वार्षिक प्रतिवेदन
Annual Report
2006 - 07

केंद्रीय बारानी कृषि अनुसंधान संस्थान
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Preface

I am happy to present the CRIDA Annual Report for 2006-07. The report contains progress of research made under different mandated activities of the institute. Dry farming areas in the country continue to face challenges like frequent droughts, water shortages, soil erosion and rising cost of production. The Hon'ble Prime Minister has called for a second green revolution to meet the growing demand of food and fodder in the country. The 11th Five Year Plan is contemplating a GDP growth rate of 8-9 % with a projected growth rate of 4% in agriculture. Rainfed agriculture has to contribute significantly to the farm sector growth to meet this projected growth rate in agriculture. Continued development and application of new technologies with matching infrastructure and credit support are critical in achieving this.

CRIDA has therefore focused on important priority areas of research like climate change, NRM, livelihood support, farming systems and crop diversification. The institutes research led to improved understanding of these issues and the report tries to put together the important achievements among them. Though development of new technologies is the primary responsibility of CRIDA, it is of late, increasingly participating in development initiatives of various government and non-governmental organizations to understand and draw lessons on issues related to participatory technology adoption by stakeholders. Farmer participatory and inter-institutional collaborative research has therefore become an integral component of CRIDA's research activities.

During the year, relative vulnerabilities in monsoon and abnormal weather events in different regions of the country were estimated; productivity and sustainability effects of different nutrient management practices were evaluated; effects of various management options for soil quality management were assessed; studies on feasibility of organic production of sesamum, pigeonpea and niger were continued; sustainability of land management options in watershed programs assessed and socio-economic issues related to adoption of rainfed technologies in a profitable mode by the farming community addressed.

The transgenics of sorghum lines developed earlier by using mtlD gene were

further characterized and found to have enhanced germination potential and remarkable improvement in root system under stress conditions; an efficient plant regeneration protocol for blackgram was developed; four genotypes of horse gram developed earlier through mutagenesis were promoted to advanced varietal trials at national level; *Pseudomonas* and *Bacillus* strains isolated from soils of dry regions were observed to impart higher temperature-tolerance in pearl millet; higher growth and increase in female flower ratio and yield of castor observed under elevated CO_2 conditions.

In addition, best nutrient management modules for obtaining high yields of medicinal, aromatic and dye yielding plants developed; some promising accessions of jatropha and pongamia for yield and for use as potential planting material identified; modifications in the machinery and processing techniques for higher oil recovery in jatropha and pongamia made; positive profitability and health effects of adoption of IPM in groundnut observed; Seventy eight need-based training programmes were conducted for farmers.

I am glad to inform that the efforts of CRIDA were recognized in the form of personal and professional recognition. Dr. M. Maheswari won the Best Woman Scientist Award and Dr. M. Vanaja reveived the Common Wealth Staff Fellowship. The institute also won the Shiksha Siromani Award for promotiong the offical language. CRIDA continues to excel in the realm of publications and national and international recognitions. All these successes are the outcome of the extensive support and guidance the institute received from the Hon'ble Director General ICAR and Deputy Director General (NRM).

Finally, I congratulate my colleagues on the editorial committee for their painstaking effort in putting this report together. I welcome any suggestions for improvement in the Annual Report presentation.

(Y S Ramakrishna)

Hyderabad
Date : November 16, 2007

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संसाधन लक्षण

- फसलों एवं नाशीजीव संबंधित लंबी अवधि के आंकड़ों के आधार पर लुधियाना क्षेत्र के लिए मौसम पंचांग तैयार किए गए। किसानों को कृषि संबंधी सलाह सेवाएं प्रदान करने के लिए इन फसल पंचांगों को प्रभावी रूप से उपयोग किया जा सकता है।

- जलवायु परिवर्तन के कारण उत्पन्न प्रभावों का मूल्यांकन करते हुए, देश के विभिन्न भागों में वर्षा की प्रवृत्तियों की जांच की गई। अध्ययनों के परिणामों से मध्यप्रदेश के पूर्वी भागों, छत्तीसगढ़, बिहार के कुछ भागों, उत्तर प्रदेश एवं भारत के उत्तर-पश्चिमी तथा उत्तर-पूर्व की वार्षिक वर्षा में कमी स्पष्ट रूप से दिखलाई दी।

- अध्ययनों के आधार पर भारत के वर्षा आधारित क्षेत्र में सूखा पड़ने की संभावना 30 से 40 प्रतिशत तक पाई गई। भारत के पूर्वी एवं उत्तर-पूर्वी भागों में जहाँ सूखा पड़ने की संभावना कम होती जा रही है, वहीं देश की उत्तर-पश्चिम दिशा में यह संभावना बढ़ती जा रही है।

- स्थानीय वाष्पन-वाष्पोत्सर्जन क्षमता एवं फसल गुणांक आंकड़ों के आधार पर मुंगफली की फली विकास अवस्था एवं अरहर के पूर्ण पकने तक जल की आवश्यकताओं में विभिन्न स्थानों पर महत्वपूर्ण भिन्नता देखी गई।

समेकित पोषक प्रबंधन

- कर्षण और समोकित पोषक प्रबंधन पर दीर्घावधि के प्रयोग परिणामों ने स्पष्ट किया कि न्यूनतम कर्षण की तुलना में पारंपरिक कर्षण से ज्वार की उपज में वृद्धि हुई जबकि मूंग की उपज पर कर्षण का प्रभाव नहीं पड़ा। इस वर्ष समोकित पोषक प्रबंधन उपचारों में से, यूरिया द्वारा 40 कि.ग्रा. नाइट्रोजन से ज्वार का अधिकतम उत्पादन प्राप्त हुआ, जबकि यूरिया द्वारा 2 टन कंपोस्ट + 10 कि.ग्रा. नाइट्रोजन से मूंग का अधिकतम उत्पादन प्राप्त किया गया। इस प्रयोग में मृदा गुणवत्ता के मुख्य सूचक उपलब्ध नाइट्रोजन, डी.टी.पी.ए., निष्कर्षणीय जिंक (Zn) तथा कॉपर (Cu), सुक्ष्मजीवी बायोमॉस कार्बन (C), मृदा का कुल (aggregates) माध्य भार व्यास (M.W.D) तथा मृदा जलीय चालकता थे। दोनों कर्षण प्रणलियों के अंतर्गत, 4 टन कंपोस्ट +2 टन ग्लैरीसीड़िया कर्तनों ने अधिकतम सापेक्ष मृदा गुणवत्ता (RSQI) सूचक दर्शाया। जुताई की विधियों से, सापेक्ष मृदा गुणवत्ता सूचक में दृष्टिगोचर-प्रभाव नहीं दिखाई दिया।

- अरजिया केंद्र में दीर्घावधि के लिए किए गए परीक्षणों के आधार पर सापेक्ष मृदा गुणवत्ता (RSQI) सूचक निकाले गए। इन सूचकों के आधार पर मृदा उपचारों का क्रम इस प्रकार रहा : 100 प्रतिशत जैविक > 50 प्रतिशत जैविक + 50 प्रतिशत अजैविक > पोषकों का 100 प्रतिशत अजैविक उर्वरक द्वारा।

- तिल के जैविक उत्पादन पर फार्म पर किए गए अनुसंधानों से पता चला कि जैविक प्रणाली की तुलना में अजैविक प्रणाली से तिल का बीज उत्पादन अधिक रहा। अजैविक प्रणाली से नाशीजीव एवं रोगों का आपतन भी कम था।

- एक उच्च निवेश रसायन पैकेज अपनाने से ज्वार का अधिकतम अनाज उत्पादन मिला जबकि अरहर का अधिकतम उत्पादन उच्च निवेश जैविक पैकेज द्वारा प्राप्त किया गया। उच्च निवेश रसायन पैकेज से अरहर में दाना क्षति न्यूनतम रही।

- अनंतपुर जिले में प्रचलित मूंगफली छिलका खाद की देशी प्रक्रिया की तैयारी एवं प्रयोग का अध्ययन किया गया एवं इसका महबूबनगर जिले में भी प्रचार किया गया। किसानों के खेतों में किए गए अनुसंधान से ज्ञात हुआ कि किसानों द्वारा अपनाई जा रही पद्धत्ति के अतिरिक्त मूंगफली छिलका खाद के उपयोग से खरीफ एवं रबी में क्रमशः 10 से 12 प्रतिशत तथा 20 से 25 प्रतिशत मूंगफली का बेहतर उत्पादन प्राप्त किया गया।

- देश की प्रमुख बारानी फसलों के 15 स्थानों से मृदा नमूने (राइज़ोस्फेयर एवं नॉनराइज़ोस्फेयर) एकत्रित किए गए तथा स्यूडोमोनास (45), बैसिलस (75), ऐजोसपेरिलम (6), राइज़ोबियम (7) एवं ए.एम. फूंगी (14) की किस्मों को अलग कर मूल्यांकित किया गया। बैसिलस किस्में जो कि लवणता, सूखा एवं उच्च तापमान के प्रति सहनशील थी एवं स्यूड़ोमोनस किस्में जो कि उच्च तापमान, लवणता, सूखा एवं कम पोषक स्तर के लिए सहनशील थी, की पहचान की गई। एक बैसिलस किस्मों को यथेष्ट रूप से पादप वृद्धि को बढ़ावा देने वाली गतिविधि के रूप में देखा गया। *बैसिलस* एवं *स्यूड़ोमोनास* किस्मों को विभिन्न कवकीय रोगजनकों के विरूद्ध जैवनियंत्रण क्षमतायुक्तों के रूप में पहचाना गया।

- उदासीन एवं कम सांद्रता युक्त पोटाशियम परमैंगनेट ($KMnO_4$) का उपयोग करते हुए लेबाइल कार्बन का अनुमान लगाने हेतु एक साधारण विधि विकसित की गई जो कि किसानों के खेतों में प्रयोग हेतु फील्ड-किट सें इस्तेमाल की जा सकती है।

वर्षाजल प्रबंधन

- आंध्र प्रदेश में कुरमापल्ली जलग्रहण क्षेत्र में सतही एवं भूजल संतुलन पर किए गए अध्ययनों से पता चला कि भूजल का उपयोग क्षमता से अधिक किया जा रहा है।

- जलग्रहणों में टिकाऊ भूमि प्रबंधन प्रक्रियाओं के मूल्यांकन से स्पष्ट हुआ कि उपचारित सूक्ष्म जलग्रहण क्षेत्र के किसान अनुपचारित सूक्ष्म जलग्रहण क्षेत्र के किसानों की अपेक्षा अधिक एवं टिकाऊ फसल-उत्पादन हासिल कर सके।

फसल एवं फसल प्रणालियां

- अजैविक दबाव सहिष्णुता की वृद्धि के लिए 'एम टी एल डी' जीन का उपयोग कर ज्वार के ट्रांसजेनिकों से पर्णखंड़ों का विकास किया गया। जब इनको पॉलिथिलाइन ग्लाइकोल 8000 (-2.0MPa) एवं NaCl (600mM) के संपर्क में लाया गया तो अरूपांतरित नियंत्रणों की तुलना में रूपांतरित पर्ण खंड़ों में बेहतर पर्ण जल मात्रा एवं क्लोरोफिल बनाए रखने की क्षमता पाई गई। जब PEG (-0.7MPa) या NaCl (200mM) दबावों से चुनौती दी गई तो भी ट्रांसजेनिक बीजों की अंकुरण क्षमता कई गुना अधिक थी। इन ट्रांसजेनिकों ने जड़ों के बायोमॉस एवं लंबाई बढ़ाने में बहुत अच्छे परिणाम दिए।

- उड़द ट्रांसजेनिक विकास के प्रयास के अंतर्गत कोटिलेडोन्स (Cotyledons) को एक्सप्लांटों के रूप में उपयोग कर बेहतर एवं त्वरित पुनर्जनन प्रोटोकॉल का विकास किया गया। विभिन्न पादप उगाऊ नियामकों की क्रिया के प्रति इसकी कॉलेसिंग फ्रिक्वेन्सि 60 से 90 प्रतिशत थी।

- अजैविक दबाव सहिष्णुता उपजाति को ध्यान में रखते हुए विभिन्न वर्षा आधारित फसलों के राइज़ोस्फेयर से विभिन्न *स्यूड़ोमोनास* एवं *बैसिलस* उपजाति को अलग किया गया। यह देखा गया कि शुष्क क्षेत्रों से अलग की गई कुछ *बैसिलस* एवं *स्यूड़ोमोनस* किस्में, बाज़रा को दो सप्ताह तक 50 डिग्री सेंटीग्रेड में भी जीवित रखने में सहायक थी।

- अरंडी में कार्बन डाई आक्साइड की मात्रा बढ़ने की

स्थिति में अरंडी की बाली की लंबाई, बालियों का भार, कैप्सूल संख्या, कैप्सूल भार एवं बीज के आकार में सुधार देखा गया। कार्बन डाई आक्साइड की मात्रा 550 पी.पी.एम. तक बढ़ाने की स्थिति में अरंडी की फसल में बढ़ती कैप्सूल संख्या एवं बीज प्रति कैप्सूल के योगदान से बीज उत्पादन में वृद्धि हुई जबकि कार्बन डाई आक्साइड की मात्रा 700 पी.पी.एस. तक बढ़ाने पर बीजोत्पादन में यह वृद्धि कैप्सूल संख्या और बीज के आकार के बढ़ने से हुई। कार्बन डाई आक्साइड की मात्रा बढ़ाने से बॉयोमॉस एवं बीज की पैदावार में वृद्धि हुई।

- बढ़ती हुई कार्बन डाई आक्साइड की मात्रा एवं तापमान का अरंडी की फसल के नाशीजीवों जैसे सेमील्यूपर एवं अन्य कीटों पर प्रभाव का अध्ययन किया गया। इससे पता चला कि कार्बन-डाई आक्साइड मात्रा बढ़ने से इन नाशीजीवों की सापेक्ष वृद्धि दर, शोधित आहार का दक्षतापूर्ण परिवर्तन एवं संनिकट पचनीयता आदि सूचक काफी प्रभावित होते हैं।

- मूंगफली फसल का परिवेश एवं वितान स्तरीय परिस्थितियों के बीच तापमान तथा सापेक्ष आर्द्रता का क्रियाशील संबंध स्थापित किया गया जिसका उपयोग मौसम आधारित पूर्वानुमान प्रणलियों के लिए किया जा सकेगा।

- वर्टीसोल्स के अंतर्गत, छोटे एवं सीमांत किसानों के लिए मक्का + अरहर - कपास + 50 भेड़ें को श्रेष्ठ कृषि प्रणाली मापदंड के रूप में पहचाना गया। मक्का + अरहर - कपास + एक भैंस + 50 भेडें (छोटे किसानों के लिए) और ज्वार + अरहर - कपास + एक भैंस + 50 भेड़ें (सीमांत किसानों के लिए) अल्फीसोल्स के लिए अनुकूल श्रेष्ठ मापदंड के रूप में पहचाने गए।

- संस्थान में कुलथी के चार 'मुटाजेनेसिस' विधि द्वारा विकसित स्ट्रेनों को उनके बेहतर प्रदर्शन के आधार पर भा.कृ.अनु.प. की शुष्क शिंबों की नेटवर्क परियोजना को अग्रिम किस्म की जांच हेतु भेजा गया।

- बी.टी. की प्रभावी किस्मों को अलग करने के प्रयासों के अंतर्गत, बीजाणु बनाने वाले बैसिल्ली (Bacilli) की उपस्थिति के लिए आठ बारानी क्षेत्रों के मृदा नमूनों की जांच की गई। उदयपुर की किस्मों से अत्यधिक *बैसिलस थुरिनजिनेसिस* के क्रिस्टलीफेरस विगलकों की प्राप्ति हुई।

- नाशीजीवों के प्रमात्रीकरण एवं रोग आपतन में सुदूर संवेदी आंकडों के उपयोग की संभावना हेतु अध्ययन किए गए। यह देखा गया कि मूंगफली के रोगमुक्त पौधों को अतिलाल बैंड़ के नज़दीक (760 से 1240 नैनोमीटर) बेहतर प्रकाश अवशोषण हुआ। तीव्र रूप से दीमक प्रभावित प्लॉट में दृश्य बैंड पर (500 से 710 नैनोमीटर) क्लोरोफिल अवशोषण की पत्तियां दिखलाई नही पड़ी।

- समोकित जैव संसाधन केंद्र ने किसानों की आपूर्ति के लिए जैव-उर्वरकों, जैव-नाशीजीवों एवं बहुप्रयोजनीय पेड़ों की रोपण सामग्री का बड़े पैमाने पर उत्पादन शुरू किया। ट्राइकोडेरमा, फ़ास्फोट विलयशील जीवाणु (पी.एस.बी.), राइज़ोबियम, विषाणु आधारित जैवकीटनाशकों का उत्पादन किया गया एवं कृषि विज्ञान केंद्र के गांवों में मूल्यांकन के लिए भागीदारी पद्धत्ति पर चने की कृषि करने वाले किसानों में वितरित किया।

वैकल्पिक भूमि उपयोग प्रणली

- आंवला, इमली एवं ऐकेशिया सेनेगल की पंक्तियों के बीच जब सेटेरिया की फसल अंतरा संस्ययन के रूप में उगाई गई तो फसल की पैदावार में कोई भिन्नता नहीं दिखाई दी। लेकिन एकल फसल की तुलना में उपज कम थी। उसी प्रकार, कुलथी का अनाज उत्पादन वृक्ष पंक्तियों के बीच अंतरासस्यन की तुलना में एकल फसल में बेहतर था। वृक्ष थाला उपचारों में, वर्मीकंपोस्ट

एवं अकार्बनिक उर्वरकों के संयोग से आंवला में अधिकतम फलोत्पादन प्राप्त हुआ।

- कृषिवानिकी प्रणालियों में कार्बन संचयन का अनुमान लगाने के लिए पेड़ की ऊंचाई एवं आवक्ष उच्चता व्यास जैसे आसानी से मापे जाने वाले लक्षणों का उपयोग कर *ल्युकैना* एवं *सफेदा* के पेड़ों के बायोमॉस का अनुमान लगाने के लिए एल्लोमैट्रिक संबंध बनाए गए।

- अश्वगंधा, बिक्सा, नील एवं मेहंदी में अधिक उत्पादन एवं गुणवत्ता प्राप्त करने के लिए श्रेष्ठ पोषक प्रबंधन मॉडयूल तैयार किए गए।

- जट्रोफा के 18 आगमनों एवं पोंगामिया जननद्रव्य के 17 आगमनों को संग्रहित कर मूल्यांकित किया गया और आशाजनक वंशावलियों की पहचान की गई । जट्रोफा को बिना कांट-छांट एवं 30 तथा 60 सेंटीमीटर पर कांट-छांट की तुलना में 45 सेंटीमीटर की ऊंचाई पर कांट-छांट करने से बीज उत्पादन में वृद्धि हुई। तीसरे वर्ष के उपरांत जट्रोफा का कृषि फसलों से अंतरासस्यन संभव नहीं था जबकि पोंगामिया में अन्य फसलें अंतराफसल के रूप में सफलतापूर्वक उगाई जा सकी।

- सघन, अर्ध-सघन एवं विस्तीर्ण भेड़ प्रबंधन प्रणालियों के मूल्यांकन ने स्पष्ट किया कि किसानों की परिस्थितियों के अंतर्गत केवल विस्तीर्ण प्रबंधन प्रणाली ही अनुकूल है।

कृषि यंत्र एवं शक्ति

- पिछले वर्ष तैयार किए गए बहु प्रयोजनीय सेल्फ प्रोपेल्लड यंत्र को डबल लीवर क्लच एवं व्हील डिज़ाइन के परिवर्तन द्वारा संशोधित किया गया जिसके परिणामस्वरूप यंत्र की मैनोवरेबिलिटी में सुधार हुआ।

- सुधार किए गए एक्सपेलर से जट्रोफा एवं पोंगामिया बीजों से अधिक तेल निकाला गया। बीज पूर्वोपचार से जट्रोफा में 26 से 30 प्रतिशत एवं पोंगामिया में 24 से 28 प्रतिशत अधिक तेल उत्पादन के साथ-साथ इसकी गुणवत्ता में भी सुधार हुआ। मूल्यांकन करने से ज्ञात हुआ कि संस्थान द्वारा विकसित विधि से निकाले गए बॉयोडीज़ल (जिसकी श्यानता कम है) को 40 प्रतिशत तक डीज़ल के रूप में प्रतिस्थापित किया जा सकता है।

- ट्रैक्टर चालित क्यारी निर्माण उपकरण द्वारा 135 सें.मी. अंतराल पर बनाई गई क्यारियों और कुंडों में अन्य संरक्षण उपायों और नियंत्रण की अपेक्षा ज्वार की अधिक उपज हुई।

- रोटावेटर में डिस्क एवं एल (L) ब्लेड लगाकर सुधार किया गया। विभिन्न फसलों के बायोमॉस लिए इन ब्लेडों के संयुक्त प्रभाव से कटाई क्षमता में 51 से 62 प्रतिशत एवं समावेशन क्षमता में 68 से 78 प्रतिशत की वृद्धि हुई।

- संस्थान द्वारा निर्मित हरबल ड्रायर में फलों, सब्जियों, औषधियों एवं सुगंधित पौध पदार्थों को सुखाने से कई वांछनीय गुण जैसेकि पोषक मूल्य, रंग एवं सुगंध बने रहे एवं पारंपरिक रूप से सुखाने की तुलना में यह अधिक सस्ता भी था।

आर्थिक-सामाजिक अध्ययन

- अनंतपुर जिले में मूंगफली किसानों के पादप सुरक्षा व्यवहार को देखने से पता चला कि नाशीजीवों के प्रबंधन के लिए बहुसंख्यक किसानों ने कर्षण घटक एवं नीम अधारित कीटनाशकों को अपनाया है। अपनाए जाने वाले समोकित नशीजीव घटकों में एन.पी.वी. एवं बी.टी. का कम उपयोग किया गया।

- ज्वार की फसल में बाज़ार सहयोग एवं लाभ में सकारात्मक संबंध पाया गया। किसानों द्वारा बाज़ार सहयोग फार्म क्षेत्रफल एवं किसानों की शिक्षा के स्तर से सकारात्मक रूप से प्रभावित हुआ तथा परिवार के सदस्यों की संख्या के साथ नकारात्मक रूप से प्रभावित हुआ।

- मक्का एवं कपास के मामले में, लाल मृदा क्षेत्र की तुलना में काली मृदा क्षेत्र में प्रौद्योगिकी अपनाने का स्तर अपेक्षाकृत बेहतर था। जबकि मक्का के मामले में, किसानों द्वारा प्रौद्योगिकी अपनाने का स्तर किसानों की विभिन्न श्रेणियों में दृष्टिगोचर रूप से अलग-अलग नहीं था।

प्रौद्योगिकी हस्तांतरण

- किसानों द्वारा बारानी प्रौद्योगिकियों, जैसेकि पंक्ति अनुपातों, अंतरफसलों, उर्वरक सिफारिशों एवं बीटी कपास उगाने इत्यादि को अधिकतम रूप से अपनाया गया।

- रख-रखाव की अधिक लागत, आधारभूत संरचनाओं की बार-बार मरम्मत, प्रशिक्षित कार्मिकों का लगातार स्थानांतरण, कुशल श्रमिकों का अभाव एवं किसानों का बदलाव के प्रति प्रतिरोध, सूचना एवं संचार प्रौद्योगिकी पर आधारित प्रौद्योगिकी हस्तांतरण इत्यादि के प्रति प्रमुख रुकावटें थी।

- ग्रामीण समुदाय को ज्ञान एवं कौशलों को हस्तांतरित करने के उद्देश्य से कृषि विज्ञान केंद्र द्वारा कैंपस में 21 एवं कैंपस के बाहर 57 प्रशिक्षण कार्यक्रमों का आयोजन किया गया। प्रशिक्षणार्थियों में कृषि से जुड़े 1981 पुरुष एवं 959 महिलाएं शामिल थी। अरंड़, शमतिल, अरहर, सोयाबीन, ज्वार, मक्का, कपास एवं धान की बेहतर प्रौद्योगिकियों पर परिषद के विभिन्न संस्थानों के सहयोग से कृषि विज्ञान केंद्र ने 1292 फ्रंटलाइन प्रदर्शन कार्यक्रम आयोजित किए।

- किसानों के खेतों पर परिचालन अनुसंधान परियोजना (ORP) से जुड़े वैज्ञानिकों ने पाया कि 166 प्रौद्योगिकियों को परिचालन अनुसंधान परियोजना के किसानों ने अपनाया एवं अन्य किसानों ने इसे विसरित किया जबकि 47 प्रौद्योगिकियों को परिचालन अनुसंधान परियोजना के किसानों द्वारा अपनाया गया एवं अन्य द्वारा विसरित नहीं किया गया तथा 20 प्रौद्योगिकियों को न तो परिचालन अनुसंधान परियोजना के किसानों द्वारा अपनाया गया और न ही अन्यों द्वारा अपनाया गया।

