	5.7	47.9	8.4	18.0	1640
Control	70.5	5.8	38.6	8.6	16.1	1503
C D (P=0.05)	6.0	0.4	4.7	0.3	1.4	70

10. Paprika

10.1. Genetic resources

10.1.1 Germplasm collection, characterization, evaluation and conservation (Coimbatore, Guntur)

The germplasm collections of nine paprika accessions maintained at Coimbatore centre were evaluated. Among the nine accessions, Acc.3 recorded the highest fresh fruit yield of 328 g/plant followed by Acc.2 which recorded a yield of 248.3 g/plant.

During the year 2007-08, twenty genotypes were evaluated at Guntur centre. Among the entries evaluated, maximum plant height was recorded by entry PGP-21 that was significantly superior to check CA-960 (50.7 cm) and on par with the other check Byadagi Kaddi (69.9 cm). Maximum number of primary branches was recorded in the entry PGP-29 that was significantly superior to the check Byadagi Kaddi (2.1), and on par with the other check CA-960 (3.0). Maximum numbers of secondary branches were recorded in the entry PGP-45 (19.3) where as maximum number of fruits was recorded in PGP-17 (132.9), which was significantly superior to the checks Byadagi Kaddi (91.5) and CA-960 (88.9). Highest yield (dry) was obtained in the entry PGP-17 (186 g) followed by PGP-77 (169.1 g) and PGP-76 (158.8 g) which were significantly superior to checks PGP-56 (Byadagi Kaddi) (107 g) and PGP-57 (CA-960) (98.6 g). Fifteen germplasm lines were collected during the period.

ICAR- Adhoc Projects

I. Project title	Strengthening the cause of geographical indication, appellation of major spices using molecular and quality profiling techniques
Investigator(s):	B. Sasikumar, T. John Zachariah
Location:	Indian Institute of Spices Research, Calicut
Duration:	1-11-2004 to 30-04-2008
Total cost of the scheme:	Rs. 23 524 lakhs

Progress of work

Summary of achievements

Molecular and biochemical characters of traded Indian pepper (Malabar pepper) was generated and transmitted to Spices Board, the nodal agency to obtain GI for the commodity and using the data, along with other detail. GI for Malabar pepper is obtained.

Developed an efficient protocol for the isolation of genomic DNA from export grade capsules of Indian, Sri Lankan and Guatemalan cardamoms which will help in the molecular characterization of the traded cardamoms. This has IPR relevance.

Physical, biochemical and molecular characterization of export grade Indian cardamom (AGEB), Guatemalan and Sri Lankan cardamoms revealed the superiority of Indian produce (AGEB).

The volatile oil of export grade capsules of India, Guatemalan and Sri Lankan cardamom has been extracted by steam distillation and analyzed. GC/MS profiling has shown a total of 31 compounds in Indian, 25 in Guatemalan and 34 in Sri Lankan cardamoms, and 23 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 -terpenyl acetate (41.65%) compared to other produce.

Developed an efficient protocol for the isolation of genomic DNA from export grade berries of black pepper from India, Vietnam, Indonesia and Malaysia.

Molecular profiling (RAPD/IISR) of traded black pepper samples from India, Vietnam, Indonesia and Malaysia revealed a comparatively high genetic similarity within the samples from particular country than between any two countries. This has IPR relevance.

Characterized export grade Indian and Chinese ginger based on physical, biochemical and molecular parameters.

Characterized export grade turmeric based on physical, biochemical and molecular parameters.

Technology developed

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

II. Project title	Cloning of <i>Phytophthora</i> resistance and defense genes from <i>Piper colubrinum</i>
Investigator(s):	K. Johnson George, M. Anandaraj
Location:	Indian Institute of Spices Research, Calicut
Duration.	November 2004 to 2007
Total cost of the scheme:	Rs. 16,53,000

Progress of the work

Different methods of gene walking viz, Amplifications using (1) degenerate random primers and R gene specific primers from the cloned fragment and (2) adaptor ligated PCR was attempted in *P. colubrinum*. Amplified products were recovered from the attempts of gene walking using DNA and RNA.

Ligation mediated walking on cDNAs from plants challenged with *Phytophthora* resulted in the amplification of fragment of size of approximately 400, which was cloned.

III. Project title:	Chemical characterization of <i>Cinnamomum</i> germplasm
Investigator(s):	N.K. Leela, J. Rema
Location:	Indian Institute of Spices Research, Calicut
Duration:	1.3.05 to 31.8.2008
Total cost of the scheme	42,75,500

Progress of the work

Eighty two accessions of *Cinnamomum verum*, collected from IISR Research Farm, Peruvannamuzhi, were evaluated for bark oil and oleoresin contents and oil composition. The oil content varied from 0.3% to 3.0%, where as oleoresin content ranged from 3.3 to 15.23% in these accessions. Maximum oil content was obtained from the accession No. 290 (3.0%) which was followed by accession no 309 (2.3%). Accession numbers 202, 338 and 548 yielded 2% oil. Accession nos. 265, 290, 301, 309, 363, 376, 378, 490, 492 and 507 contained above 10% oleoresin.

The chief constituent of the bark oil was cinnamaldehyde, which varied from 4.5% (Accn No. 210) to 59.3% (Accn No. 311). Other major constituents were eugenol (0.99 - 15.26%), benzyl benzoate (1.7-48.7%), *t*-caryophyllene (2.7-27.7 %) and linalool (1.2-26.1%). Accn Nos. 290 and 309 contained 48.4% and 51.6% cinnamaldehyde respectively.

Eighty seven accessions of *Cinnamomum* germplasm were analyzed for leaf oil composition by GC-MS analysis. The major constituents of the oil were eugenol (75-98%) and eugenyl acetate (0.11-35.6%) in all the

accessions except Acc No 405. Acc no. 405 was identified as the benzyl benzoate chemotype of *C. verum*, which contained about 76.8% benzyl benzoate.

Essential oil yield and composition of fruits of *C. verum* and *C. malabathrum* was determined during March to May 2007. Both the oils were dominated by linalool during the initial stages of fruit development. However, the concentration of linalool was higher in *C. malabathrum* (60.5%) compared to that of *C. verum* (25%). Subsequently the concentration of linalool declined with the advancement of fruit maturity. The essential oils from ripened fruits were rich in cadinene and its analogues (43% in *C. verum* and 54% in *C. malabathrum*).

IV Project title	Molecular characterization and maintenance of National repository of <i>Phytophthora</i>
Investigator(s)	Dr. M. Anandaram Dr. A. Ishwara Bhat Dr. R. Suseela Bhat
Location	Indian Institute of Spices Research, Calicut
Duration	January 2005- January 2008
Total cost of the scheme	Rs. 25,53,000/-

Progress of work

Phytophthora isolates collected from different hosts were deposited in the National Repository of *Phytophthora* (NARPH), IISR, Calicut. Collection was made during different time. Along with those, new 45 isolates collected from various places of India were added to the repository. Samples of infected leaves, roots, stems, spikes, fruits and soil were collected from different places and used for isolation. The total collection of 447 *Phytophthora* isolates were maintained at room temperature in agar slants overlaid with liquid paraffin and sterile distilled water kept in small screw cap bottles. Periodic sub culturing at six month interval was done for maintenance of the cultures. *Phytophthora* isolates survive in sterile water from six months to one year. Cryopreservation protocols were standardized for long term storage of *Phytophthora* in which skimmed milk could be used as a suitable cryoprotectant followed by DMSO and glycerol.

Morphological characterization

Colony morphology, growth rate on agar, caducity, mating type determination, pathogenicity test, *in-vitro* screening of *Phytophthora* isolates against the biocontrol agent Fluorescent pseudomonads, IISR6 and fungicide resistance were studied for different *Phytophthora* isolates in order to understand the intra specific and inter specific diversity. Carrot agar was used to study the colony morphology, growth rate at different temperatures, sporangial characters and mating type determination. The phenotypic characters of these isolates varied intra specifically and inter specifically. The LB ratio of the *P. capsici* isolates ranged from 1.7- 2.7 and mean pedicel length ranged from 38.2-209 μ m. Mating type determination of *Phytophthora* isolates done by the single unknown isolate method in which a pure culture of each isolate was paired with known A1 and A2 tester on carrot agar plates containing sitosterol (30mg/l) 30 mm from each other.

Molecular characterization of *Phytophthora*

Molecular characterization starts with ITS PCR. ITS region has typically been most useful for molecular systematics at the species level, and even within species (e.g., to identify geographic races). The ITS region of

the isolates were amplified using the primers ITS 6 (5' GAAGGTGAAGTCGTAACAAGG-3') and ITS 4 (5'-TCCTCCGCTTATTGATG-3') in order to identify the *Phytophthora* isolates. The polymerase chain reaction (PCR) amplified a product of ~800bp to 1200bp, from the isolates as routinely observed in the amplification of ITS region using ITS 4 and 6 universal primers. The ITS amplicons were digested with restriction enzymes to reveal the species identity and to reveal the intra and inter specific variations among the isolates. High levels of intraspecific and interspecific variability in the ITS regions were observed among all the isolates. RFLP fingerprints clearly showed the existence of four subgroups within *P. capsici* from black pepper.

For the confirmation of the species identity, ITS amplicons were sequenced. The entire sequence of ITS 1, ITS 2 and 5.8S, partial sequences of 28S and 18S regions were obtained for *P. capsici*, *P. palmivora* and *P. meadii*. Based on these sequences species specific primers were designed using Clustal W. This could be used as a rapid detection technique for the three species from host plants and soil.

V Project title	Studies on nematode problems of seed spice crops
Investigator(s)	I J Pruthi
Location	CCS Haryana Agricultural University, Hisar
Duration	1.4.2005 to 31.3.2008
Total cost of the scheme	Rs 9,59,312/-

Progress of work

Summary of achievements

Seed treatment in cumin with carbosulfan @ 3.0% (w/w) as seed dressing and 0.1% (1000 ppm) as seed soaking for 6 h has been found effective against *Meloidogyne* spp.