शिक्षा

- संस्थान के वैज्ञानिकों ने हैदराबाद, तिरूची, रायपुर एवं बैंगलोर में स्थित विश्वविद्यालयों एवं संस्थानों के बीस स्नातकोत्तर विद्यार्थियों का मार्गदर्शन किया। संस्थान के छ. वैज्ञानिक / तकनीकी अधिकारी आचार्य एन.जी.रंगा कृषि विश्वविद्यालय / जवाहरलाल नेहरू प्रौद्योगिकी विश्वविद्यालय, हैदराबाद से उच्च शिक्षा ग्रहण कर रहे हैं। वर्ष के दौरान एक वैज्ञानिक ने पीएच.डी. ग्रहण की।

- पंद्रह वैज्ञानिकों एवं उन्नीस अन्य अधिकारियों ने राष्ट्रीय एवं अंतर्राष्ट्रीय संगठनों द्वारा आयोजित आवश्यकता आधारित प्रशिक्षण कार्यक्रमों में भी भाग लिया।

पुरस्कार एवं मान्यताएं

- भारतीय संस्कृति निर्माण परिषद और रचनात्मक साहित्यिक एवं शैक्षणिक परिषद, हैदराबाद द्वारा राजभाषा के कार्यान्वयन के लिए संस्थान के निदेशक डॉ.वाई.एस. रामकृष्ण को शिक्षा शिरोमणि पुरस्कार, 2006 एवं श्री एस. आर. यादव, सहायक निदेशक (राजभाषा) को राष्ट्र भारती पुरस्कार, 2006 से पुरस्कृत किया गया ।

- डॉ. एम. महेश्वरी, वरिष्ठ वैज्ञानिक (पादप कार्यिकी) को भारतीय कृषि अनुसंधान परिषद द्वारा पंजाबराव देशमुख महिला कृषि वैज्ञानिक पुरस्कार, 2005 से पुरस्कृत किया गया।

- डॉ.एम. वनजा, वरिष्ठ वैज्ञानिक (पादप कार्यिकी) को राष्ट्रमंडल शैक्षणिक अध्येतावृत्ति, 2006 से पुरस्कृत किया गया।

- रोहित स्टील उद्योग द्वारा निर्मित 'क्रीडा-दो पंक्ति रोपक' को जलगांव, महाराष्ट्र में आयोजित मैकेनिकल इंजीनियरिंग प्रदर्शनी में वर्ष 2006 के लिए सर्वश्रेष्ठ अविष्कार पुरस्कार प्राप्त हुआ।

- 'क्रीडा' - बगीचा स्प्रेयर को ट्रेड ट्रैन्ड्स पत्रिका द्वारा वर्ष 2006 के लिए प्रमुख नवोन्मेष पुरस्कार हेतु चुना गया।

- संस्थान को नगर राजभाषा कार्यान्वयन समिति (नराकास) द्वारा हैदराबाद - सिकंदराबाद स्थित केंद्र सरकार के कार्यालयों में संघ की राजभाषा (हिंदी) नीति के कार्यान्वयन में सर्वश्रेष्ठ निष्पादन के उपलक्ष्य में प्रमाणपत्र सहित शील्ड प्रदान की गई।

- हैदराबाद रोज़ सोसाइटी द्वारा आयोजित वार्षिक गुलाब प्रदर्शनी, 2006 के विभिन्न वर्गों में संस्थान को दो प्रथम पुरस्कार, एक द्वितीय पुरस्कार एवं एक तृतीय पुरस्कार प्रदान किया गया।

- डॉ. मोहम्मद उस्मान को अग्रिम जल कार्रवाई एवं ग्रामीण प्रौद्योगिकी परिषद, ग्रामीण विकास मंत्रालय, भारत सरकार, नई दिल्ली द्वारा फेसिलिटेटर एवं मूल्य-निर्धारक के रूप में चुना गया।

- डॉ. बी. वेंकटेश्वर्लू उस्मानिया विश्वविद्यालय के सूक्ष्मजीव विज्ञान अध्ययन बोर्ड के सदस्य के रूप में चुने गए तथा श्री रामनाथ तीर्थ ग्रामीण विकास संस्थान के तकनीकी समिति के सदस्य के रूप में नामित किए गए।

प्रकाशन

- वर्ष के दौरान संस्थान के वैज्ञानिकों द्वारा, राष्ट्रीय एवं अंतर्राष्ट्रीय पत्रिकाओं में चौवालिस अनुसंधान लेख, तीन पुस्तकें / रिपोर्ट, बीस पुस्तक अध्याय एवं, उन्तीस तकनीकी बुलेटिन प्रकाशित हुए।

संगोष्टी, कार्यशालाएं, सम्मेलन एवं विचार-गोष्टियां

- वर्ष के दौरान संस्थान के वैज्ञानिकों ने सत्तर राष्ट्रीय विचार-गोष्टियों, संगोष्टियों एवं सम्मेलनों में भाग लेकर अनुसंधान लेखों का योगदान दिया जिनमें कई अग्र लेख थे।

संपर्क

- संस्थान राष्ट्रीय एवं अंतर्राष्ट्रीय संगठनों, जैसे इक्रीसेट, आई.पी.ई., आई.एम.ई., ए.एम.आई.ई., एम.एस.एस.आर.एफ. एवं कई सरकारी विभागों, राज्य कृषि विश्वविद्यालयों, भारतीय कृषि अनुसंधान परिषद के संस्थानों एवं गैर सरकारी संगठनों से अपना निकट संबंध जारी रखे हुए है।

Executive Summary

Resource Characterization

- Using historical weather, crop and pest data, crop weather calendars were prepared for major crops for Ludhiana region. These crop calendars could be effectively used for issuing agro-advisory services to the farmers.
- Trends in rainfall were examined in different parts of the country with a view to assess the vulnerability to climate change. Results of the studies indicated significant negative trends for annual rainfall in the eastern parts of Madhya Pradesh, Chhattisgarh and parts of Bihar, Uttar Pradesh, N-W and N-E India .
- The probability of occurrence of drought in rainfed tracts of India is 30-40% and the probability comes down in eastern and northeastern parts of India and is increasing towards northwest side of the country.
- Significant variation was observed in water requirements for groundnut at pod development stage and pigeonpea (total) at different locations based on potential evapo-transpiration and crop coefficient values.

Integrated Nutrient Management

- Results of a long-term experiment on tillage and INM revealed that sorghum grain yield was higher with conventional tillage compared to minimum tillage, while grain yield of green gram was not influenced by tillage. Among INM treatments, 40 kg N through urea gave the highest yield of sorghum, whereas 2t compost + 10 kg N through urea gave the highest yield of green gram. Available N, DTPA extractable Zn and Cu, microbial biomass C, mean weight diameter of soil aggregates, and soil hydraulic conductivity were the key indicators of soil quality in this experiment. Under both tillage systems, 4t compost + 2 t gliricidia loppings gave the highest relative soil quality index (RSQI) values. Tillage did not influence RSQI significantly.
- Soil quality assessment of a long-term experiment at Arjia showed RSQI values in the following order: 100% organic > 50% organic + 50% inorganic > 100% inorganic sources of nutrients.
- A field trial on organic production of sesamum showed relatively higher seed yield of sesamum with inorganic system compared to organic system. The incidence of pests and diseases was also lower with inorganic system.
- A high input chemical package gave the highest grain yield of sorghum, whereas, the highest yield of pigeon pea was obtained with a high input organic package. Pigeon pea grain damage was least with the high input chemical package.
- The indigenous practice of preparation and application of groundnut shell manure (GSM) prevalent in Anantapur district was studied and was introduced in Mahabubnagar district. Field experiments showed that application of GSM in addition to the farmers' practice gave 10-12% and 20-25% higher yield of groundnut in *kharif* and *rabi,* respectively.
- Soil samples were collected from 15 locations in the country from the rhizosphere and non-rhizosphere zones of major dryland crops and strains of *Pseudomonas* (45), *Bacillus* (75), *Azospirillum* (6), *Rhizobium* (7) and AM fungi (14) were isolated and evaluated. *Bacillus* strains tolerant to salinity, drought and high temperature, *Pseudomonas* strains tolerant to high temperature, salinity, drought and low nutrient status were identified. One strain of *Bacillus* exhibited considerable plant growth promoting activity. *Bacillus* and *Pseudomonas* strains with biocontrol ability against several fungal pathogens were identified.
- A simplified method for estimation of labile soil C using neutral dilute $KMnO_4$ was developed for use in field kits.

Rainwater Management

- Surface and groundwater balance study carried out for Kurmapally watershed in AP showed higher utilization of groundwater than the potential.
- Evaluation of sustainable land management practices in watersheds showed that farmers in treated microwatershed were able to achieve higher and sustainable crop yields compared to their untreated microwatershed counterparts.

Crops and Cropping Systems

- The leaf segments from transgenics of sorghum developed at the institute by using mtlD gene for enhancing abiotic stress tolerance were found to have higher leaf water content and chlorophyll retention when exposed to polyethylene glycol 8000 (-2.0 MPa) and NaCl (600mM), as compared to the untransformed controls. Even the germination potential of the transgenic seeds was several fold higher when challenged with PEG (-0.7 MPa) or NaCl (200mM) stresses. The transgenics also showed remarkably robust root system in terms of root biomass and length.
- In an attempt to develop transgenic black gram, an efficient and rapid regeneration protocol was developed using cotyledons as explants. The callusing frequency ranged from 60 to 90% in response to various plant growth regulators.
- Different *Pseudomonas* spp and *Bacillus* spp. have been isolated from rhizospere of different rainfed crops with focus on abiotic stress tolerance. Some of the *Bacillus* and *Pseudomonas* strains isolated from dry regions were observed to help in survival of pearl millet plants up to two weeks at 50° C.
- In castor, improvement in spike length, spike weight, capsule number, capsule weight and seed size were observed under CO_2 enrichment. The increased capsule number and seeds per capsule contributed to increased seed yield at 550 ppm, whereas, this was due to capsule number and seed size at 700 ppm. Increased CO_2 levels improved both biomass and economic yield.
- The impact of elevated CO_2 and temperature on larval parameters of castor semilooper and various insect performance indices indicated that CO_2 concentration significantly influenced the relative growth rate, efficiency of conversion of digested food and approximate digestibility indices.
- Functional relatioship for temperature and relative humidity between ambient and canopy level conditions of groundnut crop were worked out which could be used for weather based forewarning systems.
- Under *Vertisols*, maize+ pigeonpea-cotton +50 sheep was identified best farming system module for small and marginal farmers. Correspondingly for *Alfisols,* maize+ pigeonpea-cotton+ one buffalo+ 50 sheep (for small farmers) and sorghum+ pigeonpea-cotton+ one buffalo+ 50 sheep (for marginal farmers) were the best modules.
- Four improved strains of horse gram evolved by the institute through mutagenesis were promoted to advanced varietal trials of ICAR network project of arid legumes based on their superior performance.
- In an attempt to isolate effective strains of Bt, soil samples from eight dryland locations were screened for the presence of spore forming *Bacilli*. The recovery of crystalliferous isolates of *Bacillus thuringiensis* was the highest with Udaipur strains.
- To assess the feasibility of using remote sensing data in quantification of pests and disease incidence, higher absorption was observed in the near infrared region between 760-1240 nm for healthy plants compared to the diseased plants of groundnut. In the severely affected termite plots, the typical chlorophyll absorption bands in the visible region between 500-710 nm were found missing.
- Integrated Bioresource Centre took up mass production of bio-fertilisers, bio-pesticides and planting material of multipurpose trees for supply to the farmers. *Trichoderma*, Phosphate Solubilizing Bacteria (PSB), *Rhizobium* and Viral biopesticides were produced and distributed to chickpea farmers in a participatory mode for on-field evaluation in KVK villages.

Alternate Land Use Systems

- Grain yields of setaria intercropped between rows of aonla, tamarind and *Acacia senegal* did not differ with the tree species, but were lower compared to sole crop yields. Similarly, grain yield of horse gram was higher in sole crop compared to intercrop between tree rows. Among tree basin treatments, a combination of vermicompost and inorganic fertilizers gave the highest fruit yield of aonla.
- Allometric relationships were worked out to predict the biomass of leucaena and eucalyptus trees using easily measured characteristics such as tree height and diameter at breast height, for estimating carbon sequestration in agroforestry systems.
- The best nutrient management modules for obtaining high yield and quality of aswagandha, bixa, indigo and henna were worked out.
- Eighteen accessions of Jatropha, and 17 accessions of Pongamia germplasm were collected and evaluated, and promising lines were identified. Pruning of Jatropha at 45 cm height resulted in enhanced seed yield compared to no pruning and pruning at 30 and 60 cm. Intercropping with field crops was not possible in Jatropha from the third year, whereas, in Pongamia, intercrops could be taken up successfully.
- Evaluation of intensive, semi-intensive and extensive sheep management systems showed that under farmers' conditions, only extensive management system is viable.

Farm Machinery and Power

- The multi purpose self propelled machine fabricated last year was modified by providing double lever clutch and change of wheel design which resulted into improved machine maneuverability.
- Modified expeller gave higher oil recovery from Jatropha and Pongamia seeds. Seed pretreatment enhanced oil recovery from 26 to 30% in Jatropha and 24 to 28% in Pongamia, and also improved the oil quality. Performance evaluation showed that the biodiesel obtained using CRIDA process, which has lower viscosity, can be substituted for diesel up to 40%.
- Bed and furrow at 135 cm spacing, formed using tractor drawn bed forming equipment gave higher yield of sorghum over other conservation measures and control.
- Rotavator was further modified with combination of discs and 'L' blades. The combined effect of these blades increased the chopping efficiency from 51 to 62% and incorporation efficiency from 68 to 78% for different biomass species.
- Drying of fruits, vegetables and medicinal and aromatic plant produce in a institute designed herbal dryer retained the desirable characteristics such as nutritive value, colour and aroma, and was more economical than conventional drying.

Socio-economic Studies

- A look into the plant protection behaviour of groundnut farmers in Anantapur district showed that a majority of farmers followed cultural components and neem-based preparations for managing pests. Use of NPV and Bt are among the less adopted IPM components.
- Market participation and profitability of sorghum were found to be positively related. Market participation was found to be positively influenced by farm size and education of the farmer and negatively by the family size.
- Technology adoption levels were relatively higher in black soil region compared to red soil region in case of maize and cotton. However, the adoption levels did not differ significantly across categories of farmers in case of maize.

Transfer of Technology

- Dryland technologies like row ratios, intercrops, fertilizer recommendations and growing of Bt cotton had maximum adoption by farmers.
- High cost of maintenance, frequent repairs of infrastructure, frequent change of trained personnel, scarcity of skilled labour force and farmers'

resistance to change were some of the hindrances to the use of ICT-based transfer of technology.

- The KVK conducted 21 on-campus and 57 off-campus training programmes with a view to transfer knowledge and skills to the rural community. The trainees included 1981 farm men and 959 farm women. The KVK with support from various ICAR institutes conducted 1292 frontline demonstrations on improved technologies of castor, niger, pigeon pea, soybean, sorghum, maize, cotton and paddy.
- The ORP scientists identified 166 technologies that were adopted by ORP farmers and diffused to other farmers, 47 technologies that were adopted by ORP farmers and not diffused to others and 20 technologies that were neither adopted by ORP farmers nor by others.

Education

- Twenty post graduate students from various universities and institutions in Hyderabad, Tiruchi, Raipur and Bangalore are being guided by the CRIDA scientists. Six scientists/ technical officers of the institute are pursuing higher studies at ANGRAU/JNTU, Hyderabad. One scientist attained Ph.D. during the year.
- Fifteen scientists and 19 other officers underwent need-based training programmes conducted by national and international organizations.

Awards & Recognitions

- Dr. Y.S. Ramakrishna, Director, CRIDA was awarded *Shiksha Shiromani Award 2006* and Shri S.R. Yadav, Asstt. Director (OL), was awarded with *Rashtra Bharati Award 2006* by Bharatiya Sanskriti Nirman Parishad and Rachnatmak Sahityik avam Saikshanik Parishad, Hyderabad for implementing the Official Language.
- Dr. M. Maheswari, Senior Scientist (Plant Physiology) was awarded the Punjabrao Deshmukh Women Agril. Scientist Award 2005 by ICAR.
- Dr. M. Vanaja, Senior Scientist (Plant Physiology) was awarded Commonwealth Academic Staff Fellowship 2006.
- CRIDA's Two Row Planter manufactured by Rohit Steel Industries received best invention award for the year 2006 at a Mechanical Engineering exhibition held at Jalgaon, Maharashtra.
- CRIDA Orchard Sprayer was selected for Prominent Innovation Award by the TRADE TRENDS magazine for the year 2006
- Award for best performance in implementation of the official Language (Hindi) policy of the union among the Central Government Offices in twin cities from Town Official Language Implementation Committee
- CRIDA was awarded with two First prizes, one Second prize and one Third prize in different categories of Annual Rose Show, 2006 organized by Hyderabad Rose Society
- Dr. M. Osman was empanelled as Facilitator Cum Evaluator with Council for Advancement of People's Action and Rural Technology (CAPART), Ministry of Rural Development, Government of India, New Delhi
- Dr. B. Venkateswarlu was nominated to the Board of Studies of Microbiology, Osmania University and also as technical committee member of Sri Ramanandha Tirtha Institute of Rural Development.

Publications

- Forty-four research papers in international and national journals, three books/reports, twenty book chapters and twenty-nine technical bulletins were published during the year.

Symposia, Workshops, Conferences and Seminars

- During the year, CRIDA scientists attended seventy National Seminars, Symposia and Conferences and contributed research papers, many of them as lead papers.

Linkages

- The institute continued its close collaboration with national and international organizations like ICRISAT, IPE, IME, AMIE, MSSRF and several government departments, SAUs, ICAR institutes and NGOs.

1 Introduction

Rainfed agriculture occupies a prominent place in Indian economy and rural livelihoods. It is spread over 64% of net cultivated area, contributing over 40% to the national agricultural production. Rainfed areas support 40% of India's population and play a vital role in food security. Over 87% of coarse cereals and pulses, 55% of upland rice, 77% of oilseeds and 65% of cotton are cultivated under rainfed farming. Resource poor farmers, the backbone of rainfed agriculture, were largely bypassed by green revolution whose benefits were mostly reaped by the already resourceful farmers holding irrigated lands.

1.1 Rainfed Farming - Historical

Rainfed agriculture constitutes a major part of Indian agriculture that it necessitates a comprehensive approach and multi-disciplinary research for improving food and nutritional security in the country. Food and Agriculture Organization (FAO) of the United Nations indicated the tremendous potential of rainfed agriculture which could feed the entire world by use of improved technology. The concern on the issues of rainfed areas has been expressed from time to time since the first Famine Commission and Royal Commission on Agriculture. However, it was not until 1923 that the first systematic and scientific approach to the problem of dry farming research was initiated. These earliest attempts tried to improve the system and tackle the problems of rainfed areas (scarcity tracts) of erstwhile Bombay State. During 1933-35, the then Imperial (now Indian Council of Agricultural Research (ICAR) initiated a broad-based dry farming research project at Solapur, Bijapur, Hagari, Raichur and Rohtak to formulate appropriate strategies. After independence, renewed efforts were made to improve stability and productivity of rainfed agriculture since the 1950s more through efforts on developing appropriate Soil and Water Conservation practices.

1.2 CRIDA's Genesis

Recognizing the importance of rainfed agriculture, the ICAR gave a new impetus by launching the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) in 1970, based at Hyderabad with 23 cooperating centres spread across the country.

Pooling of expertise and leveraging the strengths of AICRPDA network eventually resulted in the establishment of Central Research Institute for Dryland Agriculture (CRIDA) at Hyderabad, on April 12, 1985 to provide the leadership in basic and strategic research in dryland agriculture leaving the location-specific problems and their solutions to AICRPDA centres. To give fillip and further strengthen the activities in this field, the All India Coordinated Research Project on Agrometeorology (AICRPAM) was launched in 1983, also at Hyderabad, with 10 cooperating centres under different SAUs. The strength of AICRPDA and AICRPAM is presently placed at 25 centres each.

1.3 Mandate

CRIDA conducts problem oriented interdisciplinary research with the following mandate:

- To conduct basic and applied research for improving the productivity of natural resources in drylands
- To develop techniques and systems for long-term conservation and efficient utilisation of dryland environmental resources
- To understand crop growth process and yield management more specifically under moisture-stress
- To carry out economic evaluation of technologies, to study the constraints, and to develop suitable resource
- To evolve appropriate extension, training and communication methodologies for accelerating transfer of technology

Following the recommendations of the Second Quinquennial Review Team in 1991 and the felt needs of the VIII Five Year Plan and beyond, the mandate of the Institute was redefined as follows which as on date is applicable.

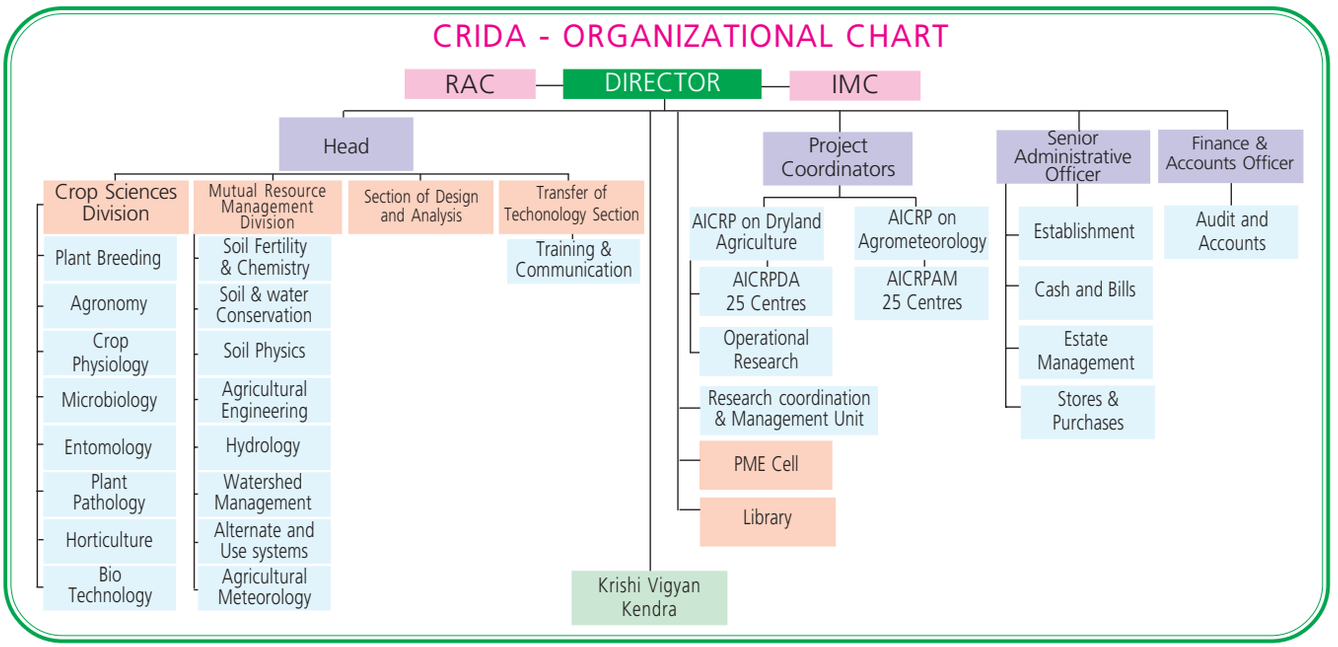
- Undertake basic and applied researches that will contribute to the development of strategies for sustainable farming systems in the rainfed areas,
- Act as a repository of information on rainfed agriculture in the country,
- Provide leadership and co-ordinate network research with state agricultural universities for generating location-specific technologies for rainfed areas,
- Act as a centre for training in research methodologies in the fields basic to management of rainfed-farming systems,
- Collaborate with relevant national and international agencies in achieving the above objectives, and
- Provide consultancy.

The following programmes have been identified to address the mandate:

Programme No.	Programme title	Main components of sub-programmes
I	Resource characterisation	Rainfall and soil characteristics, length of growing season, land capability-based potential and constraints, climatic analysis, crop weather modelling, and geographic information system
II	Rainwater management	*In situ* moisture conservation, water harvesting and recycling, groundwater recharge studies, sustained management of surface and groundwater resources and efficient water-use strategies.
III	Crops and cropping systems	Efficient crops and cropping systems, crop diversification for sustained water use and productivity, germplasm enhancement/ evaluation and stress physiology
IV	Soil and nutrient management	Soil physical condition management - tillage, crusting, drainage, soil fertility care, integrated and micro-nutrient management and supply systems (chemical fertilizers and natural nutrient sources including micro-organisms), sustenance of soil quality and sustainable agriculture
V	Alternate land use systems	Efficient utilisation of different categories of lands through capability-based resource planning and generation of food, fodder and fuel. Promotion of tree borne oilseeds for non-arable lands.
VI	Energy management	Development of low-cost seeding, Post-harvest processing & value addition devices
VII	Socio-economic aspects	Socio-economic and policy research studies, impact of research, constraints and feedback, transfer of technology
VIII	Training	Training of primary and secondary stakeholders and use of modern tools like ICT.