Mustard and neem cake as soil application @ 5-10 g/kg soil has also shown improvement in plant growth parameters and reduction in nematode galling.

Soil application of neemate (neem based granular pesticide) has not been found effective against *Meloidogyne* spp. in fenugreek, coriander and cumin.

None the lines of fenugreek and coriander have been found resistant to *M. incognita* whereas all the lines of fennel showed resistant reaction to this nematode.

RKB-68 strain of *Bacillus* spp. in coriander and strains RKB-68 and RKB-91 in fenugreek have shown promising results in improving plant growth parameters and reducing root-knot nematode infection under pot conditions.

Field evaluation of various effective practices for the management of root-knot nematode (*Meloidogyne* spp.) in fenugreek and coriander crops showed maximum performance of mustard cake application @ 5g/ha, followed by soil treatment with carbofuran @ 1 kg a.i./ha and seed treatment with carbosulfan @ 3.0% on a.i. basis (w/w).

List of Publications

Dholi

1. Singh, S.P. and Dwivedi, D.K. 2007. Impact of zinc, boron and iron elements on yield and economics of ginger (*Zingiber officinale* Rosc.). International Journal of Agriculture Science 3(1): 136-138

Guntur

2. Giridhar, K., Sarada, C. and Reddy, Y.T. 2008. Efficacy of biofertilizers on the performance of rain fed coriander (*Coriandrum sativum* L.) in vertisols. J. Spices Aromatic Crops 17(2): 98-102.
3. Giridhar, K., Sarada, C. and Reddy, Y.T. 2008. Influence of micronutrients on growth and yield of coriander in rain fed vertisols. J. Spices Aromatic Crops 17(2): 187-189.
4. Sarada, C. and Giridhar, K. 2008. Threats in production of coriander (*Coriandrum sativum* L.) in Andhra Pradesh. J. Spices Aromatic Crops 17(2): 158-162.
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- 19 Singh Kumhar, B L , Sastry, E V D and Singh, D 2007 Some Aspects of Mutation Breeding in Fenugreek under Field Evaluation In Singh, K , Jakhar, M L and Singh, D (Eds), Multitherapeutic Medicinal and Spiced Plants Vol 1 Aavishkar Publishers, Jaipur Pp 282-285

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List of Research Programmes

Project Code	Title	Centres
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
PEP/CI/3.2	CVT 2000 – Series V Panniyur, Sirsi and Ambalavayal	Chintapalle, Pampadumpara,
PEP/CI/3.3	CVT 2006 Pampadumpara, Pundibari,	Chintapalle, Dapoli, Panniyur, Sirsi, Yercaud and Pechiparai
PEP/CM/4	Nutrient Management Trial	
PEP/CM/4.4	Development of organic package for spices based cropping system – Observational trial	Chintapalle, Sirsi, Panniyur, and Dapoli
PEP/CM/4.5	Organic farming in black pepper - 2006 Sirsi and Yercaud	Panniyur, Dapoli, Pechiparai,
PEP/CM/4.6	Effect of micronutrients in black pepper (adaptive trial)	Panniyur
PEP/CM/4.7	Rooting of orthotropic shoots in black pepper Sirsi and Yercaud	Dapoli, Panniyur, Pechiparai,
PEP/CP/5	Disease Management Trial	
PEP/CP/5.1	Adaptive trial on management of <i>Phytophthora</i> foot rot of black pepper in farmers field	Chintapalle, Dapoli, Panniyur, Pampadumpara, Mudigere and Sirsi
PEP/CP/5.2	Trail on management of <i>Phytophthora</i> foot rot of black pepper in existing plantation	Chintapalle, Dapoli, Panniyur, Pampadumpara, Mudigere and Sirsi