1.4 Organizational Setup

The organizational setup of CRIDA is given below:



1.5 Past Achievements

Some of the accomplishments of the institute are as follows.

- Resource characterization and inventorisation of natural, bio-physical and socio-economic resources at micro-level
- Strategies for rainwater harvesting and recycling through cost-effective water conservation practices
- Technical backstopping for watershed development activities of government and non-government organizations, and meeting their HRD requirement
- Strengthened natural resource management by designing strategies for sustainable and judicious use of resources to generate optimum output
- Strategies for agricultural drought management in dryland areas, contingency planning and mid-season corrections
- Sustainability through development of sequence cropping systems, adoption of crop diversification systems/models, management practices, and crop rotations specific to Dryland areas
- Alternate land use system models for provision of better land cover, sustainable livelihood options including generation of employment opportunities and income flow to the farming community
- Cost-effective, labour and energy saving technologies by designing need-based implements for timely sowing, intercultural operations and harvesting. Also evolved low cost and highly durable fruit and vegetable preservator and herbal drier
- 'Impact studies' of improved and new dryland farming technologies on socio-economic conditions of rural people in the country to bridge the gap between technology development and technology transfer
- Weather-based forewarning of crops' pests and diseases and value added agromet advisory service through added advisory service through specific website (www.cropweatheroutlook.org)
- Co-learning strategies for farmers and scientists through action learning application at farm and watershed scale

1.6 Infrastructure

CRIDA has a 9000 sq m spacious building located at Santoshnagar in the eastern corner of Hyderabad city, which is the hub of national and international activities in agricultural research. The Institute has excellent laboratories, guesthouse, trainees hostels, seminar halls, museum, auditorium and two well laid out research farms (280+80 ha). Over the years, the Institute has built most modern facilities for conducting research and training. A synoptic over-view of the facilities is provided below:

Laboratories - CRIDA has well-equipped laboratories to support research in different disciplines of crop sciences and natural resources management.

Soil physics: The laboratory, besides basic facilities, has excellent instruments to measure physical properties of soil and special equipments such as particle size analyzer, modulus of rupture apparatus, time domain reflectometer, rainfall simulator, hysteresis apparatus, pressure plates and temperature data pads. The laboratory supports research and training in soil and water management, land degradation and resource mapping.

Soil chemistry : The laboratory is equipped with important instruments for estimating essential nutrients required for plant growth. It supports research activities on integrated nutrient management, soil quality assessment, organic matter dynamics, carbon sequestration etc.

Plant physiology : The laboratory has facilities to conduct research in stress physiology, plant nutrition, crop modelling and climate change. It is equipped with leaf area and transpiration measurement systems, osmometer, cold centrifuges, plant canopy analyzer and sap flow systems and portable photosynthesis analyser. The laboratory is equipped with six open top field chambers for quantifying the effect of increased carbon dioxide on the productivity of rainfed crops.

Agronomy : The laboratory is equipped with all basic instruments for soil and plant analyses, moisture probes and root length measurement systems. It supports research activities in soil and water management and crop husbandry.

Microbiology : The laboratory is equipped with facilities to conduct research on agriculturally important micro-organisms including molecular characterization. Important equipments include phase contrast and stereo microscopes, gas chromatogram, vacuum concentrators, PCR and electrophoresis systems.

Plant molecular biology and tissue culture laboratory : The laboratory is well equipped with up-to-date facilities for carrying out research activities pertaining to molecular biology of abiotic tolerance in rainfed crops. The researchers employ PCR machines, Gel documentation system, Gene gun, Southern, Western and Northern blotting for achieving their objectives. The plant tissue culture laboratory undertakes research on tree micropropagation.

Entomology : The Entomology laboratory is equipped with modern instrumentation facilities and equipments in the fields of insect rearing, bio-pesticide evaluation, testing of pesticides, studies on pest development and assessing the effect of climate change on insect's life cycles.

Plant pathology : The laboratory is equipped with state-of-the-art facilities to pursue research in disease epidemiology in relation to weather, development of cost effective and eco-friendly disease management options, integrated disease management and plant growth promoting microbes.

Central laboratory complex : Besides the discipline-wise research facilities highlighted above, the Institute has also established a Central Laboratory facility, which has state-of-the-art instruments. These include Inductivity Coupled Plasma (ICP) analyzer, atomic absorption spectrophotometer, auto analyser and CNS analyzer. This laboratory not only supports research at CRIDA but also assists the entire research network on rainfed agriculture in the country.

Agrometeorology and databank : The Institute is the Coordinating Centre for research and training in agrometeorology since the VII Five Year Plan, and has built up excellent equipment support. The centre has automatic weather stations, line quantum sensors, Bowen's ratio apparatus, spectro radiometers and the relevant computer packages for processing historical weather data for agrometeorological planning. State-of-the-art facilities for quality checking, storing of the meteorological data of all the AICRPAM centres and other weather stations of the country are also available. It also maintains a website 'cropweatheroutlook.ernet' providing agrometeorological information, current weather status and Contingency Crop Plans to aid the rainfed farmers across the country.

Hydrology : CRIDA has established excellent infrastructure with GIS and GPS facilities for conducting hydrology experiments. Computer controlled rainfall simulator and large tilting flume have been installed which are useful in conducting micro plot experiments under controlled conditions.

Agroforestry : The Agroforestry research is in progress at this Institute for more than two decades. There is a strong Agroforestry laboratory with several facilities like soil, plant and chemical analysis, aromatic oil estimation, secondary metabolite estimation in medicinal, aromatic and dye yielding plants.

Horticulture : A new laboratory has been established during X Five Year plan for analysis for soil, plant, fruit, leaf and other horticultural products for evaluation of components pertaining to horticultural aspects. There is also a cool chamber for storage of fruits and vegetables and their value added products to avoid spoilage.

Animal science laboratory : A new wing has been added in Animal Science in the X-plan covering both Animal Husbandry and Animal Nutrition for estimation of proximate principles, fibre fractions, in-vitro digestibility of feed and fodders, de-worming & vaccination of livestock, metabolic studies with small ruminants, clinical biochemistry parameters like serum, proteins, cholesterol, calcium, magnesium, albumin etc.

GIS and computer facilities : The GIS laboratory supports in–house mapping and analysis of watershed programme, land use, cover change analysis besides mapping of soil erosion, drought incidence, and land degradation. The laboratory is also equipped with advanced softwares like ArcGIS Package (Ver.9.0.) with two add-on modules – ArcEngine and ArcPad, digital satellite data interpretation software - *ERDAS Imagine* (Ver.9.0.) with virtual and vector GIS add-on modules for analysis and a trimble DGPS for collection of accurate geographical locations.

Transgenic glasshouse and green house : A transgenic glasshouse conferring to the containment standards for evaluating transgenic crops is available in the Institute. Apart from this, the Institute has a net house and climate controlled glasshouse for conducting pot culture experiments.

ARISNET: The network is being used effectively for e-mail, internet and file transfer protocol. The network currently has a Cat-6 cabling system with Firewall. The internet connectivity is through ERNET. The ARIS Cell trained all the administrative staff on efficient utilization of computer system and MS Office. Http://search.apnet.com provides world wide web access to on-line publications of full length articles/papers or data bases to Academic Search Premier. The database is completely researchable.

Museum – The Institute maintains a Dryland Gallery where the history of dryland research and research achievements are highlighted through charts, photographs and models.

Conference and training facilities - The Institute has three air-conditioned conference halls with a seating capacity of 30, 100 and 20, besides a large auditorium for accommodating 250 persons.

Library : The Institute has a central library, which has a collection of over 7532 books and 4156 back volumes as on March 2006. It subscribes to about 121 Indian and 22 international journals, and is equipped with AGRICOLO, AGRIS, CROP-CD and SOIL-CD. It is connected with ICRISAT e-library besides being able to extend online access to a host of foreign journals through subscription to full databases. The library is also powered with SOUL software from INFLIBNET for in-house library management.

Research farms : The Institute has two well laid-out research farms at Hayathnagar (HRF)(280 ha) and Gunegal (GRF) (80 ha) about 15 and 45 km from the main campus, respectively. Both these farms sufficiently represent the predominant soils of the rainfed regions of the country. The mean annual rainfall received at Hayathnagar farm is 750 mm and that at Gunegal is 690 mm. The research farms have well equipped infrastructure and facilities for supporting field experiments and demonstrations include weather stations, mist chambers, maintenance workshop, tractors and farm equipments and a fabrication facility for farm tools and implements.

A bio-resource centre and a field and farmer's service laboratory are shortly coming up at HRF to provide the needed support to the rainfed farmers.

1.7 Financial outlay for 2006-07

(rupees in lakhs)

	CRIDA		AICRPDA		AICRPAM		Climate change	
	Sanctioned	Utilized	Sanctioned	Utilized	Sanctioned	Utilized	Sanctioned	Utilized
Non-Plan	814.00	813.31	16.50	15.44	7.00	6.74	233.76	227.80
Plan	171.00	171.00	944.57	944.54	303.00	303.00	-	-
Total	985.00	984.29	961.07	959.94	310.00	309.74	233.76	227.80

1.8 Staff position

As on 31 March, 2007

Staff	Positions	
	Sanctioned	Filled
Scientific	68	59
Technical	80	77
Administrative	47	47
Supporting	60	55
TOTAL	255	238

2 Research Achievements

2.1 Resource characterization

2.1.1 Climate

2.1.1.1 Weather conditions at HRF

The Southwest monsoon set in on June 10, 2006 over Hyderabad. The rainfall received at HRF was 685 mm (92%) as against the normal of 742 mm.

Sowing of most of the crops commenced during 24 SMW. A few crops were, however, sown during 30-31 SMW, as there was an intermittent dry spell between 26-29 SMW. Soil moisture stress in the early establishment stage of the crop had resulted in stunted growth of crops like sorghum. However, a rainfall of 104 mm received during later part of July helped the crops sown in rejuvenation during 24 SMW. The rainfall of 181 mm received during August was by and large well distributed and the crop growth was satisfactory. A two - weeks dry spell experienced in the first fortnight of September subjected the crops to moisture stress. The rainfall of 118 mm received subsequently during second fortnight of September was beneficial to all the crops. Dry spell during September 28 to October 27 coincided with grand growth and flowering of pigeonpea. This resulted in below optimum performance of the pigeonpea crop. Short duration pulses, by and large, performed satisfactorily in spite of intermittent dry spells. A total of 26 and 16 mm rainfall received during October and November which were 74 and 56 % deficient, respectively. Moreover, this rainfall was confined to end of October to beginning of November only. This has resulted in moderate to severe soil moisture stress to long duration crops like pigeonpea at the time of maturity. Castor was also affected at the last picking stage due to high relative humidity conditions that must have provided conducive environment for the development of botrytis disease. The temperatures during the crop growing season were near normal and slightly higher in dry spell periods between 26-29 SMW and again during 36 and 37 weeks.

The southwest monsoon withdrew about 10 days in advance. The weekly weather data are given in Table 1. The actual and normal rainfall and number of rainy days during 2006 are presented in Table 2, Fig.1 and Fig.2.

Table 1. Weekly meteorological parameters recorded at HRF during 2006

Standard meteorological Week (SMW)	Rainfall (mm)	Soil Temperature (°C) at 10cm		Air Temperature (°C)		Relative Humidity (%)		Sun-Shine (h)	Wind Speed (kmh^{-1})	Pan evaporation (mm)
		0716h	1416 h	Max.	Min.	0716 h	1416 h			
1	0.0	19.5	28.8	26.5	11.0	91	39	9.4	3.2	3.5
2	0.0	21.7	30.8	28.8	15.9	91	41	9.1	3.1	3.4
3	0.0	21.9	32.2	31.4	14.1	86	26	9.5	3.5	4.6
4	0.0	20.7	30.8	29.1	11.3	62	19	10.1	4.0	5.8
5	0.0	20.7	31.2	29.1	12.5	86	28	9.9	4.0	4.9
6	0.0	21.7	32.0	30.2	12.8	67	20	9.9	4.8	5.7
7	0.0	23.0	34.1	32.7	15.3	69	21	10.0	3.3	6.3
8	0.0	25.0	36.2	34.9	16.7	61	21	10.2	4.5	7.0
9	16.8	26.0	34.8	34.3	18.1	75	33	9.5	6.7	7.0
10	12.0	24.5	33.4	31.3	19.3	91	46	7.6	6.4	4.1
11	0.0	24.5	36.0	32.1	19.2	86	36	8.8	4.5	6.2
12	0.0	27.1	38.2	34.7	19.9	69	38	9.8	4.9	7.7
13	0.0	29.4	38.7	36.5	21.0	68	24	9.1	4.6	8.0
14	0.0	30.9	40.5	38.4	22.7	67	29	8.8	4.3	8.5
15	0.0	31.9	42.3	38.0	22.7	76	36	8.3	5.5	7.8
16	42.7	27.6	38.1	34.5	21.3	81	39	8.0	5.4	6.6
17	0.0	31.0	42.0	38.4	23.7	53	25	9.3	4.4	8.8

Standard meteorol-ogical Week (SMW)	Rainfall (mm)	Soil Temperature (°C) at 10cm		Air Temperature (°C)		Relative Humidity (%)		Sun-Shine (h)	Wind Speed (kmh^{-1})	Pan evapo-ration (mm)
		0716h	1416 h	Max.	Min.	0716 h	1416 h			
18	0.0	32.8	41.8	38.3	24.2	61	31	9.2	6.8	9.7
19	6.8	31.7	43.2	39.5	23.4	66	24	9.7	5.1	9.1
20	23.0	33.3	42.1	39.4	25.2	74	32	9.3	6.3	11.0
21	54.8	29.7	38.1	35.6	24.3	73	44	7.8	8.0	8.4
22	7.4	28.4	37.0	33.3	23.5	81	48	5.7	8.7	5.8
23	37.4	29.1	37.5	34.5	23.5	79	51	6.7	9.7	8.3
24	6.3	29.1	36.9	34.1	24.3	78	46	4.3	6.7	5.8
25	23.3	28.0	34.1	33.2	23.0	82	59	3.5	4.4	6.7
26	2.4	27.5	33.8	31.3	23.2	82	56	3.0	9.6	5.0
27	5.5	27.1	33.1	32.4	23.0	73	51	3.2	12.1	6.5
28	0.0	29.0	35.2	33.0	23.3	81	53	4.1	10.9	7.8
29	0.0	29.0	35.0	33.8	23.2	83	56	4.8	11.0	8.7
30	104.4	25.1	30.5	30.1	21.7	92	73	1.8	9.7	5.2
31	102.1	24.5	28.4	27.6	19.9	86	76	1.6	12.8	4.2
32	13.0	24.9	29.5	28.6	21.2	79	65	2.8	12.7	3.9
33	17.0	27.5	32.8	30.4	22.0	83	60	4.2	10.5	5.6
34	9.0	28.5	36.1	31.2	22.6	81	56	5.7	5.0	5.5
35	40.6	27.8	33.8	30.0	21.6	82	54	3.8	5.5	4.4
36	2.7	29.4	37.4	32.5	22.0	86	52	6.9	3.9	5.1
37	14.8	30.9	38.4	32.4	21.6	89	58	6.7	3.8	4.8
38	49.1	24.0	28.0	27.2	20.3	90	73	1.4	7.7	3.6
39	51.8	24.4	32.3	30.5	2 1.4	87	59	5.7	4.5	4.8
40	0.0	25.7	33.5	29.2	20.8	86	64	4.1	4.4	4.0
41	0.0	27.2	37.5	32.6	19.0	82	43	8.7	2.1	5.8
42	0.0	27.5	36.5	31.8	18.9	43	43	8.6	3.1	4.8
43	3.6	26.7	34.4	30.8	17.8	50	50	7.8	3.7	4.4
44	36.6	23.7	27.6	25.5	19.7	81	81	1.8	4.9	3.2
45	2.0	23.3	30.7	27.7	18.0	94	62	4.2	2.4	2.4
46	0.0	22.9	31.7	28.6	15.3	92	51	8.8	3.0	3.3
47	0.0	24.7	31.5	28.8	16.1	88	47	6.5	2.7	3.3
48	0.0	24.3	32.5	30.4	16.7	91	43	7.7	3.6	4.2
49	0.0	22.1	30.9	29.4	14.5	78	42	8.5	3.4	4.5
50	0.0	21.8	30.6	29.1	13.5	83	39	9.0	3.5	4.2
51	0.0	20.0	28.0	27.7	I1.2	88	44	8.3	3.7	3.8
52	0.0	20.9	29.0	28.0	12.8	92	40	8.3	3.1	3.9

Rainfall is weekly total; other parameters are weekly mean values

Table 2. Rainfall (mm) pattern during 2006 in comparison with normal

Event/month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann. RF
RF in 2006	0.0	0.0	28.8	42.7	92.0	69.4	111.3	180.5	118.4	26.2	16.0	0.0	685.1
Normal RF	6.0	7.1	13.2	19.3	33.0	98.5	136.3	146.8	133.5	112.2	30.4	5.7	742.0
% Deviation	-100.0	-100.0	117.8	120.9	179.1	-29.5	-18.5	23.0	-11.3	-76.6	-47.4	-100.0	-7.7
RD in 2006	0	0	4	1	5	7	5	8	10	4	2	0	46
Normal RD	0.5	0.5	0.7	1.7	2.5	6.5	9.3	8.9	7.5	5.9	1.9	0.3	46

RF – Rainfall, RD – Rainy days

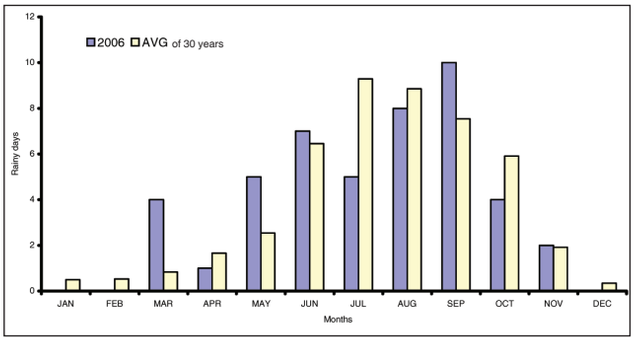


Fig.1 Actual (2006) and average number of rainy days at HRF

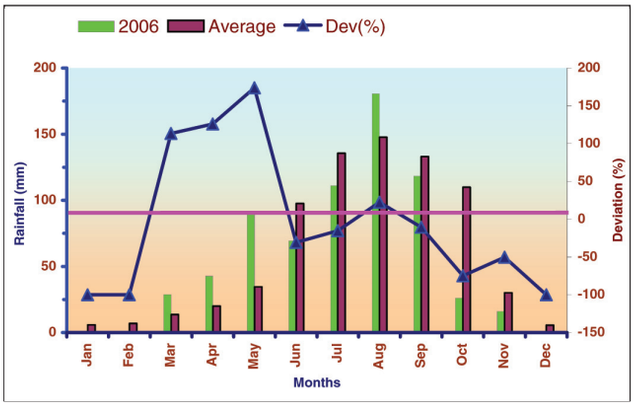


Fig.2 Deviation of rainfall during 2006 at HRF

2.1.2 Impact, Adaptation and Vulnerability of Indian Agriculture to Climate Change:

With an objective to identify the climate change situation in India and to identify the vulnerable areas to the climate change of the country the long-term rainfall averages were computed using seasonal and annual rainfall.

2.1.2.1. Identification of Vulnerable Areas

A simple method to identify the vulnerable areas of the country to climate change was developed. For each of the 1140 stations, annual rainfall plots diagrams of the 44 years (1960-2004) was compared with that of normal rainfall for 44 years and the deviations were ranked as '+ve' '-ve' or '0', based on increase, decrease or no change in rainfall, respectively.(Fig.3a) A spatial interpolation was done in GIS to exactly locate regions vulnerable to rainfall changes. Positive deviations were observed in Gujarat, Maharashtra, coastal Andhra Pradesh, Rayalaseema and Orissa. However, parts of the country comprising the area in central parts covering eastern Uttar Pradesh, eastern Madhya Pradesh, west coast and greater parts of N-W India did not show any changes. Negative trends (fall) in rainfall was noticed among the stations that are situated in deep southern

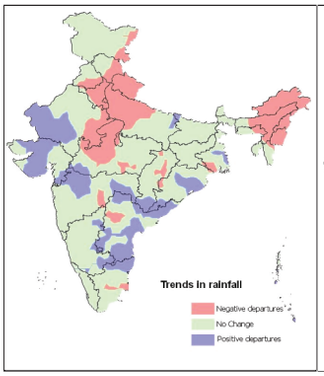


Fig.3a Spatial distribution of rainfall trends

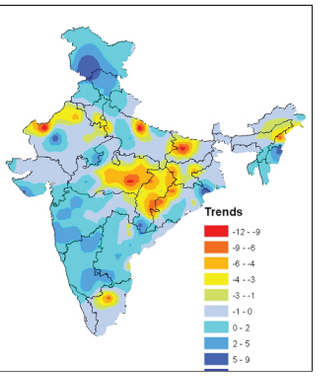


Fig.3b Spatial rainfall trend map

parts, Peninsular, Central India and parts of North and N-E regions.

Out of 1140 stations about 40 per cent have shown negative deviations while 48 per cent stations showed positive deviations while 12 per cent stations did not show any trend. Statistical significance of the above findings was tested using Man Kendall test and spatial distribution maps were generated (Fig.3b). Significant negative trends were observed in the eastern parts of Madhya Pradesh, Chhattisgarh and parts of Bihar, Uttar Pradesh, parts of N-W and N-E Indian and a small part in Tamil Nadu.

2.1.2.2. Validation of PRECIS Model Output for India

A preliminary Validation of PRECIS Model output was attempted by estimating the monthly and annual rainfall from daily rainfall for the year 2005. For this purpose, the baseline averages of 1960-1990 was considered and the average rainfall at the end of period 1990-2020 as estimated by the model for each station was computed. Using the above values and with an assumption that the changes in rainfall values between the baseline and by 2020 were linear. The incremental changes were added to the base value to arrive at the mean annual rainfall value at 2005. These estimates were compared with the actual mean values obtained using the long-term rainfall data recorded at the respective centres that are around to grid point location. The percent deviations between the predicted and the actual values were computed and spatial maps were prepared for the months June to September. Also departure maps for monsoon season and annual rainfall were prepared (Fig.4).

The model forecast was over-predicted for central, southern peninsular and Northwest India. The deviations were near normal across Indo-Gangetic Plains for all the months, seasonal and annual. No areas were found with negative deviations with respect to seasonal and annual rainfall.

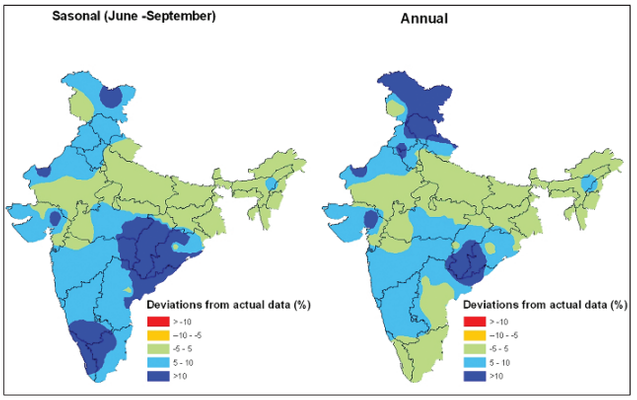


Fig.4. Evaluation of model projections with observed mean rainfall data (1990-2005)

2.1.2.3. Droughts

To analyze the drought situation and estimate probability of occurrence of severe, moderate and mild droughts, a study was taken up using IMD criteria if rainfall deviation from normal is up to 25% is termed 'mild', up to 50% as 'moderate' and > 50% as 'severe'. Spatial maps were generated using GIS (Fig.5).

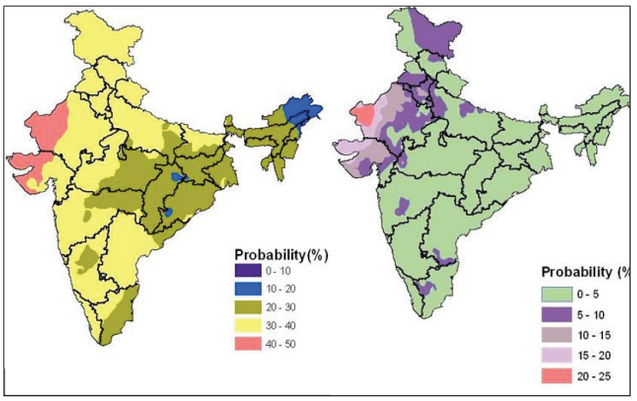


Fig.5 Per cent probability of occurrence of different droughts in India

The probability of occurrence of drought in rainfed tracts of India was estimated as 30 to 40% indicating occurrence of drought in every 3 to 4 years out of ten years. In eastern and Northeastern parts of the country the probability of occurrence of drought comes down to 2 to 3 years. The probability of occurrence of severe drought is increasing towards North west of the country.