PEP/CP/5 3	Trial on management of <i>Phytophthora</i> foot rot of black pepper in new plantation	Chintapalle Dapoli, Panniyur, Pampadumpara Pechiparai, Mudigere and Sirsi
PEP/CP/6	Pest Management Trial	
PEP/CP/6 1	Management of scale-insects of black pepper with organic products	Mudigere and 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 progenise under intensive management	Mudigere
CAR/CI/3	Coordinated Varietal Trial	
CAR/CI/3 4	CVT 2000- Series IV	Mudigere and Sakleshpur
CAR/CI/3 5	CVT 2005 series V	Pampadumpara and Mudigere
CAR/CI/3 6	CVT 2007-series VI	Mudigere, Pampadumpara and Sakleshpur
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 2	Effect of biofertilizer, <i>Azospirillum</i> on cardamom	Mudigere
CAR/CM/5 3	Effect of biofertilizers, P solubilizers on cardamom	Mudigere
CAR/CM/5 4	Effect of neem cake on productivity, pest and disease incidence in cardamom	Mudigere
CAR/CP/6	Pest Management Trial	
CAR/CP/6 1	Bioecology of natural enemies of major pests of cardamom	Mudigere
CAR/CP/6 2	Estimation of quantitative and qualitative losses due to thrips damage in cardamom	Mudigere
CAR/CP/6 3	Management of shoot fly in cardamom	Mudigere
CAR/CP/6 4	Management of cardamom root grub through entomopathogenic nematodes	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	Raigarh and Pottangi
GIN/CI/2 2	CVT 2005 - Series VI	Solan
GIN/CI/2 3	CVT 2006 - Series VII	Kumarganj, Pottangi and Pundibari
GIN/CI/3	Varietal Evaluation Trial	
GIN/CI/3 1	Initial evaluation trial (IET 2006)	Raigarh, Solan, Pottangi and Dholi
GIN/CI/3 2	Comparative yield trial	Pottangi
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	Kumarganj, Pottangi, and Raigarh
GIN/CM/5 2	Organic farming in ginger 2006	Solan, Pundibari, Pottangi, Dholi and Kumarganj
GIN/CP/6	Disease Management Trial	
GIN/CP/6 1	Disease surveillance and etiology of rhizome rot in ginger	Solan
GIN/CP/6 2	Biocontrol studies on rhizome rot of ginger (final report)	Kumarganj and Pottangi
GIN/CP/6 3	Integrated management of <i>Pythium</i> , <i>Fusarium</i> and <i>Ralstonia</i> on ginger (final report)	Kumarganj, Solan Pundibari and Raigarh
GIN/CP/6 4	Survey and monitoring of diseases in ginger	Pundibari and Raigarh
GIN/CP/6 5	Management of rhizome rot in ginger	Chintapalle and Sirsi

TURMERIC

TUR/CI/1	Genetic Resources	
TUR/CI/1 1	Germplasm collection, characterization, evaluation and conservation	Coimbatore, Dholi, Jagtial, Kumarganj, Pottangi, Pundibari and Raigarh
TUR/CI/2	Coordinated varietal trial	
TUR/CI/2 1	CVT 2000 - Series V	Jagtial and Raigarh,
TUR/CI/2 2	CVT 2004 Series VI	Chintapalle, Coimbatore, Kumarganj, Pottangi, Pundibari and Raigarh
TUR/CI/3	Varietal evaluation trial	
TUR/CI/3 1	Comparative yield trial 2005-06	Jagtial and Pottangi
TUR/CI/3 2	Initial evaluation trial 2006	Kumarganj, Pottangi 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, <i>Azospirillum</i> on turmeric (final report)	Dholi and Kumarganj
TUR/CM/5 2	Effect of organic farming in turmeric	Dholi
TUR/CM/5 3	Organic farming in turmeric	Coimbatore, Dholi, Jagtial, Pottang and Pundibari
TUR/CM/5 4	Efficacy of biocontrol agents for control of rhizome rot of turmeric	Pottangi
TUR/CM/5 5	Effect of micronutrients on turmeric	Pottangi and Raigarh
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, 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)	Kumarganj

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 2001 - nutmeg	Dapoli and Pechiparai
TSP/CI/2.3	CVT 2001 - cassia	Pechiparai
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 and Pechiparai

SEED SPICES

CORIANDER

COR/CI/1	Genetic Resources	
COR/CI/1.1	Germplasm collection, description, characterization, evaluation, conservation and screening against diseases	Coimbatore, Dholi, Guntur, Hisar, Jagudan, Jobner and Kumarganj
COR/CI/2	Coordinated Varietal Trial	
COR/CI/2.1	CVT 2001 - Series V (final report)	Coimbatore
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, Hisar and Kumarganj
COR/CI/3	Varietal Evaluation Trial	
COR/CI/3.1	Initial evaluation trial	Hisar, Guntur, Jobner, Kumarganj 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, <i>Azospirillum</i> on coriander	Dholi
COR/CM/5.2	Effect of bio-regulators on coriander	Jobner
COR/CM/5.3	Identification of drought/ alkalinity tolerant source in coriander	Guntur , Coimbatore and Kumarganj

COR/CM/5 4	Role of rhizobacteria in growth promotion of coriander	Coimbatore, Guntur, Hisar and Jagudan
COR/CP/6	Disease Management Trial	
COR/CP/6 1	Management of powdery mildew and stem gall in coriander	Coimbatore, Kumarganj, Dholi 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 cumini	Jobner
CUM/CP/5	Nutrient management trial	
CUM/CP/5 1	Identification of drought tolerance	Jobner
CUM/CP/5 2	Role of rhizobacteria on growth and yield of cumini	Jagudan
CUM/CP/6	Disease Management Trial	
CUM/CP/6 1	Management of wilt and blight diseases in cumini	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/2 2	CVT - Transplant early rabi 2006	Jagudan
FNL/CI/2 3	CVT 2007	Jagudan
FNL/CI/3	Varietal Evaluation Trial	
FNL/CI/3 1	Initial evaluation trial	Hisar, Jobner , Kumarganj 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, <i>Azospirillum</i> on fennel	Dholi
FNL/CM/5 2	Identification of drought/alkalinity tolerance source in fennel	Kumarganj
FNL/CM/5 3	Role of rhizobacteria on growth and yield of fennel	Jagudan
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 and Hisar
FGK/CI/2 3	CVT 2006	Kumarganj, Dholi, Guntur and Jagudan
FGK/CI/3	Varietal Evaluation Trial	
FGK/CI/3 1	Initial evaluation trial	Guntur, Hisar, Jagudan, Kumarganj and Jobner
FGK/CM/4	Nutrient Management Trial	
FGK/CM/4 1	Effect of biofertilizers, <i>Azospirillum</i> / <i>Rhizobium</i> on fenugreek (final report)	Dholi
FGK/CM/4 2	Identification of drought/tolerance source in fenugreek	Jobner and Guntur
FGK/CM/4 3	Effect of bio-regulators on fenugreek	Jobner, Coimbatore, Dholi and Kumarganj
FGK/CM/4 4	Role of rhizobacteria on growth and yield of fennel	Dholi, Guntur, Hisar, Jagudan and Kumarganj
PAPRIKA		
PAP/CI/1 1	Germplasm collection, characterization, evaluation and conservation of paprika	Coimbatore and Guntur