2.1.3. Utilization of Agroclimatic Information for Agro-Advisories

The demand for precise weather forecast and its utilization in day-to-day agriculture operations and preparing agro advisories to help the farmers is increasing. Hence, this project was taken up with an objective to carry out a detailed agroclimatic analysis of the five AAS Units in Andhra Pradesh viz., Anantapur, Anakapalli, Rajendranagar, Tirupathi and Jagityal.

Based on weekly averages of climatic parameters, it was noticed that duration of average weekly rainfall of above 20 mm varied 11, 22, 19, 21, 20 mm at Anantapur, Anakapalli, Rajendranagar, Tirupathi and Jagityal, respectively. Monsoon seasonal maximum and minimum temperatures varied from 32 - 35°C and 22 - 24°C at Anantapur, 32-35°C and 22 - 24°C at Anakapalli, 30-33°C and 21 - 23°C at Rajendranagar, 32-36°C and 23-26 °C at Tirupathi and 21-35°C and 21-24°C at Jagityal. Lowest minimum temperature in winter season is recorded at Jagityal followed by Rajendranagar where minimum temperatures vary between 13 and 19°C. Wind speeds at Anantapur during monsoon season vary from 9 – 19 km hr^{-1}. Similarly, higher wind speeds of about 10 to 15 km hr^{-1} were recorded at Rajendranagar and Tirupathi. Winds speeds were lowest at Anakapalli during monsoon season.

- Probability of occurrence of dry week at a limit of 20 mm through out the year was above 50 per cent even in the monsoon period at Anantapur. However, it is 30-50 per cent at Anakapalli, 40-60 per cent at Rajendranagar, and around 40-50 at Tirupathi and 20-45 per cent at Jagityal. Similarly, the conditional probabilities of a dry week followed by dry and wet week and wet week followed by wet and dry weeks for the above rainfall periods of 20 mm have also been computed. Generally at low rainfall stations like Anantapur, the probabilities of dry period during the season were high compared to higher rainfall regions like Jagityal and Anakapalli.

- From the weekly rainfall values, the commencement and end-of-the-season and duration of the season was computed by considering that at least 25 mm of rainfall per week was necessary for commencement of the crop season provided the subsequent two weeks receive half of the mean rainfall.

- The mean commencement of the season varies from 25 to 28 standard weeks among the stations. The commencement of the season at all locations could be as early as 24 week. However, variability with respect to late commencement is seen. It varies from 27 week at Jagityal to 32 week at Anantapur. Similarly, the mean end of the season varies from 43 week at Rajendranagar to 49 week at Tirupathi. The end of the season could be as early as 38 to 45 week and as late as 49 to 52 amongst the locations (Table 3.)

Table 3.Duration, commencement and end of rainy season at five agromet field units in Andhra Pradesh

Station	Start of season			End of season			Duration of season (weekly)		
	Mean	Early	Late	Mean	Early	Late	Mean	Maximum	Minimum
Anantapur	27.6	24	32	44.8	39	52	17.2	28	11
Anakapalli	25.1	24	29	44.6	39	51	19.5	25	14
Rajendranagar	25.2	24	31	43.2	38	49	18.1	25	14
Tirupathi	26.1	24	29	49.1	45	52	23.0	28	20
Jagityal	24.8	24	27	43.6	39	52	18.9	28	14

2.1.4 Water Balance and Water Requirements of Important Crops

- From the weekly average values of rainfall, potential evapotranspiration and the available soil moisture in the root zone at the five locations, normal climatic water balance computations of the five locations using the procedure of Thornthwaite and Mather were done. The normal weekly water balancer diagrams showing the periods of water deficit, water surplus, soil moisture recharge and soil moisture utilization were prepared (Fig. 6.) At an arid station like Anantapur, water deficit conditions prevailed throughout the year. Only two to three week period i.e. 39th to 41st weeks were observed where the rainfall exceeded PET and soil moisture recharge was noticed. At Rajendranagar and at Tirupathi, which are situated in semi-arid region showed water deficit conditions over greater part of the year were observed except during monsoon period. As Tirupathi receives more rain during NE monsoon period, a time lag in soil moisture recharge has been noticed between these two stations. Under normal conditions, water surplus never occurred at Rajendranagar while the period coinciding with end of October to mid-November recorded water surplus at Tirupathi. The stations, viz., Anakapalli and Jagityal situated in high rainfall region showed longer periods under soil moisture recharge and water surplus conditions compared to other three stations. The intensity of water deficit during the rest of the year was less due to better soil moisture utilization.

- The annual water balance components viz., potential evapo transpiration (PET), actual evapo transpiration (AET), water deficit (WD) and water surplus (WS) recorded at various locations are given in Table 4.

2.1.4.1 Water Requirements of Major Crops at Five Locations

- Important rainfed crops are maize and groundnut at Anakapalli; maize and cotton at Jagityal; sorghum and pigeonpea at Rajendranagar; pearl millet and groundnut at Tirupathi; and pigeonpea and groundnut at Anantapur.

Table 4. Annual water balance components (mm)

Station	Rainfall	PET	AET	WD	WS
Anantapur	560	2051	560	1491	0
Anakapalli	1049	1536	919	617	130
Jagityal	948	1533	848	685	100
Rajendranagar	754	1800	754	1046	0
Tirupathi	994	1647	994	653	-

- Based on the normal dates of sowing and the duration of crop growth stages at the five locations, the crop water requirements were computed from PET and crop coefficient values (Kc) values. Similarly, the water requirements under delayed conditions by 1 to 4 week periods were also worked out. The total water requirement of maize crop at Anakapalli and Jagityal were almost the same. However, for groundnut crop, water requirement is highest at Anantapur followed by Tirupathi and Anakapalli. Highest water requirements were found during pod development stage for groundnut crop, which varied from 140 to 160 mm at Anantapur, 110 to 136 mm at Tirupathi and 99 to 104 mm at Anakapalli. For pigeonpea crop at Anantapur and at Rajendranagar, the total water requirement varies from 658 to 697 and 560 to 608 mm, respectively. Since the crop is of indeterminate nature, the water requirements at flowering stage were higher than other crop growth stages. The water requirement of sorghum varied from 306 to 328 mm at Rajendranagar and for pearlmillet at Tirupathi varied from 370 to 402 mm. The cotton crop water requirement at Jagityal varies from 448 to 481 mm, the maximum being at boll development stage.

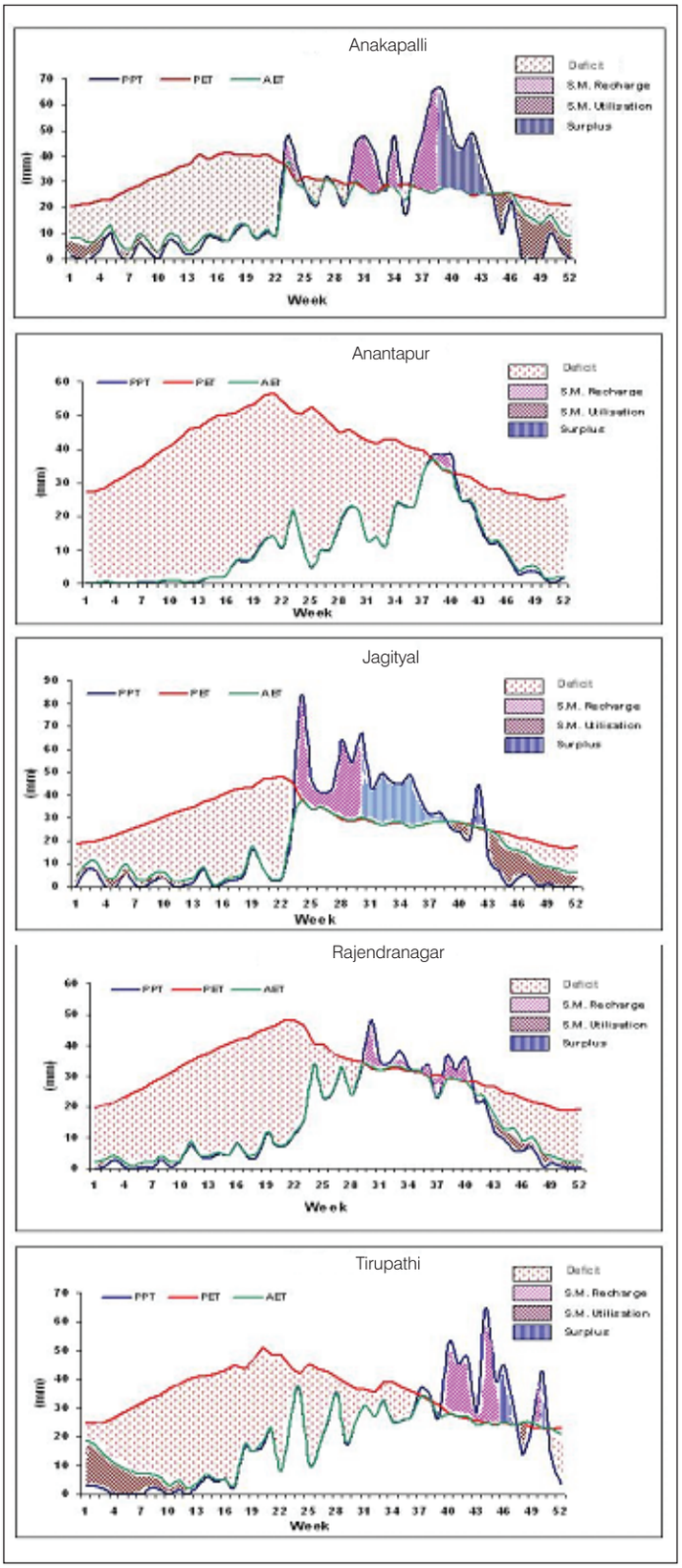


Fig. 6. Normal weekly water balance across different locations

2.1.5 Radiation and water use efficiency of sorghum and pigeonpea

Radiation and water use efficiencies are the two very important inputs to crop weather modeling. Sorghum (cv. SPV 1616) and pigeon pea (cv. PRG 100) crops were sown in 2:1 ratio on 10th June 2006 in Phase II area at HRF. Recommended package of agronomic practices were adopted. Observations on leaf area and dry matter were periodically recorded for both the crops. Transmitted PAR was recorded to work out the extinction coefficient for sorghum and pigeon pea. Bouguer-Lambert law as proposed by Monsi and Saeki (1953) has often been used to describe solar radiation transmitted through a canopy and is given below :

$$I = Io * e^{-k*L}$$

Where I and Io are the PAR values at ground level inside and above the crop canopy respectively. L is Leaf Area Index (LAI). The transmittance of PAR through a canopy i.e. the ratio of PAR inside canopy (I) and PAR above canopy (Io) is calculated from the above law as:

$$T = I/Io = e^{-k*L}$$

The extinction coefficients (k) for sorghum (cv. SPV 1616) and pigeon pea (cv. PRG 100) were worked out as 0.493 and 0.445 respectively by fitting linear equations i.e. logarithmic transformation {- ln (I/Io) = k*L} of the above equation. Daily insolation (MJ m^{-2}) was recorded in an automatic weather station installed at around hundred meters distance from this field. Ritchie's water balance methodology was adopted for working out actual evapo-transpiration and in turn the WUE of these crops/ cultivars. The findings of the study are:

- LAI was 1.80 for sorghum grown as inter crop with pigeon pea and 2.94 for sole crop. The leaf area index of the pigeon pea inter cropped with sorghum was 2.30 while for sole pigeon pea it was 5.70. The extinction coefficient 'k' for sorghum and pigeon pea were 0.493 and 0.445, respectively (Fig.7a and b).
- The RUE (Fig.8a and b) was 2.534 (r^2 = 0.974) and 1.588 (r^2 = 0.991) g MJ^{-1} for sorghum and pigeon pea respectively.
- Linear curves (Fig.9a and b) with an intercept on X-axis fit well in respect to water use vs dry matter production for both the crops. The intercepts of 39 and 81 mm on X - axis for

sorghum and pigeonpea represent the threshold values of water which is evapo-transpired before any measurable dry matter is accumulated in sorghum and pigeonpea respectively.

- Considering the cumulative evapotranspiration and total dry matter produced, the WUE is worked out to be 3.43 and 1.86 g kg^{-1} of water use for sorghum and pigeonpea respectively (Fig. 9a and b).

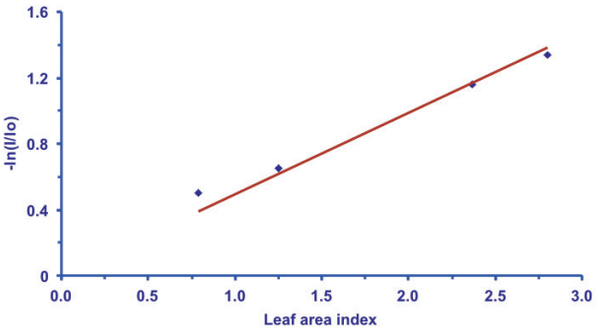


Fig. 7a A plot of - ln(I/Io) vs leaf area index for sorghum (cv. SPV 1616)

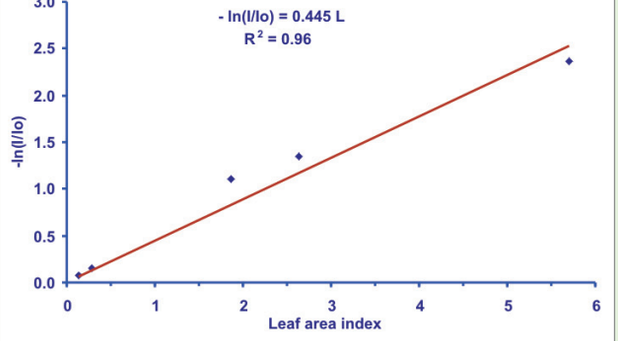


Fig. 7b A plot of - ln(I/Io) vs leaf area index for pigeon pea (cv. PRG 100)

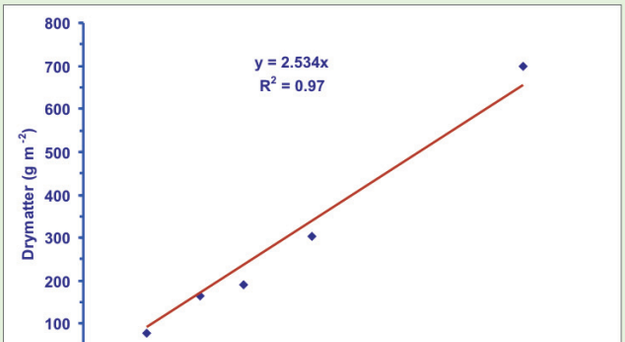


Fig. 8a Relationship between dry matter and cumulative IPAR for sorghum (cv. SPV 1616)

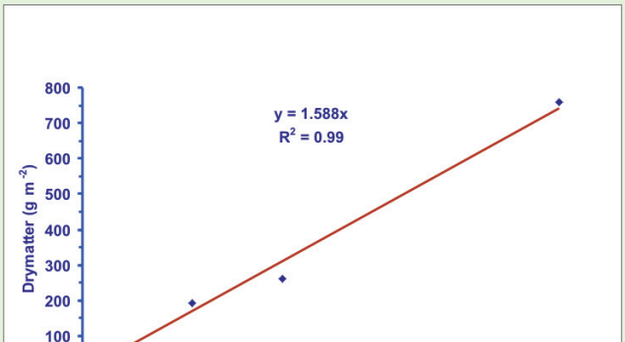


Fig. 8b Relationship between cumulative IPAR and dry matter for pigeon pea (cv. PRG 100)

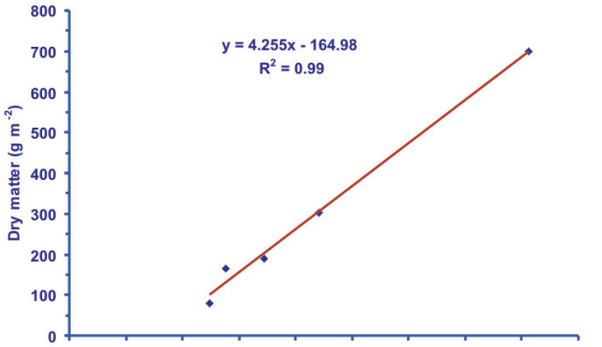


Fig 9a Relationship between drymatter and water use for sorghum (cv. SPV 1616)

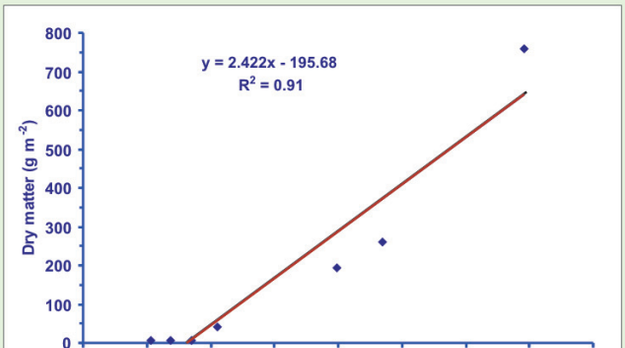


Fig 9b Relationship between dry matter and water use for pigeonpea (cv. PRG 100)

2.1.6 Spectral characteristic of rainfed *kharif* sorghum

The present investigation deals with sorghum yield estimation within a toposequence of Alfisol using two different approaches (i) a simple water balance model where additive and multiplicative forms of water production functions are used to predict yield, and (ii) using spectral characteristics of crop. Efforts have been made for better estimation of yield by combining both - the water balance approach and spectral characteristics of crop.

A root zone soil moisture model has been used to evaluate the seasonal soil moisture fluctuation and actual evapotranspiration within a toposequence having varying soil depth of 30 to 75 cm as well as different available water capacity ranging from 6.9 to 12.6% (V/V). The higher r^2 values between modeled and observed values of soil water ($r^2 > 0.69$ significant at $P < 0.001$) and runoff ($r^2 = 0.95$, significant at $P < 0.001$) indicated good agreement between model output and observed values. The spectral reflectance values were averaged between 0.52 to 0.59, 0.62 to 0.68 and 0.77 to 0.86 mm wave lengths to give values of reflectance for green, red and near–infrared bands, respectively. The spectral bands were decided based on the LISS-IV multi-spectral camera used in the Indian Resource-sat 1 remote sensing satellite. The vegetation indices like simple ratio, normalized difference vegetation index (NDVI), green NDVI, perpendicular vegetation index, soil adjusted vegetation index (SAVI) and modified SAVI (MSAVI) were recorded through out the growth period of sorghum. A soil line was established using spectral reflectance of soil under different moisture levels (Fig. 10). The indices, except perpendicular vegetation index measured during booting to anthesis stages, were positively correlated ($P < 0.05$) with leaf area index and yield. The mean value of all the vegetation indices as well as crop dry mass and LAI under recommended fertilizer doses for entire toposequence are presented in Table 5. The MSAVI measured during booting to milk-grain stage have the highest positive correlation with yield. Variation was noticed when additive and multiplicative forms of water-production functions calculated from water budget model were used to predict crop yield.

Efforts have been made to use both – the multiplicative and additive relative water production function and MSAVI recorded from booting to milk-grain stage for estimating yields (Table 6). The relative yield

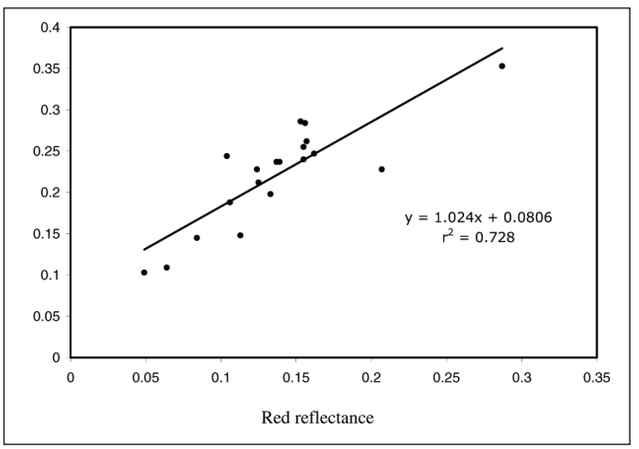


Fig.10. Soil line using spectral reflectance from bare soil in red and infrared band under different moisture levels

Table 5. Mean values (± standard error) for crop dry biomass (g m^{-2}), leaf area index (LAI), and vegetation spectral indices measured for sorghum at booting to milk-grain stages

Index	Stage of growth			
	Booting	Heading	Anthesis	Milk –grain
LAI	2.612 (0.49)	2.574 (0.44)	2.356 (0.42)	2.213 (0.33)
Dry biomass	749 (102)	1087 (155)	1127 (146)	1227 (122)
Simple Ratio	7.425 (1.52)	7.599 (1.63)	7.291 (1.44)	7.012 (1.47)
NDVI	0.753 (0.04)	0.767 (0.05)	0.759 (0.03)	0.750 (0.03)
GNDVI	0.742 (0.04)	0.734 (0.03)	0.683 (0.02)	0.628 (0.03)
SAVI	0.577 (0.03)	0.609 (0.03)	0.636 (0.04)	0.556 (0.03)
MSAVI	0.598 (0.03)	0.658 (0.03)	0.667 (0.04)	0.561 (0.04)
PVI	0.268 (0.04)	0.361 (0.04)	0.268 (0.05)	0.251(0.04)

Table 6. Coefficients of determination from multiple regressions using yield as the dependent variable and MSAVI, and relative yield values from both the additive and multiplicative models as independent variables

Spectral vegetation Index	Growth stage	Relative yield values	
		Multiplicative water production function	Additive water production function
MSAVI	Booting	0.678 (P<0.001)	0.643 (P<0.001)
MSAVI	Heading	0.682 (P<0.001)	0.673 (P<0.001)
MVASI	Anthesis	0.641 (P<0.001)	0.624 (P = 0.001)
MVASI	Milk-grain	0.643 (P<0.001)	0.625 (P = 0.001)

Values in the parentheses are the significant levels of probability

values using multiplicative water production function as well as MSAVI recorded during heading stage gave the highest coefficient of determination with <0.001 level of significance.

The multiple regression equation is given below:

Y (estimated yield) = 2.586 ´ MSAVI (heading stage) +1.94 ´ relative yield value using multiplicative water production function – 1.424.

The above equation was used for estimating yield during 2005-06 (r^2 = 0.583, p =0.004). Both the spectral characteristics as well as the water production functions calculated from water balance model gave better estimates of yield in comparison to the methods which use these parameters separately.

2. 2 Integrated Nutrient management

Soil quality management is a prerequisite for sustaining the productivity of crop and cropping systems in rainfed areas. In order to address this issue, CRIDA has planned a series of INM experiments both short and long term. In addition to INM, CRIDA has also initiated experiments on organic agriculture for better management of soil health. The details and the results of the experiments conducted are discussed below:

2.2.1 Soil quality improvement

2.2.1.1 Low tillage and integrated nutrient management strategies for semi-arid tropics

A long-term experiment was initiated during 1998 with sorghum (cv CSH-9) and green gram (cv ML-267) as test crops at HRF, CRIDA. The main objective of the study was to identify effective Integrated Nutrient Management (INM) module to enhance the crop yields, and to improve organic matter and overall soil quality of these soils. The experiment was conducted in a strip plot design with two tillage (conventional (CT) and minimum (MT)) and five INM treatments (control (T_1), 40 kg N through urea (T_2), 4 t compost + 20 kg N (T_3), 2 t Gliricidia loppings + 20 kg N (T_4) and 4 t compost + 2 t Gliricidia loppings (T_5)) for sorghum crop and control (no nitrogen) (T_1), 20 kg N through urea (T_2), 2 t compost + 10 kg N (T_3), 1 t Gliricidia loppings + 10 kg N (T_4) and 2 t compost + 1 t Gliricidia loppings (T_5) for green gram crop. Recommended level of phosphorus was applied equally to both sorghum and green gram crops uniformly. This year (2006) was the ninth year of the study.

2.2.1.1.1 Effect of tillage and INM treatments on soil quality

The pooled results on crop response to INM treatments for 8 years of the study have been presented in the previous year report. During the year 2006, sorghum grain yields under conventional and minimum tillage varied from 827 to 1849 and 731 to 1455 kg ha^{-1} respectively. When averaged over treatments, conventional tillage maintained significantly higher yields compared to minimum tillage. Among the INM treatments, irrespective of tillage, 40 kg N through urea recorded significantly higher yields of 1650 kg ha^{-1} which was at par with 4t compost + 20 kg N through urea (1645 kg ha^{-1}). Interactive effects of CT + 4t compost + 20 kg N through urea and CT + 40 kg N through urea recorded significantly higher yields compared to other treatments. While, the interactive influence of RT + 40 kg N through urea proved significantly superior with a yield level of 1455 kg ha^{-1}. The green gram grain yields varied from 565 to 1067 kg ha^{-1} and 604 to 1042 kg ha^{-1} under conventional and minimum tillage respectively. Tillage did not show any significant influence on the green gram grain yields. Irrespective of the tillage, 2t compost + 10 kg N through

urea recorded significantly highest green gram grain yields of 1011 kg ha^{-1}. Interactive effects of tillage x treatments on crop yields were also found significant (Fig. 11). The results of the current year are almost in conformity with the earlier findings of last 8 years.

The long-term impact on soil quality was monitored after the harvest of 7th year crop. The data on long-term yield and 21 soil quality indicators viz pH, EC, organic carbon, available N, P, K, exchangeable Ca and Mg, available S and DTPA extractable micronutrients such as Zn, Fe, Cu, Mn and B, microbial biomass carbon(MBC), microbial biomass nitrogen (MBN), $KMnO_4$-oxidizable labile carbon (LC), dehydrogenase assay (DHA), bulk density (BD), mean weight diameter(MWD) of soil aggregates and hydraulic conductivity (HC) were used to identify the key indicators and to compute the integrated soil quality index, by using Principle Component Analysis (PCA) and Linear scoring techniques.

The salient findings of the studies are:

- Available N, DTPA extractable Zn and Cu, microbial biomass carbon (MBC), mean weight diameter of soil aggregates (MWD) and hydraulic conductivity (HC) emerged as the key indicators for Alfisol under sorghum –green gram strip-cropping under conventional and minimum tillage.

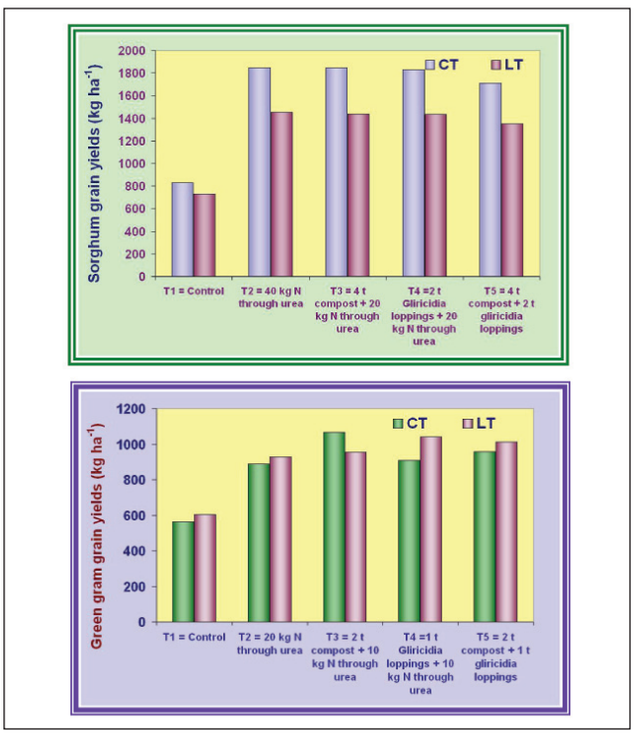


Fig. 11. Effect of INM treatments on grain yields of sorghum and green gram under conventional and minimum tillage conditions

- Tillage alone did not show any significant effect on RSQI, while the conjunctive nutrient use treatments significantly influenced the RSQI.
- Irrespective of the tillage, among the treatments, , 4t compost + 2 t gliricidia loppings showed the highest RSQI (0.98) followed by 2 t gliricidia loppings + 20 kg N through urea (0.93) which was at par with 4 t compost + 20 kg N through urea (0.92).
- The interaction effects of tillage and conjunctive nutrient use treatments were also found significant on RSQI. The interaction of conventional tillage with 4 t compost + 2 t gliricidia loppings resulted in highest RSQI (0.96) followed by that with 4 t compost + 20 kg N through urea (0.92).
- Under minimum tillage also, 4t compost + 2 t gliricidia loppings proved to have the highest RSQI (1.00) which was followed by 2t gliricidia loppings + 20 kg N through urea (0.97).
- These results clearly indicated that under both the tillages, application of sole organic treatment comprising of 4t compost + 2t gliricidia loppings behaved significantly different from rest of the treatments and maintained highest RSQI values.
- From the viewpoint of relative performance in terms of soil aggradation or improvement of soil quality, the treatments were found in the order of T5>T4>T3> T2>T1 (Fig. 12).
- Based on the criteria followed in the methodology in the present case, the order of per cent contribution of key soil indicators towards the RSQI was: MBC (29 %)>KMnO4 oxidizable available N (28 %)> DTPA-Zn (25 %)>DTPA-Cu (9 %) >HC (6%) >MWD (3%).

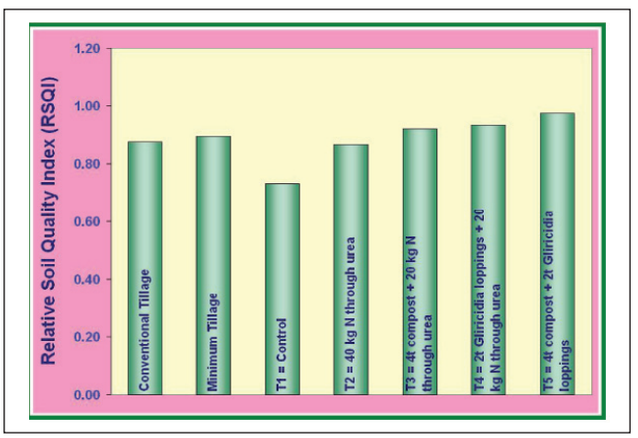


Fig. 12. Average effects of long term influence of tillage and INM treatments on relative soil quality index under sorghum-green gram strip cropping in Alfisols of Hyderabad

- Apart from identifying soil quality indicators and computing soil quality indices, various pools of carbon viz., soil organic carbon (SOC), inorganic carbon (IC), microbial biomass carbon (MBC), $KMnO_4$ oxidizable carbonic (LC), particulate organic carbon (POC) and total carbon (TC) as influenced by tillage and INM treatments were also estimated. After 8th year of the study, the tillage treatments showed significant effect on SOC, IC, POC, and TC in surface soil layers (0-5 cm). Whereas, INM treatments significantly influenced SOC, IC, MBC, LC, POC and TC in the surface soil layer (Fig. 13).

2.2.1.2 Restoration of soil quality- residue management with zero/ minimum tillage

With the objective of improving organic C content in soil and to improve the soil quality , an experiment comprising of surface application of 4 levels of sorghum residues @ 0, 2, 4, 6 t ha^{-1} in combination with uniform dose of 60 kg N ha^{-1} with Zero tillage was initiated during 2005. During the year 2006, sunflower crop (Ganga Kaveri- GK 2002 and KBSH-1) sown but could not be established due to initial dry spells and compacted surface layer under zero tillage. Further, to generate biomass by capitalizing the remaining part of the season, short duration legume crops viz., cowpea (C-152) (kharif) and horsegram (CRHG -17) (Rabi) were taken up. Due to irregular rainfall, compaction and weed growth in zero tillage, biomass yields of both the crops were affected. Soil carbon pools as influenced by residue application were estimated. The salient findings of the study were as follows.

- The yields of above ground dry biomass in cowpea varied from 228 to 319 kg ha^{-1}. The highest yield of above ground dry biomass was recorded under application of 4 t ha^{-1} of sorghum stover which was at par with 2 t ha^{-1} of sorghum stover (312 kg ha^{-1}).
- Application of sorghum stover above 4 tha^{-1} however, did not show any significant increase in the above ground biomass yields and were even lesser than the control. This may be attributed to the ill effects of immobilization occurred due to application of higher rates of sorghum stover.
- The pod yield of horsegram raised as a subsequent crop after cowpea was significantly influenced and varied from 322 to 468 kg ha^{-1}. Horse gram grain

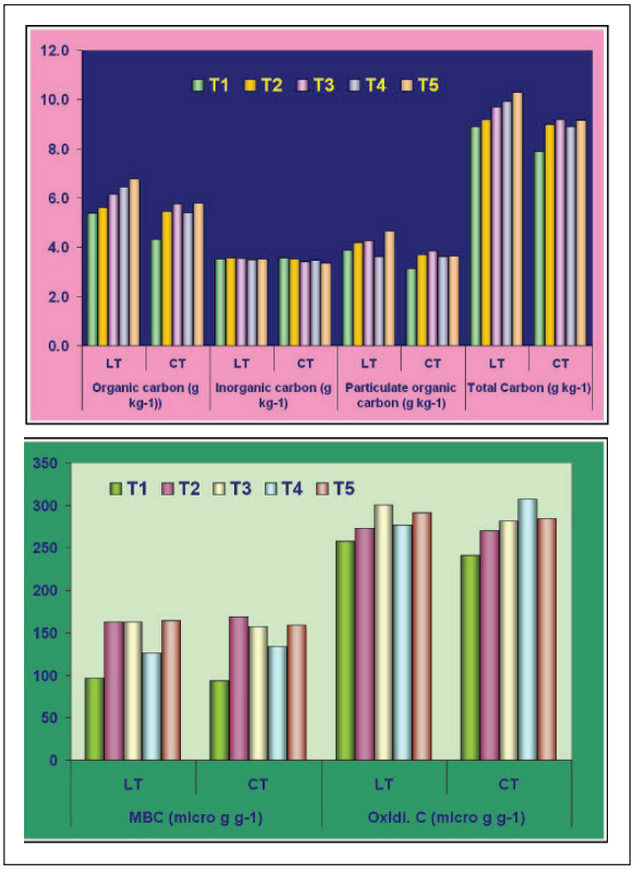
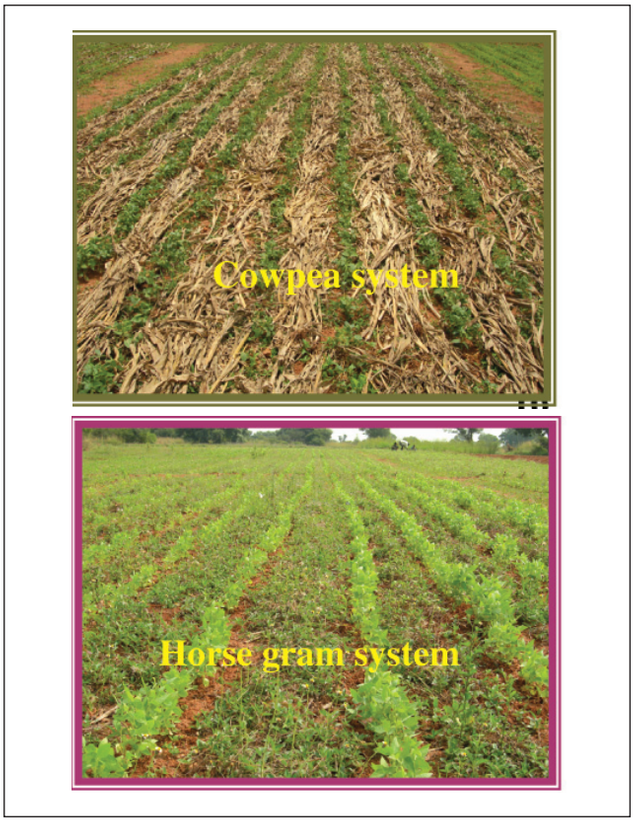


Fig. 13. Long term effect of tillage and INM treatments on soil carbon pools



Soil quality restoration - residue management in zero / minimum tillage

and husk yields were also significantly influenced by different residue levels and ranged from 196 to 290 kg ha^{-1} and 126 to 179 kg ha^{-1} respectively.

- Sorghum stover applied @ 6 t ha^{-1} did not adversely affect the yield of the second crop and recorded the highest horse gram pod yield (468 kg ha^{-1}), grain yield (290 kg ha^{-1}) and husk yield (179 kg ha^{-1}).

- Based on the data generated after the 1st year of the experiment, it was observed that, except microbial biomass carbon, the other C pools were not significantly influenced by the application of various levels of sorghum residues + 60 kg N ha-1 + zero tillage at both surface (0-5 cm) and sub-surface (5-20 cm) depths.

2.2.1.3 Soil quality assessment under long-term management practices at dryland center

A long-term experiment on *"integrated nutrient supply system for rainfed semiarid tropics"* which was initiated in 1998 to minimize the dependence on the use of inorganic fertilizers and to build up soil fertility and to improve soil health was adopted fro soil quality assessment study. Relative soil quality was worked using 19 physical, chemical and biological soil quality indicators. The salient findings of the study were as follows:

- Relative soil quality index (RSQI) was significantly influenced by the different cropping systems and highest RSQI was observed under block system of maize –blackgram (1.00) followed by maize block system (0.92). The relative order of performance of the systems in terms of RSQI was: black gram block system- (1.00) > maize block systems- (0.92) > maize-blackgram strip system- (0.67) (Fig 14).

  Another long-term experiment on "low till farming strategies for resources conservation and improving soil quality" which was initiated during the year 2000 in order to assess the impact of low till system on crop yields was adopted for soil quality studies. Relative soil quality indices were computed after analysis of the soil samples collected from surface layer for 19 soil quality indicators.

- The tillage practices followed did not show any significant influence on the relative soil quality index while the soil nutrient management treatments had significant influence on RSQI.

- Irrespective of the tillage, application of 100% organic source of nutrient recorded significantly highest RSQI of 0.90 followed by application of 50% inorganic + 50 % organic source (0.80). The lowest RSQI was observed in application of 100% inorganic source (0.79) (Fig 14).

  The interaction effect of tillage and treatments also showed significant influence on the RSQI. Among all the treatments, Conventional tillage + 2 weedicide + Hoeing+ 100% organic N recorded the highest RSQI of 0.95 which was at par with that of low tillage + herbicide + 1 weedicide + hoeing+ 100% inorganic N (0.94) and Low tillage + herbicide + 1 weedicide + Hoeing+ 100% organic N (0.91). The lowest RSQI was recorded in Conventional tillage + 2 weedicide + Hoeing+ 100% inorganic N (0.67).

- Out of the nine treatments, five treatments maintained RSQI > 0.8 and proved quite superior.

- In farmers fields, the RSQI was found to be significantly highest under maize-blackgram system (1.00) followed by groundnut-sesame cropping system (0.75) which was at par with that observed in groundnut-taramira system (0.72) (Fig 15).

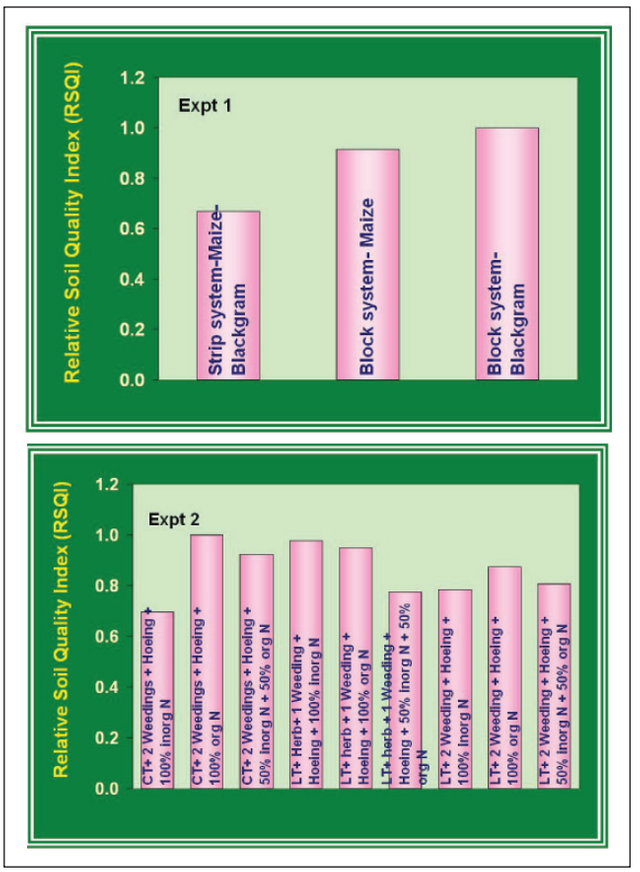


Fig. 14. Relative soil quality index of the long-term tillage treatments at Arjia

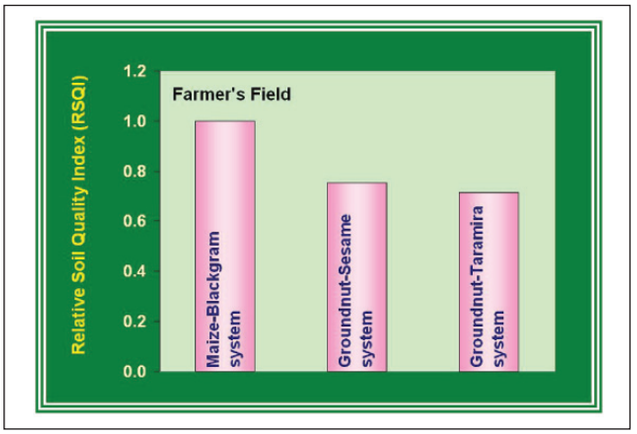


Fig. 15. Relative soil quality index of the long-term management treatments at experimental stations and farmers fields

2.2.1.4 Assessment and improvement of soil quality and resilience in watershed

Sakaliseripalli micro-watershed in Chintapalli Mandal of Nalgonda district of Andhra Pradesh (63 km from Hyderabad) was selected for watershed scale assessment of soil quality. The major lithology of the area consists of weathered granites. Physiography of the area consists of residual hills, isolated hillocks, pediments, undulating pediplains and valleys. The soil samples were collected at 50 x 50 m grid interval and the grids were marked using Differential GPS. Total cultivable area of microwatershed is 78.79 ha, out of which 19% area is under permanent fallow. There are both irrigated as well as rainfed cropping systems in the watershed. Within irrigated system, rice, cotton, vegetables like tomato, bhendi, chilli and fodder grasses like napier, para grass are dominant cropping systems. Among the rainfed systems, pigeonpea, pigeonpea+jowar or castor or bajra, horse gram, are dominant cropping systems. There are 12 bore wells and 11 open wells in the study area. Out of 11 open wells, 3 were with water and rest were dry. There was considerable spatial variability with respect to important properties of soils within the watershed (Table 7).

Table7. Soil properties of Sakaliseri Palli micro-watershed

Parameters	Mean	Min. value	Max. value	CV%
Bulk density (Mg/kg)	1.65	1.35	1.84	6.91
Organic carbon (%)	0.510	0.204	0.984	38.82
PH	7.39	6.39	8.671	8.86
EC (dS m^{-1})	0.157	0.044	0.847	85.35
Available Nitrogen (kg h^{-1})	181.61	112.90	301.05	26.05
Soil moisture at 0.3 bar (%)	10.45	6.13	18.01	22.68
Soil moisture at 15 bar (%)	4.09	1.31	9.97	40.09
Infiltration (cm h^{-1})	0.667	0.08	1.975	70.31
Soil texture	Loam sand, Sandy Loam, Loam, Sandy Clay Loam, Clay Loam			

2.2.2 Improving soil water and nutrient use efficiency using zeolite

A field experiment was conducted at HRF to study the application of zeolite as soil amendment for pit modification of mango plantation. Four soil amendments, viz., zeolite, bentonite, fuller's earth and black soil (@1% of soil weight) were taken as treatments and two types of applications like mixing of soil amendments with soil, FYM and fertilizer were applied in entire pit and mixed applied in periphery of 40 cm radius from the seedlings. Fertilizer and FYM were applied as per recommended dose in each pit. Two control pits, one with only soil and the other by mixing soil, FYM and fertilizers (without any amendments) were also taken as treatments. Zeolite, bentonite, fuller's earth and black soil have 25, 4.4, 2, and 4 times higher cation exchange capacity than the experimental soil. Zeolite and bentonite have more than 50% ESP. Bentonite, zeolite and fuller's earth also have very high available water capacity. Two methods of applications have been considered based on the high ESP of soil amendments to study its impact on seedlings establishment. Out of eight zeolite treated pits, five seedlings survived, while it was cent percent in case of bentonite treated pits. Soil samples from 0-20cm depth were collected 40 days after planting and analyzed. There was no significant difference in soil properties due to methods of application and soil amendments. Zeolite treated pits showed increase in sodicity as evident from higher values of ESP and pH in this soil. Available N was highest in bentonite treated plots followed by zeolite, black soil and lowest in fuller's earth treated plots.

2.2.3 Organic Farming

2.2.3.1 Survey on organic farming practices

This project was initiated in 2005 with the objectives of analyzing the existing organic farming practices in different rainfed farming locations of the country and developed protocols for organic production of selected rainfed crops. Twenty farmers from 17 villages of six districts in Gujarat. *viz*. Junagadh, Rajkot, Jamnagar (traditional groundnut areas) and Bhavnagar, Surendranagar and Ahmedabad (non-traditional areas) were interviewed to know about use of organic crop cultivation practices by them.

- In all the villages groundnut, cotton and sesame were grown predominantly in kharif. The other crops

grown were sugarcane, pearlmillet, castor and cumin.

- All the farmers used both inorganic and organic fertilizers for crop nutrition. Among the organic sources, 15 farmers used FYM and five farmers used vermi compost. Three farmers also used castor cake as a source of nutrition. In recent years, castor cake has been used in this region not only as a nutrient but also to enrich natural microbial population in soil. Only one farmer used rhizobium culture.

- For management of biotic stresses, most of the farmers used chemical pesticides (especially insecticides). One farmer used only pheromone traps, bird perches and Trichoderma, 12 farmers resorted to only chemicals and seven farmers used a combination of chemicals and bio pesticides (Trichoderma). Trichoderma was used mainly to manage stem rot in groundnut caused by Sclerotium rolfsii (which at times causes upto 30% stand loss).

2.2.3.2 Comparing organic and conventional production method for sesame under field conditions

This was a field trial initiated at GRF during 2005 *kharif*. This season represented the second year of the long term field experiment. A crop rotation was followed wherein in the plots where sesame was grown during 2005, pigeonpea (*PRG-100*) was grown during 2006 without any inputs. Sesame (*Swetha Til*) was grown in new plots where pearlmillet was raised during 2005 to deplete the nutrients in surface soil. The treatments imposed for sesame during kharif 2006 (a drought year) were as followed during kharif 2005 *i.e.* control (no inputs), organic (meeting the nutrient requirements through permitted inputs on nutrient equivalent basis) and inorganic (package of practices for the area). Besides yield, nutrient uptake, initial and final soil fertility parameters, the nutrient loss through runoff was also monitored during this year.

The seed yield was highest in inorganic followed by organic and control treatments. The inorganic system produced higher plant height, biomass and chlorophyll. (Table 8). Number of siliquas m^{-2} were significantly higher in inorganic but test weight in organic and inorganic were similar. The overall crop growth and yield were significantly lower during this year as compared to *kharif* 2005 mainly due to long dry spell, but there were clear differences between organic and chemical treatments.

Highest nutrient uptake was recorded in chemical treatment followed by organic and control. However, the per cent N in stalks was higher in organic treatments. Both organic and chemical treatments recorded very close values for per cent and uptake figures (Tables 9 & 10).

Table 8. Yield and yield parameters of sesame under organic and chemical production

Treatment	Plant height* (cm)	Day to 50% flowering	No. of Siliquas m^{-2}	Chloro phyll reading (SPAD) **	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Test weight (g)
Control	110.4	58	184	17.8	96	483	2.70
Organic	121.2	55	331	27.83	193	802	2.85
Chemical	126.6	55	370	39.51	247	970	2.82

*95 DAS; ** 71 DAS

Performance of rainfed sesame at 55 DAS under organic and chemical production systems

Table 9. Nutrient uptake by seed and straw under different systems

Treatment	Seed (kg ha^{-1})			Straw (kg ha^{-1})			Total uptake (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
Control	3.37	0.84	0.23	2.30	1.42	3.06	5.68	2.26	3.29
Organic	7.62	1.59	0.50	5.45	1.85	5.21	13.07	3.44	5.72
Chemical	10.37	2.04	0.63	6.00	2.39	6.29	16.38	4.43	6.92

Table10. Total oil and fatty acid contents in seeds of sesamum produced by organic and chemical systems

Production system	Total oil content (%)	Fatty acids (%)		
		Saturated*	Unsaturated	
			Oleic	Linoleic
Control	51.55	10.11	40.05	49.84
Organic	51.29	9.78	41.08	49.14
Chemical	50.73	9.95	41.99	48.06

* Palmitic+stearic

As in the previous year, there was no significant difference in the total oil content, but the percent of unsaturated oils (oleic and linoleic) are slightly lower in control and organic treatments as compared to chemical. The incidence of pests and diseases was least with chemical system. Only pod borer incidence was significantly high in organic, while phyllody, bacterial leaf spot and aphids were comparable. The natural enemies like coccinellids were also not significantly different with treatments.