Staff Position

PROJECT COORDINATOR'S OFFICE

Project Coordinator	:	Dr M Anandaraj
Scientist SS (Hort.)	:	Dr D Prasath
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 (July 2006) (Post shifted to RARS Ambalavayal)
2. Agronomist (Hort.)	:	Vacant
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 Mammooty
2. Jr. Breeder (Asst. Professor)	:	Dr V P Neema
3. Jr. Pathologist	:	Vacant
4. Jr. Horticulturist (Agronomy)	:	Vacant
5. Farm Supervisor (Gr. II)	:	Mr K Lakshmanan
6. Farm Supervisor (Sr. Gr.)	:	Mr P P Muralidharan
7. Farm Supervisor (Gr. I)	:	Mr P Krishnan
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.)	:	Mr K M Devaraju
3. Breeder	:	Dr B M Dushyanthakumar
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. Horticultural Research Station, ANGRAU, Chintapalle

- | | | |
|------------------------|---|---|
| 1. Horticulturist | : | Sri D Lakshminarayana |
| 2. Junior Pathologist | : | Dr. N. Rajk |
| 3. Technical Assistant | : | Post filled on contract basis
from 26-5-2007 |

8. Regional Agricultural Research Station, ANGRAU, Jagtial

- | | | |
|------------------------|---|----------------------|
| 1. Jr. Pathologist | : | Ms M Pameela |
| 2. Jr. Horticulturist | : | Mrs K Uma Maheshwari |
| 3. Technical Assistant | : | Mr G. Srikanth |

9. Horticultural Research Station, ANGRAU, Guntur

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

10. Department of Vegetable Crops, Dr YSPUHF, Solan

- | | | |
|-----------------------------|---|----------------------|
| 1. Breeder (Olericulturist) | : | Dr B N Korla |
| 2. Jr. Pathologist | : | Dr N P Dohroo |
| 3. Jr. Biochemist | : | Dr Neerja S 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 L C Murmu |
| 4. Technical Assistant | : | Mr L K Mishra |

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

- | | | |
|-------------------|---|--------------------|
| 1. Sr. Breeder | : | Dr EVD Sastry |
| 2. Breeder | : | Dr Dharendra 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/Oleoculturist	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	Dr A K Mishra
3	Technical Assistant	Dr A N Mishra
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, UBKV, Pundibari	
1	Horticulturist	Vacant
2	Jr Breeder	Dr N Bhowmik
3	Jr Pathologist	Mr S Bandyopadhyay
4	Technical Assistant	Mrs A Das
5	Technical Assistant	Mr B Dutta
18	Dept of Horticulture, KKV, Dapoli	
1	Horticulturist	Prof R N Nawale
2	Jr Pathologist	Prof U A Gadre
3	Jr Breeder	Prof U B Pethe
4	Technical Assistant	G R Gawandi
5	Technical Assistant	Mr A B Jadhav
19	Regional Agricultural Research station, IGAU, Raigarh	
1	Horticulturist	Dr C R Gupta (upto 10-3 2008)
2	Jr Breeder	Vacant
3	Jr Pathologist	Dr A K Singh
4	Technical Assistant	Mr D S Kshatri
5	Technical Assistant	Vacant)

AICRPS- Budget Provision

Centrewise Budget Provision 2007-08
(Rs. in lakhs)