Yield of rotation crop

Pigeonpea was planted as a rotation crop in plots where sesame was grown during *kharif* 2005. No inputs were given to pigeonpea and the treatment effects represent the residual effect of the treatments applied to the sesame during previous year. The crop was sown in the first fortnight of June and it received a total rainfall of 504 mm during growth period. The residual effect also mirrored the performance of the treatments with the main crop *viz.* highest yield was obtained in chemical (952 kg ha^{-1}) followed by organic (770 kg ha^{-1}) and control (432 kg ha^{-1}). The pigeonpea crop was slightly chlorotic showing N deficiency in the control treatment which was also reflected in the chlorophyll meter reading.

Treatment effects on nutrient loss through runoff

Two runoff events on 04-09-2006 and 20-09-2006 (with rainfall amounts of 8.6 mm and 81 mm respectively occurring two days prior to the event) were monitored in sesame plots for nutrient loss. Data on analysis of runoff water from both the events showed considerable loss of P, K and small quantities (<1 ppm) of Fe, Cu and Mn. In general, the loss was high in chemical plots as compared to organic for phosphorus while no differences were found for potassium. No clear treatment effects were seen with respect to micro nutrients.

Treatment effects on soil nutrient status at the end of the season

No significant change in pH, considerable decrease in organic carbon content were noted in control while it remained unchanged in other two treatments. Available P, K and Zn increased, while available Fe, Mn, Cu sharply declined.

2.2.3.3 Organic production of pigeonpea and sorghum

Sorghum (SPV-1616) and pigeonpea (PRG-100) were grown during *kharif* 2006, the second year of the project, with six production packages: 1. High input chemical (HIC), 2. Low input chemical (LIC), 3. Integrated (INT), 4. Zero input (ZIP), 5. Low input organic (LIO) and 6. High input organic (HIO). Sorghum and pigeonpea plots were interchanged so as to rotate the crops. Some of the expensive organic inputs and practices adopted in 2005 were not used this year in order to lower the production costs of high input organic package.

The high input chemical package consistently gave the highest dry matter levels during sorghum crop growth, and grain yield at harvest (2420 kg ha^{-1}) followed by the high input organic package (2118 kg ha^{-1}) (Fig. 16). Grain yield with the zero input package was significantly lower compared to the other production packages. There was no significant pest problem in the crop and no control measures were warranted.

Pigeonpea dry matter production was highest with the high input chemical package in the early and middle stages of crop growth, but towards maturity, higher drymatter production was observed with the high input organic package. Grain yield of pigeonpea was highest with the high input organic package (1323 kg ha^{-1}) followed by the high chemical input package (1280 kg ha^{-1}) (Fig.16). There were no significant differences in the population of jassids and *Helicoverpa* larvae on pigeonpea among packages. However, there were significant differences in grain damage by lepidopteran pests and pod fly among packages. The lowest grain damage was observed with the high chemical input package (18.7%) although it was statistically on par with the grain damage with high input organic package (22.7%) (Fig.17).

2.2.4 Drought and soil fertility management :

Under this priority area, research was carried out on drought management in castor, evaluation of an indigenous practice of nutrient management with potential for drought mitigation, INM for higher productivity of niger and site specific nutrient assessment and management.

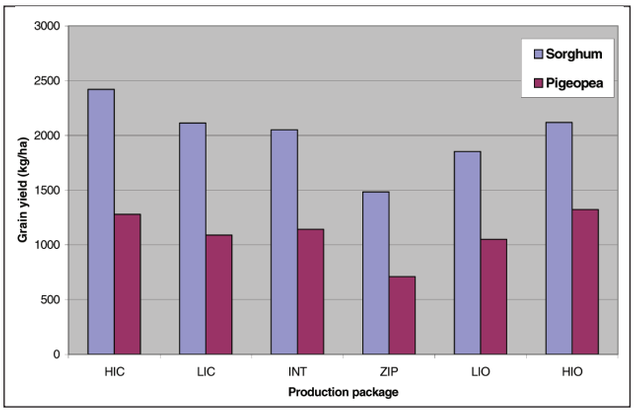


Fig. 16. Sorghum and Pigeonpea grain yields with difference production packages

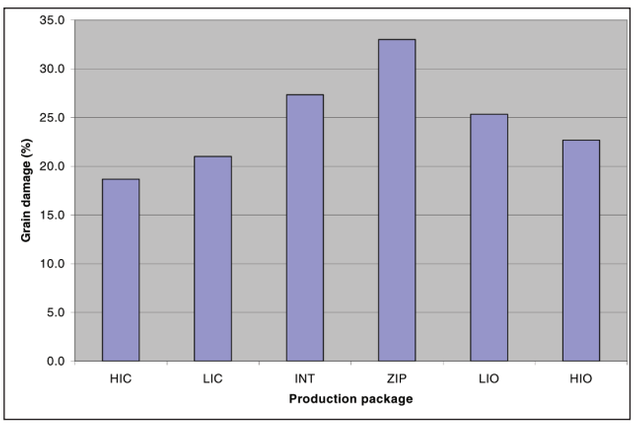


Fig. 17. Grain damage in pigeonpea with different production packages

2.2.4.1 Drought management in castor

Castor is an important non-edible oilseed crop grown mostly in Telangana districts of Andhra Pradesh. It is generally grown under rainfed conditions during *kharif* season and suffers from moisture stress caused by intermittent dry spells and sub-optimum nutrient supply. Resource poor farmers do not use much inputs and hence the productivity is low and unstable. To evolve simple low cost integrated moisture conservation and INM practices to improve productivity and minimize drought effects, a field experiment was carried out during 2006-07 season at HRF of CRIDA, Hyderabad.

Recommended agronomic practices were followed with regard to row spacing (90 cm) and plant density (about 55,000 ha^{-1}). The trial consisted of 8 treatments : with and without application of farm yard manure (FYM) as main plots and four sub plots as application of 25% N through gliricidia + 75% N through inorganic fertilizers (T1), making conservation furrow along with application of inorganic (50-30-0) fertilizers (T2), application of additional dose of 10 kg N ha^{-1} through top dressing along with normal dose (T3), and application of 100% N through inorganic fertilizers (50-30-0) (T4) and control. Castor cultivar Jyothi was sown in the first fortnight of July and a total of 506 mm rainfall was received during the crop growth period. Severe drought occurred for one month (28^{th} September to 27^{th} October) and moderate drought occurred for three weeks (from 7^{th} November to 30^{th} November) during the crop season.

The results of the experiment are presented in (Table 11. Dry matter yield and number of filled capsules were highest under the treatment of application of 25% N through gliricidia and 75% N through inorganic fertilizers. This resulted in higher seed yield compared to 100% inorganic fertilizers (RDF). Higher seed yield were obtained with 25% N through gliricidia + 75% N through inorganic N. Next best treatment was making conservation furrows between castor rows and application of additional dose of 10 kg N ha^{-1} through top dressing along with normal dose of fertilizers. The lowest bean yield was obtained with 100% of N through inorganic fertilizers (50-30-0). Application farm yard manure (FYM) improved bean yield in castor compared to no application. The yield enhancement was about 9 to 11% in all the treatments except under 25% N through gliricidia + 25%

Table 11. Effect of different drought management practices on growth, yield and yield attributes of castor

Treatments	Dry matter (g m^{-2})		Seed yield (kg ha^{-1})		Yield attributes			
	With FYM	Without FYM	With FYM	Without FYM	Filled capsule number m^{-2}		1000 bean weight (g)	
					With FYM	Without FYM	With FYM	Without FYM
T1	113.7	109.1	812(23.4)	773(30.8)	396	378	205.2	204.4
T2	107.6	198.6	768(16.7)	701 (18.6)	377	346	203.8	202.6
T3	105.1	97.8	752 (14.3)	691 (16.9)	372	342	202.0	201.8
T4	94.1	84.6	658	591	328	396	200.4	199.4
Mean	105.1	97.6	748	689	368.3	340.5	202.9	202.1

Note : Figures in parentheses are percentage increase in bean yield over RDF; RDF : 50-30-0.

N through inorganic fertilizer treatment where the enhancement was only about 5%. The overall results indicated that low cost INM practice like application of 25% N through gliricidia + 75% N through inorganic fertilizer and making conservation furrows in castor rows can be recommended for adoption for drought proofing in rainfed castor in Alfisols of Telanagana.

2.2.4.2 Use of groundnut shell as manure

Following a detailed survey of various indigenous practices prevailing in drought prone districts, a common practice of using groundnut shell as cattle shed bedding was studied in detail for its value both as organic manure and for drought proofing in different cropping systems in Mahabubnagar district of Andhra Pradesh. The groundnut shell manure (GSM) prepared after use as cattle shed bedding was compared with compost, inorganic fertilizers and farmers practice (FP). Data from two years (2004-05, 2005-06) of experimentation was compiled during 2006. The main conclusions drawn from the study are

- Both during a drought year (2004-05) and a good rainfall year (2005-06), the GSM applied fields recorded 10-12% higher yields over FP during *kharif* and 20-25% during *rabi*.
- Compost-applied fields recorded equivalent yields to GSM applied fields.
- Only organic treatment recorded lower yields than FP initially but continuous application showed similar yields as that of FP. From fourth season onwards improvement over FP was also observed.
- In kharif groundnut system, sequential application for two years, GSM increased the soil moisture holding capacity by 14-22% over FP in different seasons ranging from drought year to normal rainfall year in gravelly soils (Fig. 18) during cropped period.
- In kharif castor- rabi groundnut system, GSM increased soil moisture by 10-13% during *kharif* and by 30-32% during *rabi*.
- In kharif groundnut-rabi groundnut system, 5-6% increase in soil moisture during kharif and 35-37% increase during rabi was observed.

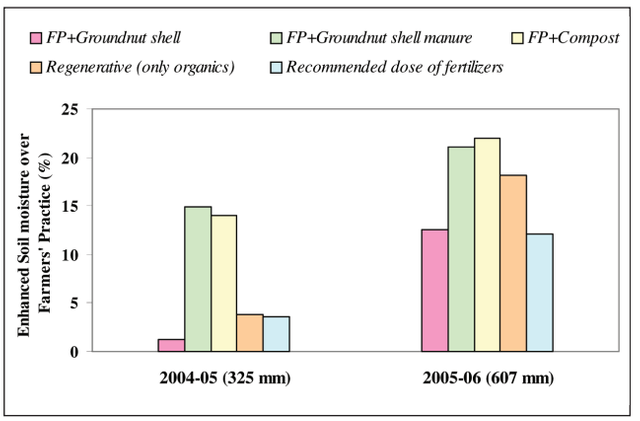


Fig. 18. Enhanced soil moisture (%) in kharif groundnut system due to two years of continuous application of treatments

2.2.4.3 INM in Niger

Niger is an important minor oilseed crop grown in rainfed and tribal regions. In view of its growing importance as an export crop mainly as bird feed, an experiment was carried out to assess the impact of integrated nutrient management for yield enhancement in Alfisols. The first year (2005) results indicated that treatment comprising of 50% of nitrogen through inorganic and 50% through organic gave highest yield. During the second year (*kharif* 2006) also, 6 treatments were tried at HRF. These were: Control (T1) ; RDF (Inorganic) (T2); RDF (Organic) (T3); RDF (50% inorganic + 50% organic) (T4); RDF (Inorganic) + 15 kg S ha^{-1} (T5) ; RDF (Organic) + 15 kg S ha^{-1} (T6) . Data on seed yield and oil content are presented in Table 12.

Table 12. Seed and oil yield of niger under different treatments at HRF

Treatments	Seed yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
Control (T1)	156	36.96	58
RDF (Inorganic)(T2)	322	34.94	117
RDF (Organic)(T3)	353	37.25	132
RDF (50%inorganic +50% organic)(T4)	455	36.48	166
RDF (Inorganic) +15 kg S ha^{-1})(T5)	385	36.19	139
RDF (organic) +15 kg S ha^{-1}(T6)	420	36.23	152

Highest dry matter, leaf area and seed yield were obtained with T4. The net income and BC ratio were also higher when 50% of recommended nutrients were applied through organic sources and 50% through inorganic sources. Supply of entire nutrient requirements through organic (vermicompost) reduced the net income and BC ratio due to higher cost of inputs. Application of 15 kg ha^{-1} sulphur along with recommended dose of nutrients resulted in 65 kg of additional seed yield over RDF alone (Table 13). The crop produced upto 5 t ha^{-1} bio-degradable stalks which can be recycled through vermicomposting.

2.2.4.4 Nutrient status in pod zone and root zone of groundnut

To find out the nutrition related constraints in groundnut, soil samples from farmers fields in Kadiri and Anantapur divisions of Anantapur district, which is the major groundnut growing district in the country, were analyzed. Both pod zone and root zone were analyzed for macro and micro nutrients to know if there is a differential depletion pattern so that tailor made nutrient supply management can be adopted.

Macro and micro nutrient analysis of soils was done in the pod zone (0-5 cm) and root zone (0-30 cm) of groundnut crop before planting and after harvesting. Analysis of samples from 20 farmers fields from 10 villages indicated that all soil samples were neutral in pH (6.1 to 8.4) and low in organic carbon (0.04 to 0.23%). All the soils were sandy loam in texture with water holding capacity ranging between 10.2 to 13.6%

All the 20 samples were low in available nitrogen, whereas 12 samples were high for available P and 8

Table 13. Returns and BC ratios in niger under different INM treatments at HRF

Treatments	Cost of Cultivation (Rs ha^{-1})	Gross Income (Rs)	Net Income (Rs)	B:C Ratio
Control (T1)	2,483	2,340	-143	0.94
RDF (Inorganic (T2)	3,040	4,830	1,790	1.59
RDF (Organic) (T3)	4,402	5,295	893	1.20
RDF (50% inorganic + 50% organic) (T4)	3,724	6,825	3,101	1.83
RDF(Inorganic) + 15 kg S ha^{-1}) (T5)	4,450	5,775	1,325	1.30
RDF (organic) + (T6) 15 kg S ha^{-1}	3,762	6,300	2,538	1.67

samples were medium. Similarly 4 samples recorded high for available K and 16 samples as medium. All the 20 samples recorded low for calcium in the pod zone and medium in the root zone. For micro nutrients, except zinc , none of the other micro nutrients were found deficient in the pod zone. The overall data both in the pod zone and root zone indicated that despite groundnut being a nitrogen fixing crop, an universal deficiency of available nitrogen was found in all samples. Among other nutrients, only calcium, sulphur and zinc were found deficient in the pod zone while only sulphur and zinc were found deficient in the root zone. Based on this study, the ameliorative measures suggested are :

- Along with recommended doses of nitrogen; deficient secondary elements like calcium and sulphur are to be applied in pod zone depth (0-5 cm).
- To overcome the problem of churning of soil and mixing of top soil (0-5cm) with deep soil (5-30 cm) during primary tillage; Ca, and S containing materials must be applied every year in the pod zone depth.
- Calcium and S can be supplied by gypsum whose application to groundnut is a standard practice. It is usually applied (3-5 q ha^{-1}) at three weeks after planting.
- Zinc can be applied as basal dose (50 kg ha^{-1} Zinc Sulphate once in three years).Two spray applications (5 g Zinc Sulphate L^{-1} of water) of Zn can be done at weekly intervals when crop shows symptoms of Zn deficiency.

2.2.4.5 Site specific nutrient management

In order to evolve site specific nutrient management approach, a study was taken up to assess the soil fertility constraints in Machanapalli village of Rangareddy District of Andhra Pradesh. A total of 43 surface soil samples (0-20 cm) were collected from farmers' fields during May 2006 and analyzed for various fertility parameters. Results of the analysis indicated that about 81 and 58% of the fields in the village were low to medium and deficient for available phosphorus and zinc, respectively. There was a build-up of available P due to excessive application of diammonium phosphate, as 58% of the soils tested were high for Olsen's P (Fig. 19). This had led to P induced Zn deficiency in this village as high P levels in the soils inhibit Zn uptake. Available Fe, Mn and Cu were adequate to meet crop requirements. The results clearly indicate that

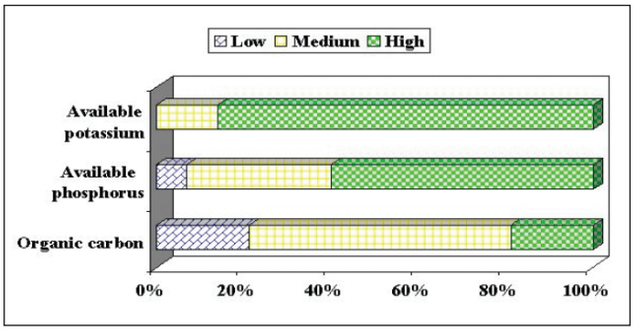


Fig. 19. Fertility status of Machanapalli village: Macronutrients

macro level soil testing doest not suffice to give effective recommendations. Individual field level testing can give more detailed insights into the deficiency levels and thereby accurate recommendations to overcome deficiencies can be given.

In a related study, soil samples from different blocks of HRF were analysed to assess the impact of land use systems on fertility. The results indicated that

- blocks with mono-cropping/intercropping showed the lowest organic carbon (OC) followed by agroforestry, Jatropha and Pongamia plantations. Blocks under native vegetation (forestry) recorded highest mean OC content followed by blocks under horticulture (Table 14).

Table 14. Mean organic carbon, available phosphorus and potassium status of different blocks under different land uses at HRF

Landuse	Organic carbon(%)	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
Monocropping / intercropping(34)*	0.60	48.15	154
Forestry (17)	0.88	27.15	278
Agroforestry (48)	0.64	20.89	236
Jatropha / Pongamia(10) plantations	0.72	14.82	252
Horticulture (12)	0.77	27.0	228
Medicinal & bush plantations(05)	0.73	57.8	352

*values in the parentheses indicate number of blocks under each land use

- with respect to available P, blocks under monocropping/intercropping and under medicinal and bush plantations recored higher P status as compared to other land uses.
- fields under monocropping/intercropping recorded lowest available K values whereas highest K content was recorded under medicinal and bush plantations.

2.2.5 Application of microorganisms in agriculture and allied sectors

This is an ICAR network project aimed at isolating agriculturally important microorganisms from different agro-ecosystems in the country, characterizing them and developing consortia of organisms as inoculants. CRIDA was assigned the responsibility of rainfed ecosystem with sorghum, millets and pigeonpea as test crops. The two sub projects at CRIDA dealt with i) Nutrient management and bio control and ii) Management of abiotic stress. The progress report of these two sub projects is given below:

2.2.5.1 Nutrient management, PGPR and biocontrol

The major aim of this sub project is to isolate efficient strains of nutrient mobilizing and growth promoting bacteria from root zones of major crops in rainfed agro-ecosystem. During the year, extensive soil sampling was done from 15 locations of the country from the rhizosphere and non-rhizosphere zones of crops like maize, sorghum, pigeonpea, cotton, cowpea, chickpea, rainfed rice, pearl millet, foxtail millet, groundnut and gram.

2.2.5.2 Strain isolation and characterization

From these soil samples, *Pseudomonas* (45), *Bacillus* (75), *Azospirillum* (6), *Rhizobium* (7) and AM Fungi (14) were isolated. Among these strains, ten strains of *Pseudomonas* and 38 *Bacillus* strains were screened for their tolerance to high temperature, drought, salinity and oligotrophy (low nutrients). Eight *Pseudomonas* strains and 38 *Bacillus* strains were evaluated for their plant growth promoting activity on sorghum and pigeonpea seedlings. Forty isolates of *Pseudomonas* and 36 *Bacilllus* strains were evaluated for their antagonistic activity against fungal phytopathogens viz. *Sclerotium rolfsii* (with wide host range), *Botrytis ricini* (gray mold of castor), *Fusarium ricini* (wilt of castor), *Rhizoctonia solani* (with wide host range), and *Alternaria porri* (purple blotch of onion).

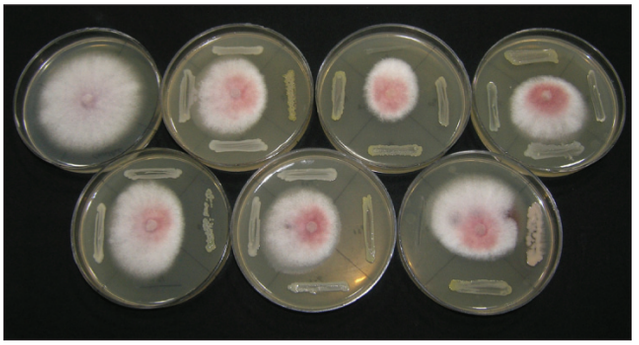
Among 38 strains of *Bacillus* spp., B1, B14, B25, B27, B29 and B36 strains were tolerant up to 50°C while B7, B16 and B30 could tolerate NaCl concentration up to 7%, and B5, B11 and B31 exhibited drought tolerance upto a concentration of 29.57% PEG. Among ten strains of *Pseudomonas* spp, P8 and P20 were tolerant upto 50°C, P8, P20 and P21 were found to tolerate NaCl concentration of 7%, P5 and P8 were more drought tolerant and P2, P5, P9 and P21 were able to grow in low nutrient conditions.

2.2.5.3 Plant growth promotion

Eighteen strains of *Bacillus* and 8 strains of *Pseudomonas* were tested for their plant growth promoting ability with pigeonpea and sorghum. Out of 18 strains of *Bacillus*, only one strain (B 36) showed >50% increase in seedling growth, 8 strains showed 25-50% increase in seedling growth and 9 strains showed less than 25% growth enhancement over control. P1, P4, P6, P7 were able to tolerate high temperatures.

2.2.5.4 Bio control activity of *Pseudomonas* and *Bacillus spp.*

Among 7 strains of *Pseudomonas* tested for their bio control ability against S. rolfsii, B. ricini, F. ricini, R. solani, and A. porri, P18 was most effective against A. porri; P19 was effective against B. ricini, and F. ricini; PUK 3 was effective against S. rolfsii and P28 was effective against R. solani. Similarly, *Bacillus* strains B5, B9, B15, B18 and B36 were found to inhibit all the 5 fungal phytopathogens. These strains were the best bio-control agents among the isolated *Bacillus*. *Botrytis* was inhibited by these *Pseudomonas* strains viz. P6, P8, P10, P17, P18, P19, P20, P21, P24, P28, P33, P35, P36 and PUK-3. *Fusarium ricini* was inhibited by 25 strains of *Pseudomonas strains* viz. P1, P2, P5, P6, P7, P10, P11, P13, P15, P16, P18, P19, P20, P21, P22, P23, P24, P25, P26, P28, P33, P35, P36 PUK-3 and 4. Among them, the promising ones are P8, P18, P19, P20, P21, P28, P36, PUK 3.



In vitro bio control activity of *Pseudomonas* spp. aganist *Botrytis*

2.2.5.5 Management of abiotic stress

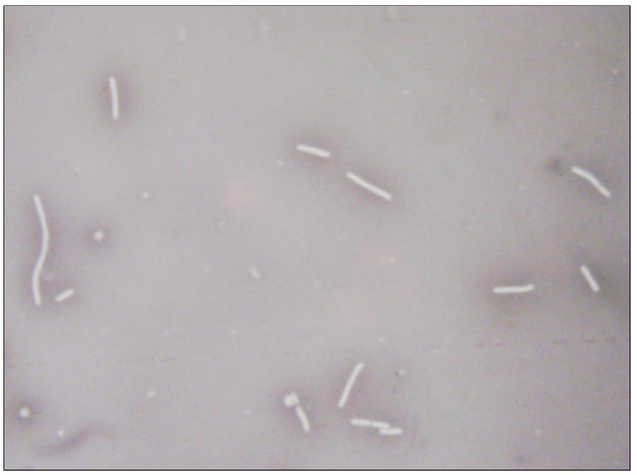
Under this subproject, microbes capable of higher stress tolerance themselves and those that can help plants in tolerating drought and salinity are to be isolated, characterized and tested as consortia partner under laboratory and field conditions. During the year, 55 strains of *Bacillus* and *Pseudomonas* were isolated from Rhizosphere of 7 rainfed crops from 9 locations. The soil temperatures at these locations ranged from 35-43° C.

2.2.5.6 Screening for salt and temperature tolerance

Out of the total 55 strains collected 10 *Bacillus* and 12 *Pseudomonas* strains were evaluated for thermo and osmo tolerance. *Pseudomonas* strains P1, P4, P6 and P7 could grow upto 7% NaCl (1.2 M) and temperatures up to 50°C, while *Bacillus* strain B2 could grow upto 11% NaCl (2 M) and strains B4, B6 and B7 upto 50° C.

2.2.5.7 Studies on tolerance mechanism

In order to understand the stress tolerance mechanism, detailed studies were conducted on strain P4 for production of exo polysacharides (EPS) and osmoprotectants. It was found that the strain produced more EPS under stress conditions (Fig. 20). For example, P4 produced 22.58 mg sugars ml^{-1} supernatant (as estimated by anthrone method) as against 150 mg ml^{-1} with NaCl stress (7%) and 60 mg ml^{-1} under temperature stress (50°C). Paper chromatographic analysis revealed the presence of mannose and raffinose as the main components of EPS.



Pseudomonas fluorescence (P4) cultured at 50°C

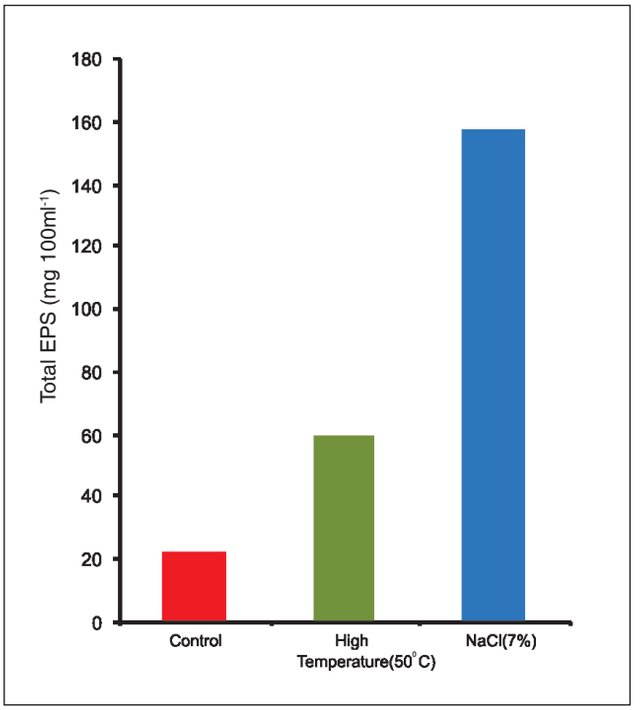


Fig. 20. Total EPS production by *Pseudomonas fluorescence* (P4) under different stress conditions

2.2.6 Field kit for estimating labile carbon

Organic matter is the most widely acknowledged indicator of soil quality. Temporal changes in active soil organic matter may provide an early indication of soil's capacity to perform under different management practices. A simplified method where neutral dilute solutions of potassium permanganate and other chemicals react with most of the active organic matter and change the colour of $KMnO_4$ from deep purple to light pink or colourless was developed. The lighter the colour of the $KMnO_4$ solution after reacting with soil, the greater the amount of active or labile carbon content and better the soil quality . The strength of $KMnO_4$ suitable for tropical soils having <1% organic carbon was found to be 0.01M. The procedure has been tested for soils under different cropping systems as well as soil from the farmers' field.

<180	**180-230**	**230-280**	**>280**
poor	**fair**	**good**	**excellent**

Colour chart for labile carbon estimation

2.3 Rainwater Management

Rainwater management plays a pivotal role in rainfed agriculture. This central issue, alongwith the larger concept of watershed management, has been the focal theme of research carried out at the institute.

2.3.1 Rainfall-runoff and groundwater dynamics in semi-arid regions

Studies were carried out to quantify the rainfall-runoff and ground water dynamics in semi-arid region of India. The site selected was Kurmapally watershed with an area of 107 sq km and falling in Nalgonda and Mahabubnagar districts of Andhra Pradesh. The topography of the watershed was undulating terrain with severe erosion. The average annual rainfall in about 575 mm that is erratic both in space and time. The soils in these watersheds are well drained gravelly to loamy skeletal soils. Resource losses were monitored at different places within the study area. A hydrograph from Vinjamur gauging station recorded 8.1% of runoff from a single storm of 75 mm (Fig. 21).

Surface and ground water balance was carried out for the study area based on the methodology suggested by CGWB for different years commencing from 2002. In all the years, ground water utilization is higher than the potential (Fig . 22).

The watershed area was also assessed for priority treatment by subdividing into the sub watersheds through GIS and morphological parameters. Based on the hypsometric integral, the watershed reached a saturation point thereby indicating less scope for further degradation. However, few sub watersheds were identified which could be prone for erosion process based on drainage density, hydrometric integral etc. This process can be utilized for quick identification of sub watersheds prone for erosion using GIS and digital elevation models. Fig. 23 indicates two sub watersheds that are prone for further erosion. Fig. 24 indicates the proportionate distribution of watershed area and water shed elevation indicating a lower chance of erosion. It is necessary to identify these sub watersheds at a district/ state level and could be considered for priority treatment. This would be an alternative to the existing methodology of quantitative soil erosion estimation through sediment yield index.

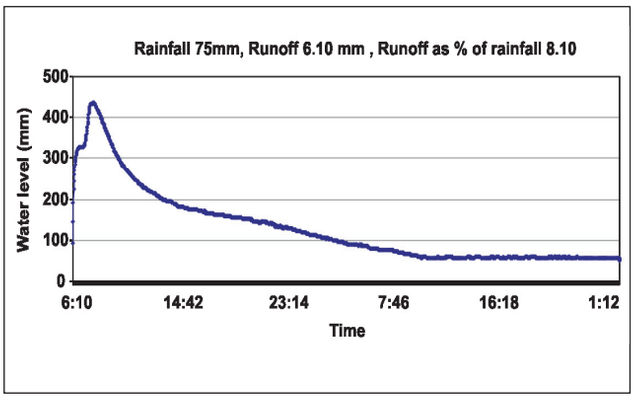


Fig. 21. A typical hydrograph recorded from Vinjamur gauging station on 22.09.2006

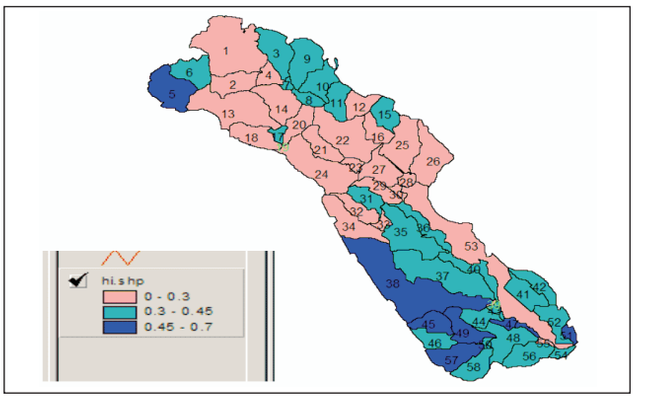


Fig. 23. Characterization of sub watersheds based on hypsometric integral

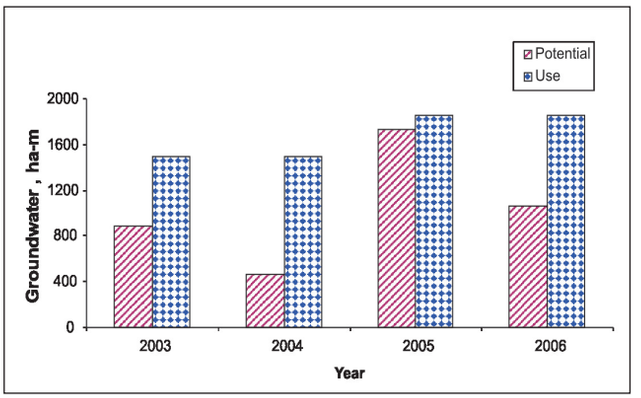


Fig. 22. Temporal variablility of groundwater potential and use in Kurmapally watershed

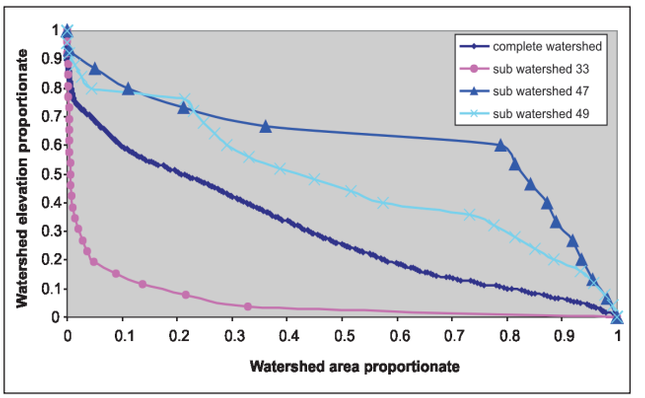


Fig. 24. Variability of hypsometric integral for sub watersheds

2.3.2 Dynamics of water resource utilization in lift irrigation schemes

Studies of dynamics of water resource utilization in Lift Irrigation Systems (LIS) were carried out in Kanuparthy LIS, Prakasam district, Amarachinta LIS, Mahaboobnagar district of Andhra Pradesh. Study sites were identified in consultation with APSIDC.

Water productivity estimates were made based on the actual evapotranspiration, water applied at field level and at project level. A daily water balance model for rice was used to estimate the different components of water balance simulating the submerged bunding conditions in farmer's fields (Fig. 25).

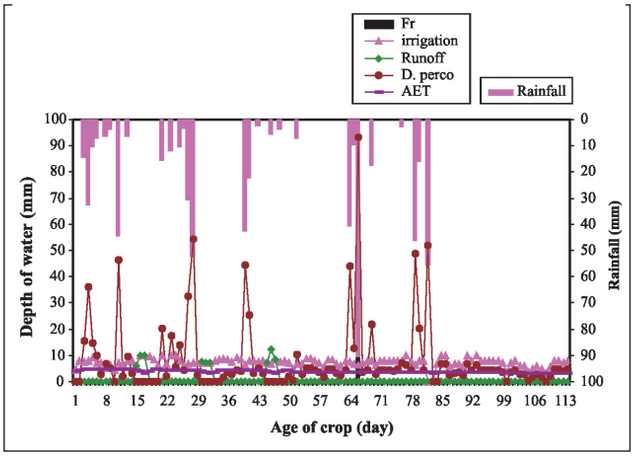


Fig. 25. Daily water balance in rice fields with daily irrigation during monsoon-2005 at Amarachinta LIS

Some of the observations made during the study are mentioned below:

- There was variation in the irrigation water application. Percolation losses were found to be high when occurrence of rainfall coincides with the release of water from LIS. This was a lacuna on part of management as the prevailing practice in releasing water from LIS is made irrespective of rainfall occurrence.
- The daily water release from Amarachinta LIS was more during post- monsoon season as compared to that of monsoon season due to higher values of PET. It was noticed that there was not much difference in water balance output with daily and alternative day irrigation as the soil was more pervious nature. As far as Kanuparthy LIS was concerned, the total water release in cropping period (post monsoon) was very high (2580 mm).
- The depth to water table in Amarachinta LIS increased from 13.30 to 9.78 m below ground level during pre-monsoon and 8.55 to 5.01 m during post-monsoon over the span of past 5 years. The annual rainfall influenced the net recharge. Maximum net recharge was 5.25 m in year 2005, depth water table was 12.00 and 6.75 m during pre-monsoon and post- monsoon season respectively with corresponding rainfall of 950 mm.
- There was gradual improvement in command area (1182 to 1567 ha) as well as per cent water utilization (50 to 81%) after the management of LIS was transferred from state government to the beneficiary society.
- In case of Amarachinta LIS, the field water use efficiency was found to be 3.854 and 5.110 kg (ha-mm)$^{-1}$ during monsoon and post monsoon season respectively, whereas the crop water use efficiency based on actual evapotranspiration was found to be 12.48 and 9.40 kg (ha-mm)$^{-1}$ for monsoon and post monsoon seasons respectively. In case of Kanuparthy LIS these values were found comparatively low (field water use efficiency 1.86-2.43 kg (ha-mm)$^{-1}$ and crop water use efficiency 14.8 kg (ha-mm)$^{-1}$).
- Project water use efficiency (Amarachinta LIS) during monsoon season was estimated as 2.781 kg (ha-mm)$^{-1}$ during monsoon and 3.08 kg (ha-mm)$^{-1}$ during post monsoon season in the year 2005. Initially at the time of commissioning the Kanuparthy LIS (1992) it was 1.12 kg (ha-mm)$^{-1}$, now it increased to 1.90 kg (ha-mm)$^{-1}$ during the year 2005 which is above 44%.
- Increase in input consumption was observed after the inception of LIS. The mechanization level increased, labour shortage was experienced due to crop diversification. The study revealed that the command area of both the LIS could be increased substantially by adopting water efficient crops substituting the present rice crop.

2.3.4. Evaluation of impact of sustainable land management practices in treated micro-watershed

2.3.4.1 Methodology

Five watersheds were selected in AESR 7.2 in Telengana region of Andhra Pradesh to assess the impact of land management practices in treated watersheds. The impacts have been assessed for five aspects also called the five pillars' of sustainability namely – Productivity,

Security, Protection, Viability and Acceptability. Evaluation was attempted at two spatial extents namely, field and watershed level using sustainability indicators. Sixty-one relevant indicators were identified for addressing the core-issues related to land management under rainfed agriculture in AESR 7.2. A bivariate correlation technique was used to identify critical indicators for each of the aspects of sustainability. Using critical indicators, a framework was generated to quantify the impact of land management practices for measuring agricultural sustainability in treated and untreated micro-watersheds in each of the five selected villages. The framework integrates bio- physical and socio-economic indicators for evaluation and monitoring of watershed development program in India.

Sustainability indicators identified for each of the five aspects of sustainability as mentioned earlier, were grouped under five domains of agriculture and allied activities namely crop production, livestock management, irrigation water availability, soil health, and livelihood and human well-being (Table 15). For instance, to assess agricultural productivity in watersheds, five indicators were identified and were used for analysis. For assessing economic security, twenty-one indicators were identified out of which twelve were found critical and used for study. In case of environmental protection for which eighteen indicators were identified, twelve were found critical and used for assessing sustainability. For study of economic viability, twenty-three indicators were identified out of which only twelve were found to be significant and used for analysis. For assessing social acceptability, fifteen indicators were identified out of which ten were found critical and hence used for the study.

Selected indicators were provided weightage and indices were calculated for determining sustainability of watershed development program. Cob–web diagrams were drawn to indicate the strength and weaknesses of watershed projects. To assess sustainability of crop productivity at watershed-level for which five indicators were constructed, three were found to be critical namely, crop yield (weighted), availability of irrigation water and livelihood options. In case of evaluation of security of production and livelihood, three indicators viz., size of land holding, availability of irrigation water and off-farm income sources were found to be crucial. For assessing sustainability of protection of livelihood, five indicators were assessed namely, crop cafeteria index, use of FYM and crop residue, adherence to contingency planning and slope. For evaluating viability of agricultural enterprise, four indicators were identified for analysis - off-farm income, income from draught power, animal produce and higher crop yield. For assessing social acceptability of watershed development program and its principles, five indicators viz., use of conservation measures, decision–making process, membership of associations, mulching and use of FYM and fertilizers, were found critical.

As an illustration, an assessment of one treated micro-watershed in Pamana village located about 70 km to the south west of Hyderabad in Chevella Mandal, Rangareddy District, AP, is presented here. Evaluation of improved land management practices initiated under watershed development program in the treated micro-watershed (TMW) covering an area of 130.6 ha was compared with that of an untreated micro-watershed (UTMW) covering 99.9 ha.

2.3.4.2 Impact Assessment

Yield levels of various crops cultivated in TMW and

Table 15. Framework of indicators for assessing sustainability of watershed development program

Agricultural System	Pillars of Sustainability				
	Produc-tivity	Protection	Security	Viability	Acceptability
Cropping system	Crop yield	Soil Fertility SoilOC Size of land holding Depth of soil Rainfall Availability of Irrigation water	Soil nutrient balance Cropping diversity Crop cafeteria index UseofFYM Water quality (TDS)	Net farm profitability Input use efficiency (quality of pesticides, fertilizer nutrients used) Off-farm income (Income from other sources) Wages from labour	Use of conservation measures S & WC structures Farm- decision making criteria (crop selection) Membership of watershed committee, User association, etc

Agricultural System	Pillars of Sustainability				
	Productivity	Protection	Security	Viability	Acceptability
Livestock resource	Livestock management	Growing fodder crop	Use/availability of crop residue Vaccinations Visit to veterinary doctors Fodder cultivation	Income from draft power Draft power (Plough by bullock! tractor) Animal produce (meat and milk production)	Bank loan for purchase of cattle, bullock pair, etc.
Irrigation water availability	Irrigation water	Availability of ground water Surface water storage Depth of ground water Rainfall	Water harvesting structures Crop contingency plans	Depth of ground water Small rainfall variability Drought! Flood events Lesser no. of bore wells	Excavation of farm ponds&percolation structures Maintaining contour & diversion bunds in fields
Soil fertility status&NRM	Soil health	Depth of soil S&WC structures Vegetation cover Slope Planting trees	Tree plantation Vegetative cover Slope	Short fallowing Crop rotation Soil fertility status	Practice of plough-across- slope Maintaining ground cover Mulching Use of FYM with fertilizer
Livelihood & rural economy	Livelihood& human well-being	Farm income Health awareness Medical facility Off-farm income sources Decrease in landless persons	Literacy Women & child nutrition Crop diversity Vegetable gardening	Off-farm employment Off-season income sources Literacy B:C ratio Gini-coefficient No migration No distress sale of land Decrease in wasteland High crop yield	Land ownership Women's participation Small family norm Literacy
No. of indicators used	5	12	12	12	10
Total no. of indicators constructed	5	21	18	23	15

UTMW in Pamana were compared with mean values from the district and the state. Average composite yield level was found higher in TMW, ie., 36.24 q ha^{-1} when compared with that of UTMW, i.e., 17.15 q ha^{-1}. Net average income accrued to farmers, as compared with the minimum income norm of $ 2 $capita^{-1}$ day^{-1}, advocated under the aegis of Human Development Index. In case of farmers in TMW, was Rs. 13.19 $person^{-1}$ day^{-1} with max. income being Rs. 44.35 $capita^{-1}$ day^{-1}. In case of UTMW, it was Rs. 4.31 $capita^{-1}$ day^{-1} with max. income being Rs. 13.34 $capita^{-1}$ day^{-1}.

In order to evaluate economic viability of SLM practices, B:C ratio were calculated for each farm

household in both types of micro-watersheds. B:C ratio on an average was found to be higher in case of farm holdings in TMW (1.94) when compared to those in UTMW (1.43) indicating profitability of agricultural enterprise in case of the former. As a case of exception, one farmer achieved a B: C ratio of 5.07 in TMW while the average was only 1.94.

B: C ratio varied among farm holdings of different categories. To indicate dependence of profitability and agricultural enterprise on size of land holding, B:C ratios were calculated for varying size of land holding as indicated in Table 16. It is evident that in both types of watersheds, farmers with land - holdings of 2-5 ha had better B: C ratio when compared to those of other categories. However, this analysis is not conclusive as there were no farmers with larger land holdings in both types of watersheds with whose agricultural enterprise a comparison could be made. On the other hand, as there is a majority of marginal and small farmers in most villages in this AESR, emphasis may be laid on increasing profitability of agricultural enterprise of these farmers.

The study also indicated a large gap in income levels from farming activity in the treated and untreated micro-watersheds. Incomes were lower than the HDI recommendation of $ 2 capita^{-1} day $^{-1}$. Distribution of equity was also analyzed and it was noticed that while

Table 16. B: C ratio of agricultural enterprise mong various category of farmers in micro-watersheds in Pamana village

Types of farmers	Farmer (%)		Mean B:C ratio	
	TMW	UTMW	TMW	UTMW
Marginal (<1 ha)	61	59	1.70	1.48
Small (1-2 ha)	29	24	2.08	1.15
Medium (2-5 ha)	10	18	3.03	1.63

equity of distribution of net income was 0.5 in treated micro-watershed, it was lower, i.e., 0.39 in case of UTMW. This is hardly encouraging as it indicates distribution of poverty rather than income or wealth.

In the final analysis, while all farm holdings were evaluated to be unsustainable to varying degrees in both types of micro-watersheds in Pamana, farmers in TMW were able to achieve higher and sustainable crop yield when compared to their counterparts in UTMW (Fig. 26). With respect to economic security, although size of farm holding was found to be an asset, the situation of remaining indicators namely, availability of irrigation water and off-farm income sources, was unsustainable. In case of environmental protection, it was noticed that farmers

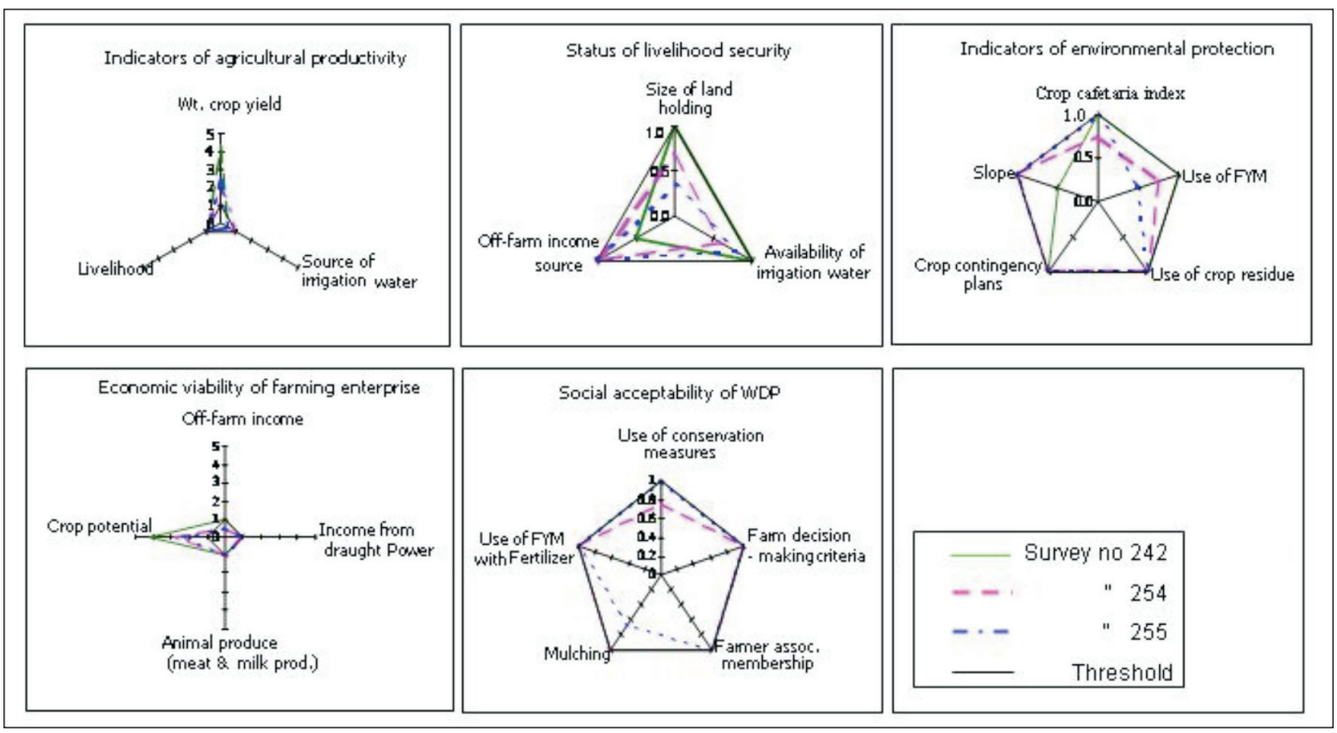


Fig. 26. Evaluation of sustainability of treated micro-watershed in Pamana using critical indicators

in TMW were using their land judiciously by practicing SLM diligently when compared to those of UTMW. Study of economic viability of agricultural enterprise as indicated by crop yield levels or crop potential level, was higher in case of TMW when compared to UTMW. For evaluation of social acceptability it was found that indicators like use of conservation measures, farm-decision making, membership of farmers associations, mulching and use of FYM along with chemical fertilizers were all practiced by farmers of TMW only.

It was noted that the integrated framework of sustainability indicators developed for identifying the strengths and weakness of watershed development program in various villages like Pamana was useful. Temporal analysis of these indicators at periodic interval would be useful in establishing the efficacy of watershed development program implemented in rainfed AESR. This methodology would also facilitate comparison of various watersheds at different time periods. The analysis also helps in identifying the weak aspects of the program in any given case; these issues must be strengthened at the earliest if agricultural sustainability is to be achieved in any given micro-watershed or village.