Name of the centres	Pay and Allowances		TA		RC		Tech. Assessment		Grand Total		Grand Total
	Total	ICAR	Total	ICAR	Total	ICAR	(ICAR)	(ICAR)	ICAR Share	State Share	
Pampadumpara(KAU)	3,017	2,263	0,300	0,225	1,800	1,350		1,350	3,838	1,279	5,117
Panniyur (KAU)	41,783	31,337	0,400	0,300	2,400	1,800	0.100	1,900	33,537	11,179	44,716
Mudigere (UAS-B)	28,667	21,500	0,400	0,300	2,400	1,800		1,800	23,600	7,867	31,467
Sirsi (UAS-D)	24,267	18,200	0,200	0,150	1,200	0,900		0,900	19,250	6,417	25,667
Yercaud (TNAU)	11,600	8,700	0,200	0,150	1,200	0,900		0,900	9,750	3,250	13,000
Coimbatore (TNAU)	10,933	8,200	0,200	0,150	1,200	0,900	0.100	1,000	9,350	3,117	12,467
Chintapalli (APAU)	4,727	3,545	0,200	0,150	1,200	0,900		0,900	4,595	1,532	6,127
Jagtlal (APAU)	2,625	1,969	0,200	0,150	1,200	0,900	0.050	0,950	3,069	1,023	4,092
Guntur (APAU)	14,133	10,600	0,200	0,150	1,200	0,900	0.050	0,950	11,700	3,900	15,600
Solan (YSPUHF)	20,400	15,300	0,300	0,225	1,800	1,350	0.050	1,400	16,925	5,642	22,567
Pottangi (OUAT)	1,967	1,475	0,200	0,150	1,200	0,900	0.100	1,000	2,625	0,875	3,500
Jobner (RAJAU)	14,920	11,190	0,500	0,375	3,000	2,250	0.150	2,400	13,965	4,655	18,620
Jagudan (GAU)	10,800	8,100	0,200	0,150	1,200	0,900	0.100	1,000	9,250	3,083	12,333
Hisar (HAU)	9,737	7,303	0,200	0,150	1,200	0,900	0.100	1,000	8,453	2,818	11,271
Dholi (RAU)	3,733	2,800	0,200	0,150	1,200	0,900	0.050	0,950	3,900	1,300	5,200
Kumarganj (NDUAT)	26,267	19,700	0,300	0,225	1,800	1,350		1,350	21,275	7,092	28,367
Pundibari (BCKVV)	6,400	4,800	0,300	0,225	1,800	1,350	0.050	1,400	6,425	2,142	8,567
Dapoli (KKV)	23,333	17,500	0,300	0,225	1,800	1,350	0.050	1,400	19,125	6,375	25,500
Raigarh (IGKV)	11,237	8,428	0,300	0,225	1,800	1,350	0.050	1,400	10,053	3,351	13,404
AICRPS Workshop					0,315	0,315		0,315	0,315		0,315
Grand Total	270,547	202,910	5,100	3,825	30,915	23,265	1,000	24,265	231,000	76,895	307,895

Statement of fund released to AICRPS Centers (2007-08) (Rs. in lakhs)

Name of the Centre	Allocation 2007-08	Ist half released	II nd half released	Tech. Ass.	Add. Fund released	Grand total
Pampadumpara (KAU)	3.838	3.838				3.838
Panniyur (KAU)	33.537	5.00	5.00	0.100	23.437	33.537
Mudigere (UAS-B)	23.60	4.300	4.30		15.00	23.60
Sirsi (UAS-D)	19.25	2.125	2.125		15.00	19.25
Yercaud (TNAU)	9.75	2.475	2.475		4.800	9.75
Coimbatore (TNAU)	9.35	2.575	2.575	0.100	4.10	9.35
Chintapalli (APAU)	4.595	2.075	2.075		0.445	4.595
Jagtial (APAU)	3.069	2.125	0.894	0.050		3.069
Guntur (APAU)	11.70	2.325	2.325	0.050	7.00	11.70
Solan (YSPUHF)	16.925	3.938	3.937	0.050	9.00	16.925
Pottangi (OUAT)	2.625	2.525		0.100		2.625
Jobner (RAJAU)	13.965	6.113	6.112	0.150	1.590	13.965
Jagudan (GAU)	9.25	3.025	3.025	0.100	3.10	9.25
Hisar (HAU)	8.453	2.425	2.229	0.100	3.699	8.453
Dholi (RAU)	3.90	1.925	1.925	0.050		3.90
Kumarganj (NDUAT)	21.275	4.638	4.637		12.00	21.275
Pundibari (BCKVV)	6.425	2.888	2.887	0.050	0.60	6.425
Dapoli (KKV)	19.125	3.538	3.537	0.050	12.00	19.125
Raigarh (IGKV)	10.053	3.988	3.987	0.050	2.028	10.053
AICRPS Workshop	0.315		0.315			0.315
Total	231.00	61.841	54.360	1.00	113.799	231.00

Weather Data

Chintapalle

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
April' 07	94.2	7	34.3	17.5	84.5	63.3
May	71.2	5	36.8	20.8	76.0	53.6
June	342.6	13	29.4	21.0	87.6	71.5
July	91.8	9	27.6	21.3	88.2	79.1
August	201.2	15	27.2	20.6	87.0	78.0
September	246.0	14	26.7	20.8	89.3	81.2
October	275.0	11	26.7	18.0	91.0	74.4
November	20.6	1	26.9	11.8	83.4	58.2
December	0	0	26.3	10.9	81.9	51.0
January' 08	0	0	26.7	8.5	82.3	38.9
February	20.8	2	26.7	13.5	82.8	45.1
March	88.6	7	29.8	14.8	82.7	42.5

Coimbatore

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
April' 07	57.7	5	23.9	35.3	86	40
May	80.8	4	23.7	34.5	85	47
June	60.6	5	23.6	32.1	80	55
July	82.0	7	23.1	29.6	84	64
August	84.3	5	22.3	30.4	89	59
September	14.4	1	21.3	31.2	85	55
October	278.8	10	21.8	30.6	90	60
November	56.5	4	19.9	29.7	90	53
December	114.9	3	19.3	28.4	89	54
January' 08	10.0	1	29.8	18.8	89	41
February	21.8	1	31.8	19.3	85	36
March	0	0	34.7	21.9	81	32

Dapoli

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
April' 07	0.2	0.0	33.2	20.4	93.2	62.7
May	14.8	2.0	33.4	23.1	87.8	62.2
June	1273.5	23.0	31.1	24.3	94.0	83.0
July	971.1	27.0	28.7	23.8	95.9	92.2
August	1067.6	31.0	28.2	23.3	97.0	87.8
September	919.4	21.0	28.7	22.9	98.3	91.4
October	11.8	1.0	32.1	20.8	96.3	70.0
November	3.6	1.0	32.8	16.6	95.4	70.7
December	0.0	0.0	32.1	14.6	95.2	59.9
January' 08	0.0	0.0	31.57	10.71	94.48	46.23
February	0.0	0.0	29.9	11.6	91.9	45.9
March	16.0	2.0	32.4	17.4	91.6	50.5

Dholi

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January' 07	21.3	7.2	92.3	60.6	Nil	Nil
February	24.0	11.6	93.3	63.5	26	3
March	27.8	14.0	87.0	47.9	21.6	3
April	35.6	22.7	75	39	30.0	4
May	36.5	25.6	76	41	64.0	2
June	34.4	26.8	78	65	106.5	4
July	31.0	26.6	90	81	698.1	23
August	31.5	27.2	89	76	631.1	21
September	31.6	26.8	89	75	620.4	13
October	31.3	24.3	91	65	170.3	4
November	28.0	17.6	90	56	18.5	1
December	23.2	10.7	89	49	0	0

Guntur

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
April' 07	25.00	2	36.5	24.3	81	42
May	26.2	3	41.8	27.7	61	29
June	190	8	35.7	26.5	76	55
July	262.6	12	34.15	24.48	82.4	58.1
August	224.2	11	32.3	25.1	83.8	66.1
September	171.3	10	31.6	24.8	87.5	68.6
October	95.8	6	31	22.7	85.5	68.1
November	66.6	2	30.8	19.4	87.8	53.1
December	0	0	30.53	18.97	84.23	47.9
January' 08	0.05	0	30.3	20.7	90.84	45
February	83.9	3	30.9	20.7	90.97	55
March	0.0	0	33.0	23.0	88.9	48.2

Hisar

Month	Rainfall (mm)	Temperature (°C)		Relative Humidity (%)	
		Max	Min	Max	Min
April' 07	2.0	38.1	17.7	66	23
May	46.2	39.8	23.8	59	27
June	167.7	38.5	26.5	72	45
July	21.0	36.9	26.5	81	52
August	71.0	35.3	26.3	86	60
September	66.3	34.0	23.7	90	55
October	0.0	33.7	13.9	83	27
November	0.0	29.4	10.6	88	35
December	3.8	21.5	4.8	92	39
January' 08	3.3	18.6	3.2	90	38
February	0.9	21.0	4.0	86	37
March	0.0	32.2	12.0	85	31

Jagtial

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January'07	0.0	0	30.2	14.4	74	36
February	0.0	0	30.6	15.7	62	30
March	0.0	0	33.5	17.5	58	32
April	3.4	0	38.5	22.0	60	34
May	8.2	1	42.1	26.2	47	24
June	96.0	8	36.3	25.9	70	52
July	169.0	9	33.6	24.5	76	61
August	151.0	10	32.3	23.6	80	63
September	244.2	11	32.2	23.0	84	69
October	76.2	4	32.1	18.7	77	46
November	29.0	1	31.2	14.2	70	34
December	0.0	0	30.9	13.9	68	36

Jobner

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January'07	1.4	0	23.9	4.4	84.2	31.8
February	5.8	0	25.5	10.6	82.7	37.7
March	12.5	2	31.4	14.0	70.7	23.7
April	1.3	0	39.8	20.8	45.2	15.4
May	0.0	0	40.6	24.9	43.0	17.0
June	5.7	1	39.2	26.8	62.0	35.0
July	83.4	8	34.2	25.3	82.0	50.0
August	19.5	2	32.9	25.2	83.0	57.0
September	0.0	0	0.0	0.0	0.0	0.0
October	0.0	0	0.0	0.0	0.0	0.0
November	0.0	0	0.0	0.0	0.0	0.0
December	0.0	0	0.0	0.0	0.0	0.0

Mudigere

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
April' 07	67.0	8	82.30	76.2	29.81	16.33
May	76.0	6	94.38	88.06	31.74	17.01
June	1102.6	18	90.06	81.40	24.88	18.15
July	1193.8	26	91.51	81.74	23.38	17.40
August	1107.4	25	91.77	85.48	23.00	17.70
September	753.4	25	89.40	78.46	26.66	18.563
October	310.6	8	88.54	78.64	26.22	18.06
November	23.2	2	85.17	75.13	26.62	17.33
December	0	0	84.45	74.45	26.69	15.81
January' 08	0	0	77.80	57.61	27.66	15.28
February	46.0	2	88.34	60.68	29.86	15.89
March	244.4	9	86.82	76.25	28.25	17.79

Panniyur

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)
			Max	Min	
January' 07	0	0	34.4	22.4	72.7
February	0	0	35.5	22.2	88.1
March	0	0	36.1	25.6	89.7
April	43	3	36.8	26.8	83.3
May	137.6	7	35.5	26.4	81.9
June	1048.9	24	30.7	25.8	86.9
July	1342.8	31	28.4	26.0	91.5
August	846	23	28.9	24.9	91.5
September	812.4	27	29.5	25.4	91.3
October	296.1	19	31.2	24.6	90.6
November	103.8	3	33.3	22.8	88.8
December	0	0	34.4	22.9	87.8

Pechiparai

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)
			Max	Min	
January'07	3	0	34.6	20.4	80.0
February	30	2	34.9	20.6	83.4
March	25	1	34.9	21.5	83.2
April	15	2	33.0	22.2	92.7
May	250	9	33.1	23.8	96.3
June	125	4	30.1	22.8	93.7
July	110	8	30.1	22.8	93.2
August	120	12	30.8	20.5	91.5
September	395	18	29.9	22.3	89.5
October	520	14	30.0	20.7	92.4
November	215	12	30.8	20.4	80.5
December	144	8	32.5	20.5	84.8

Pottangi

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January' 07	20	01	25	16	82.0	62.0
February	0	0	27	17	80.0	61.0
March	18	01	31	18	84.0	60.0
April	22	01	36	22	85.0	61.0
May	132	04	32	20	92.0	67.0
June	421	14	30	19	96.0	80.0
July	611	17	27	18	96.0	88.0
August	760	22	27	17	98.0	88.0
September	710	14	24	17	98.0	91.0
October	422	08	24	16	98.0	93.0
November	210	08	22	16	87.0	74.0
December	40	02	20	14	82.0	72.0

Pundibari

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
January' 07	0	01	25.5	7.1	100	55
February	77.0	8	25.7	12.1	98	52
March	8.6	4	32.2	12.6	97	41
April	162.2	11	31.9	17.8	97	62
May	265.4	15	34.1	22.3	94	57
June	633.1	20	31.8	23.4	95	79
July	407.7	20	32.1	22.6	99	79
August	523.6	19	34.3	24.7	95	71
September	369.9	16	33.3	23.8	97	64
October	131.8	5	34.5	19.5	97	66
November	0	0	30.3	14.0	96	60
December	0	0	25.5	8.7	100	56

Sirsi

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)	
			Max	Min	Max	Min
April' 07	25.0	4	34.9	22.5	86.3	61.1
May	22.2	2	33.5	21.7	88.9	61.0
June	780.0	17	29.1	21.2	91.0	68.6
July	907.7	30	33.5	21.7	88.9	61.0
August	540.8	29	26.6	20.8	90.6	84.2
September	316.1	28	27.9	20.8	91.0	84.3
October	82.2	4	33.5	21.7	88.9	61.0
November	27.3	2	30.1	14.6	91.5	71.1
December	0.0	0	29.8	15.0	91.5	65.7
January 08	0.0	0	30.2	13.1	91.3	63.2
February	16.8	1	31.1	15.3	91.2	61.2
March	140.6	7	32.7	17.3	88.0	51.6

Solan

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)
			Max	Min	
April' 07	6.2	1	30.9	13.3	49
May	19.6	4	33.2	16.7	50
June	86	10	32.5	19.1	63
July	111.1	10	30.4	20	81
August	342.6	13	29	20	83
September	59.8	6	28.1	17.7	80
October	52.8	2	28.4	9.2	56
November	0	0	25	5.1	58
December	10	3	22.3	2.3	58
January' 08	0	0	17.2	2.4	69
February	38.8	9	20.0	4.0	66
March	0	0	29.1	9.6	53

Yercaud

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative Humidity (%)
			Max	Min	
April' 07	182.5	6	30.4	20.5	66.0
May	53.5	6	31.0	21.1	65.8
June	96.0	8	26.2	18.3	83.5
July	127.5	10	25.7	16.7	89.9
August	304.0	11	25.2	17.9	92.5
September	355.0	18	24.9	16.3	91.5
October	213.5	10	26.0	17.8	83.0
November	077.5	6	23.0	16.0	76.0
December	192.5	7	20.0	16.0	87.4
January' 08	8.5	1	22.5	14.4	64.4
February	30.5	1	22.5	14.4	64.4
March	84.0	8	24.9	17.8	81.0

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