2.4 Crops and cropping system

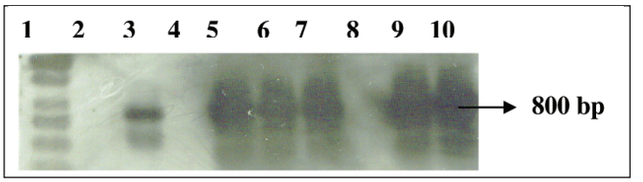
The crops and cropping systems practiced in a region are governed by its natural resources, climatic and edaphic factors. In order to understand the interaction of crops and cropping systems with the environment, basic, applied & strategic research is being pursued under various themes at the institute viz., understanding and management of various biotic and abiotic stresses, response of crops to changing climate, evolving appropriate farming systems, identifying appropriate farming systems, identifying appropriate microbial strains which can contribute effectively in harsh environments, developing profitable decision support systems and better use of under exploited crops. The achievements made during the year are presented below:

2.4.1 Genetic transformation of rainfed crops

2.4.1.1 Genetic transformation of sorghum for enhancing drought tolerance

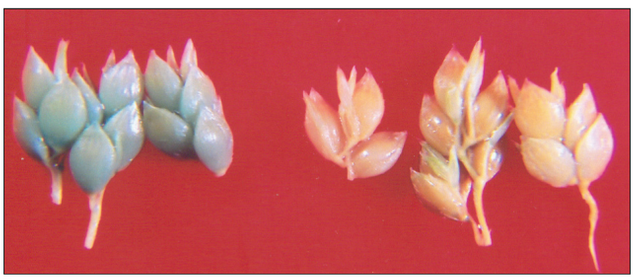
Drought continues to be a major yield-limiting factor in rainfed agriculture. *Sorghum bicolor* L. Moench cv. SPV 462 was transformed with the *mtl*D gene encoding for mannitol -1- phosphate dehydrogenase with an aim to enhance its drought tolerance. During the year, molecular analyses and physiological evaluation of the independent transgenic lines were carried out to confirm the transgene integration and expression in selected transgenic plants.

Genomic DNA of T1 transgenics and also of untransformed plants was PCR amplified using *mtlD* gene specific primers, and subjected to Southern hybridization using *mtlD* probe which confirmed the integration of the transgene sequence into the genome of the plants while the DNA from the untransformed plants did not show any signal .



Southern analysis of PCR amplified products of T1 transgenics obtained using *mtlD* gene specific primers. *mtlD* Probe was used. Lane 1: 1Kb ladder; Lane 2: blank; Lane 3: positive control; Lane 4: control Lanes 5-10:T1 transgenics

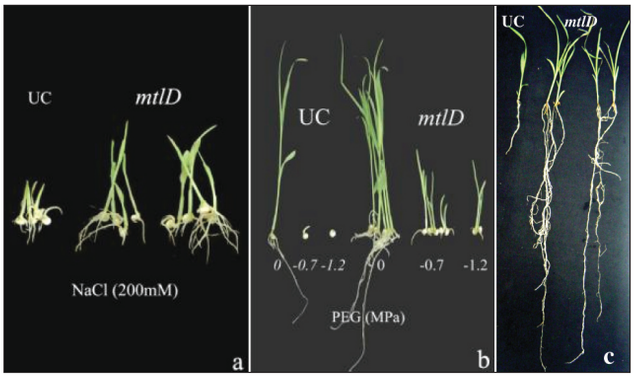
Further, total RNA isolated from T2 plants was subjected to RT- PCR using *mtlD* gene specific primers. Transgenic plants showed the expected 800 bp band, which demonstrated the transgene expression in these plants while untransformed control did not show such band. Also, developing florets from T1 plants were tested for GUS expression, which demonstrated the presence of (GUS) reporter gene indicating the transgene integration



Transgenic Untransformed

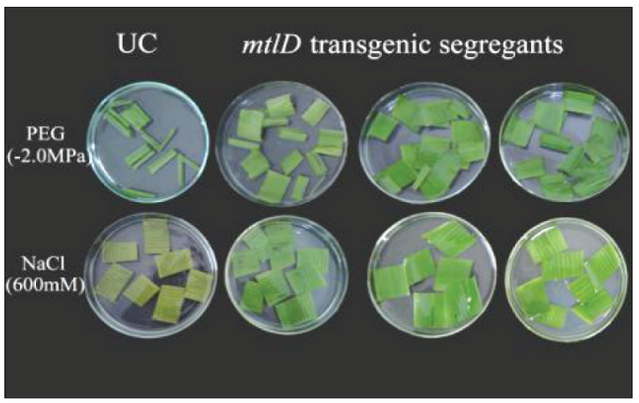
Stable GUS expression in developing florets

Preliminary physiological analyses were conducted on *mtlD* transgenics. The effects of PEG -0.7 MPa and NaCl 200 mM stress were studied by recording the % germination in untransformed controls as well as in transgenic seeds. Germination was several folds higher in *mtlD* transgenics as compared to controls Root and shoot lengths and root volume were significantly higher in transgenic lines as compared to controls at 15 days after stress and after recovery. The *mtlD* transgenics also showed significantly higher recovery in root growth.



Effect of NaCl (a) and PEG (b) on germination of T_0 seeds and root growth at 15 days after recovering from NaCl stress (c)

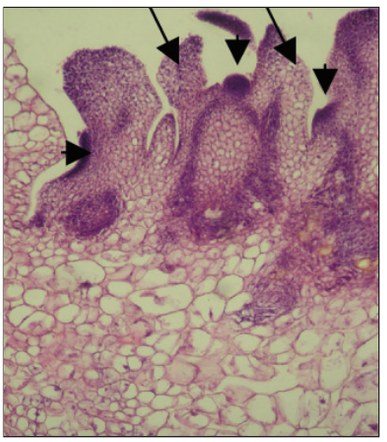
To assess the impact of *mtlD* gene on tolerance to water deficit and salinity, leaf segment assays were performed using youngest fully expanded leaf at 40 days after sowing from transgenic and untransformed control plants grown in glass house. Leaf segments from *mtlD* transgenic plants when incubated on PEG 8000 (-2.0 MPa) in general maintained remarkably higher leaf water content compared to control, which lost up to 30% moisture and exhibited severe leaf rolling . Leaf segments when incubated on 600mM NaCl retained chlorophyll and remained green while in control there was significant loss of chlorophyll.



Leaf rolling and chlorophyll loss in leaf discs of mtlD transgenics incubated in PEG (-2.0 MPa) and NaCl (600mM)

2.4.1.2 Genetic transformation of green gram

To develop transgenic green gram for improved drought tolerance, an efficient transformation protocol was developed using *Agrobacterium* mediated approach. Cotyledonary node explants from seedlings of green gram (ML 267) were used for transformation. Binary vector pCAMBIA 2301 was mobilized into *Agrobacterium* strain LB 4404 for optimization of transformation conditions viz., growth stage, quantity of bacterial culture, acetosysingone concentration, infection time and duration of co-cultivation. Transformation efficiency was determined based on GUS expression levels. The transformed explants were assessed for kanamycin sensitivity by culturing at various concentrations out of which 50 mg L^{-1} was found to be optimum for selection of transformants.



Longitudinal section of cotyledonary node explants depicting direct organogenesis in green gram

Histology studies revealed a direct organogenesis for shoot regeneration in green gram. Axillary shoot regeneration was observed as meristematic dome arising from the nodal regions of the explants. Continuous meristem formation was also apparent at the base of the newly formed shoots, primarily from the epidermal and sub-epidermal cells of the explants.

2.4.1.3 Regeneration of black gram

In an attempt to develop transgenic black gram, an efficient and rapid regeneration protocol was developed using cotyledons as explants. The callusing frequency ranged from 60 to 90% in response to various plant growth regulators. The frequency seemed to depend more on concentration of the BAP (Table 17). MS + B5 medium containing 4 mg L^{-1} BAP was most effective in producing regenerative calli. These cultures expressed maximum regeneration potential with shoot number up to12 per calli on regeneration media with no exogenous hormone supplementation. Green and robust shoots thus developed were successfully rooted within 15 days on 1/ 3rd MS medium. Over 90% of rooted plants grew well and produced normal seeds after transfer to the green house.

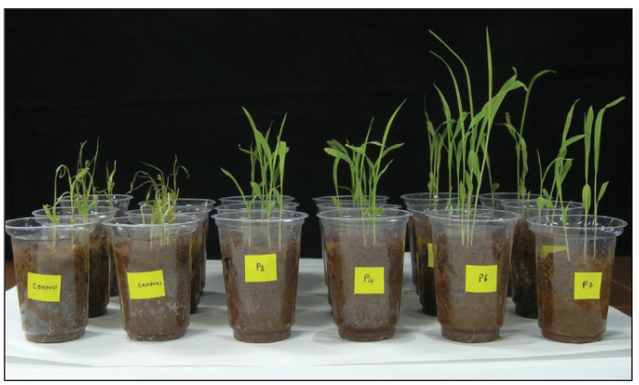
Table 17. Effect of various concentrations of BAP, NAA and IAA on callus induction and shoot regeneration from cotyledons of blackgram (T-9)

Growth regulators BAP	NAA (mg l^{-1})	IAA	Explants responded (%)	Callus diameter (mm)	Explants showing shoots (%)	Shoots per explant (no.)
0	0	0	n.d	n.d	n.d.	n.d.
1	0	0	90 ± 5.77	5.0 ± 0.58	50.0 ± 5.77	1.7 ± 0.67
2	0	0	70 ± 5.77	5.3 ± 0.33	63.3 ± 3.33	2.3 ± 0.33
3	0	0	80 ± 6.77	6.3 ± 0.67	76.7 ± 3.33	4.3 ± 0.33
4	0	0	80 ± 6.77	6.7 ± 1.33	83.3 ± 3.33	2.7 ± 0.33
1	0.5	0	60 ± 8.82	9.0 ± 1.15	n.d.	n.d.
2	0.5	0	70 ± 3.33	7.7 ± 0.88	n.d.	n.d.
3	0.5	0	80 ± 3.33	7.3 ± 0.33	n.d.	n.d.
4	0.5	0	90 ± 3.33	8.0 ± 0.58	n.d.	n.d.
1	0	1.0	60±11.55	7.3 ± 0.33	n.d.	n.d.
2	0	1.0	70 ± 8.82	7.7 ± 0.33	16.7 ± 3.33	1.3 ± 0.33
3	0	1.0	80 ± 6.67	6.7 ± 0.33	23.3 ± 3.33	1.7 ± 0.33
4	0	1.0	90 ± 5.77	7.3 ± 0.33	n.d.	n.d.

n.d. : Not Detected

2.4.2 Improvement of stress tolerance in plants

Some of the *Bacillus* and *Pseudomonas*, which were able to tolerate high temperatures and rhizosphere competent, have also shown excellent plant growth promoting abilities on pearl millet. Preliminary studies have also shown that microbial strains isolated from dry regions (yet to be identified) are able to help in survival of pearl millet plants upto two weeks at 50° C.



Influence of seed treatment with micro-organism on tolerance of millet seedlings to high temperature stress (50°C)

2.4.3 Evaluation of under exploited crops and forages

Horse gram is an important contingency crop for rainfed regions. Four improved strains of horse gram were evolved by CRIDA through mutagenesis. Based on superior performance, these strains were introduced into the advanced varietal trials of ICAR network project of arid legumes. All the entries were evaluated at HRF of CRIDA as one of the centers in southern locations during late *kharif* 2006-07 which is the second year in the testing. Each entry was grown in four replications of 8 rows of 4 m length. The crop was raised under rainfed conditions without any inputs with spacing of 30 x 10 cm.

Data were collected on seed yield, fodder yield, days to 50% flowering, days to maturity and presented in Table 18 for all the entries (which are coded) . It was observed that for pods per plant the variability in the range was 1:2, for branches per plant it was 1:1.5, for plant height 1: 1.5 and seeds per pod 1:1.35. The variability was highest for pods per plant followed by branches per plant, plant height and seeds per pod.

Table 18. Performance of horse gram entries for yield and maturity in AVT of the National Network project on Arid Legumes during *Kharif* 2006

Code number of the entry	Seed Yield (kg ha^{-1})	Fodder Yield (kg ha^{-1})	Days to 50% flowering	Days to maturity
HG-20	870.53	534.22	49	99
HG-21	851.18	595.23	48	100
HG-22	1155.64	787.19	47	98
HG-23	903.26	566.96	48	99
HG-24	836.00	568.44	50	99
HG-10	907.73	528.27	51	100
HG-11	803.56	542.25	50	101
HG-12	878.56	584.81	47	96
HG-13	1011.89	570.53	50	100
HG-14	969.63	636.90	47	100
HG-15	849.10	553.56	48	100
HG-8	836.30	410.71	49	100
HG-7	261.01	163.68	51	101
Mean	836.41	541.75	48.84	99.46

2.4.4 Forage production in marginal soils

Since forage production in rainfed regions requires adoption of drought tolerant species, particularly suitable for marginal lands, four sub types of *Cenchrus ciliaris* i.e. Molope, Co-1, Guyandah and Australian were evaluated for germination, establishment , growth, yield and drought tolerance during *kharif* 2006 at HRF. Since it was the first season only, establishment and initial growth data were collected.

Molope recorded significantly highest dry forage yield of (2.25 t ha^{-1}), followed by Co-1, (2.00 t ha^{-1}), Guyandah (1.75 t ha^{-1}) and Australian (1.4 t ha^{-1}). These yields (Table 19) were pooled from 2 harvests, first at 90 days after germination and second at 60 days after first harvest. First harvest yielded 0.75 t ha^{-1}) and the subsequent harvest yielded 1.13 t ha^{-1} revealing that rate of biomass production during re-growth was faster than the initial growth rate during first 90 days.

At 90 days after germination (first harvest), Molope recorded highest plant height (76 cm) followed by Co-1 (73 cm), Guyandah (70 cm) and Australian (68 cm). Similar trends were revealed at second harvest of 90+60 days after germination. Data on dry weight increment showed that at 90 days after germination (first harvest),

Table 19: Growth and yield of *Cenchrus ciliaris* sub types (dry weight in t ha^{-1}) during first year

Days after germination	Molope	Co-1	Guyan -dah	Austra -lian	Mean
60	0.25	0.20	0.20	0.20	0.225
90 (first harvest)	0.85	0.78	0.70	0.60	0.75
90 +30	0.45	0.40	0.25	0l25	0.34
90 + 60 (second harvest)	1.40	1.22	1.05	0.85	1.13
Total yield from two harvests	2.25	2.00	1.75	1.45	1.86

Molope attained significantly higher dry weight 80 g plant^{-1}, followed by Guyandah and Australian. In terms of drought tolerance, Molope > Co-1 > Guyandah > Australian were found superior in that order.

2.4.5 Interaction of elevated carbondioxide and plant growth parameters

2.4.5.1 Crop response to elevated CO_2

Studies on response of various crops to elevated CO_2 were continued during the year. Earlier studies indicated differential response of pulses, cereals and oilseeds to elevated CO_2 in root growth, flowering and yield. The response of castor (cv.DCS-9) to elevated CO_2 was studied during the year using open top chambers (OTCs). Three CO_2 levels were maintained in OTCs : 700 ppm, 550 ppm and 365 ppm (Ch-control) in addition to open control.

The shoot length of castor increased with enhanced levels of CO_2 more so at higher concentration. Root length, volume and dry weight were significantly increased under 700 ppm followed by 550 ppm over Ch-control and open control. Root shoot ratio initially was low and reached highest value at 90 DAS. The leaf area, leaf weight and leaf area duration was increased during the crop growth period at elevated CO_2 levels than at ambient level, whereas specific leaf weight decreased under elevated CO_2 , possibly due to more expansion of leaf than the increment in dry weight under elevated CO_2. Crop growth rate also increased under both elevated CO_2 and open control than Ch-control which may ultimately increase the yield.

The improvement in spike length, spike weight, capsule number, capsule weight and seed size were observed under CO_2 enrichment. The increased capsule number and seeds per capsule contributed to increased seed yield at 550 ppm, where as this was due to capsule number and seed size at 700 ppm. (Table 20). The seed yield increased by 17.3% with 150 ppm increase in CO_2 from 550 to 700 ppm. This clearly showed that the increased CO_2 levels improved both biomass and economic yield.

The oil content was reduced under elevated CO_2 than Ch-control and open control. The palmitic, stearic, oleic and linolenic acids were increased under 700 ppm, whereas palmitic and stearic decreased at 550 ppm than Ch-control and open control. The major constituent of castor oil, ricinoleic acid content decreased under elevated CO_2.

Table 20. Yield and its components of castor (DCS-9) primaries under elevated CO_2 (550 and 700 ppm) and chamber and en control conditions

Parameters	Conditions			
	700 ppm	550 ppm	Ch-Control	Open Control
Total plant biomass (g)	423.8	386.6	358.7	339.3
Spike length (cm)	26.0	27.2	23.8	19.2
Effective spike length(cm)	24.4	23.7	21.2	13.5
Spike dry wt. (g)	35.7	35.6	24.4	14.1
No. of capsules	31.2	37.4	18.9	11.0
Capsule dry wt. (g)	26.8	25.4	17.4	11.4
Seed wt. (g)	17.9	17.1	6.7	7.5
Husk wt. (g)	8.9	8.2	10.7	3.8
100 Seed wt. (g)	23.5	23.3	22.0	20.0
Harvest Index	4.2	4.4	1.9	2.2

2.4.5.2 Elevated CO_2 and N metabolism

The photosynthetic responses of C_3 and C_4 plants to increased CO_2 levels are different and this differential response is likely to be for nitrogen metabolism also. To explore this, nitrate uptake and assimilation studies were taken up with a C_3 (sunflower) and C_4 (pearl millet) crop plants at ambient (365 ppm) and elevated CO_2 (550ppm) levels.

Nitrate uptake was determined in 10 day old plants by ambient depletion technique at various concentrations of nitrate *viz*; 0.025,0.05, 0.075, 0.1, 0.2, 0.5, 1.0 and 2.0 mM. The uptake rates were relatively more under elevated CO_2 conditions. This was more prominent at higher concentrations of nitrate in both sunflower and pearl millet.

Leaves from 15 day old seedlings of sunflower and pearl millet grown with 0,5,15 and 30 mM NO_3^- under ambient and elevated CO_2 were used for the assay of NR activity and estimation of reduced N. Nitrate reductase activity (μmole NO_3^- reduced g^{-1} fr. wt. h^{-1}) was more in sunflower compared with pearl millet. It was significantly higher at 5 and 15 mM under elevated CO_2 compared with ambient conditions in both the crop species. This increase was 33% and 4 % in pearl millet where as it was 23% and 11% in sunflower at 5 and 15 mM (Fig.27a). The nitrogen content (mg g^{-1} dry wt.) was higher in sunflower at 5 mM (7.25%) and 15mM (19.7%) nitrate levels under elevated CO_2 conditions (Fig. 27b), however

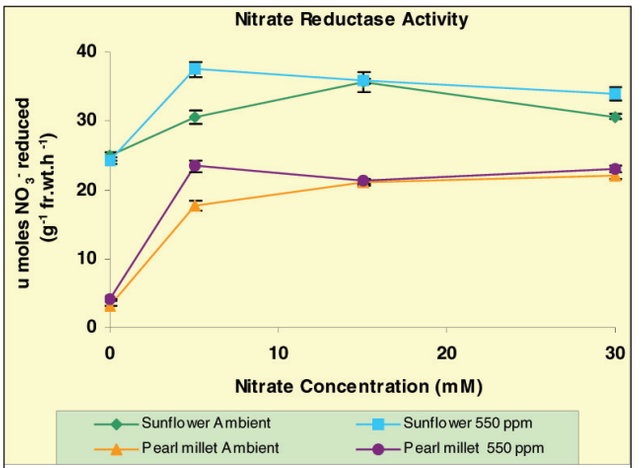


Fig. 27a. Nitrate reductase activity in leaves of sunflower and pearlmillet grown at different nitrate concentrations under ambient and elevated CO_2 conditions

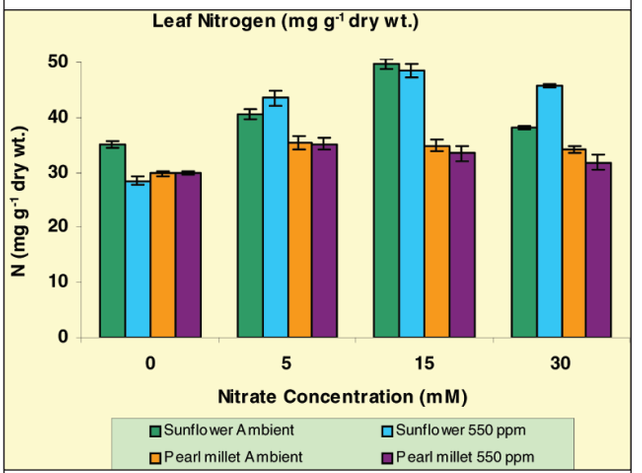


Fig. 27b. Nitrogen content in leaves of sunflower and pearlmillet grown at different nitrate concentrations under ambient and elevated CO_2 conditions

there was no significant difference in leaf nitrogen content of pearl millet.

2.4.5.3 Elevated CO_2 and insect feeding

Experiments were conducted to evaluate the impact of elevated CO_2 on castor semilooper (*Achaea janata*). The host castor crop was grown under ambient as well as elevated CO_2 conditions. Four treatments were adopted to study the impact of host-mediated effect (plant growing conditions) on insects and were maintained in open top chambers. The crops were grown under four different conditions *viz*., ambient (365 ppm CO_2), elevated CO_2 (550 and 700 ppm) and chamber without elevated CO_2 . Insect larvae were reared under two different conditions viz., 550 ppm CO_2 with 27°C and 365 ppm with 25°C.

For each treatment,10 larvae were selected and reared on foliage taken from the above treatments. The larval parameters namely larval length and weight, % of feeding, weights of faecal matter and leaves, larva, pupa and adult periods and hatchability of eggs were recorded. Using the data on larval parameters, various indices of insect performance *viz*., relative growth rate (RGR), efficiency of conversion of digested food (ECD), approximate digestibility (AD), relative consumption rate (RCR) and efficiency of conversion of ingested food (ECI) were determined gravimetrically.

The impact of elevated CO_2 and temperature on various insect performance indices of *A.janata* is presented in Table 21. Substantial differences were noticed among the treatments. Larvae survived very well

Table 21. Impact of elevated CO_2 and temperature on indices of *Achaea janata*

Treatments		RGR ($mg^{-1}g^{-1}$ day^{-1})	RCR ($mg^{-1}g^{-1}$ day^{-1})	ECD (%)	AD (%)	ECI (%)
Insect rearing condition	Plant growing condition					
CO_2 550 ppm +27°C	CO_2 550	0.062	1.11	6.5	87.7	5.7
CO_2 550 ppm+27°C	CO_2 700	0.062	1.173	6.4	85.6	5.4
CO_2 550ppm +27°C	Chamber Control	0.074	0.874	11.8	74.6	6.8
CO_2 550ppm+27°C	Open Control	0.078	0.882	11.8	74.6	8.8
CO_2 365ppm+25°C	$CO_2$550	0.056	1.082	6.2	87.4	5.3
CO_2 365ppm+25°C	$CO_2$700	0.063	1.417	5.1	88.8	4.5
CO_2 365ppm+25°C	Chamber Control	0.073	1.045	7.8	90.4	7
CO_2 365ppm+25°C	Open Control	0.076	0.787	10.7	84.4	9.7
SEm±		0.003	0.129	1.01	2.5	0.8
L SD at 0.05		0.006	NS	2.02	NS	NS
Host mediated factor 1						
CO_2 550		0.059	1.094	6.4	87.5	5.5
CO_2 700		0.062	1.295	5.7	87.2	5
Chamber Control		0.073	0.959	9	86.6	7.8
Open Control		0.077	0.835	11.7	79.5	9.3
SEm±		0.002	0.091	0.7	1.8	0.6
LSD at 0.05		0.004	0.195	1.5	3.8	1.2
Direct effect of CO_2 and temp-factor2						
CO_2 550ppm+27°C		0.069	1.009	8.8	82.7	7.1
CO_2 365ppm+25°C		0.067	1.083	7.6	87.7	6.6
SEm±		0.005	0.065	0.5	1.3	0.4
L SD at 0.05		0.011	NS	1.1	2.7	NS
CV%		4.87	15.14	14.98	3.67	14.08

in all the treatments. Development time increased by 20-25% in larvae fed on foliage obtained from elevated CO_2. The two factors (*viz*. host mediated factors and CO_2 concentration) also significantly influenced the RGR, ECD and AD indices. Both relative consumption rates and total consumption varied significantly and larvae consumed more foliage than the ambient and chamber treatments. Foliage obtained from elevated CO_2 was 8% more digestible than ambient CO_2 foliage. Larvae fed on leaves with elevated CO_2 were much less efficient in converting digested castor leaves into body mass. Finally, efficiencies of ingested food (ECI) for larvae on high CO_2 foliage decreased substantially for insects fed on elevated CO_2.

2.4.6 Farming systems

2.4.6.1 Participatory Farming systems analysis

Crop yields in rainfed area of Southern Telangana Zone are unsustainable due to erratic rainfall. Integration of crop, livestock and tree-based systems are expected to provide stabililty in production for higher returns. With this background, farming system modules under Vertisol and Alfisol regions involving marginal (< 1 ha), small (1 to 2 ha) and medium to large (> 4 ha) farmers were documented in Shabad Mandal of Ranga Reddy district.

For marginal farmers in Vertisols, maize + pigeonpea – cotton (60:40) + 50 sheep recorded the highest net income (Rs 23,200 ha^{-1}) and employment generation (982 man days) followed by maize + pigeonpea + 50 sheep (Rs.22,457 ha^{-1} and 793 man days) and maize + pigeonpea + 2 buffaloes (Rs.22,431 ha^{-1} and 63 man days) for marginal farmers under rainfed conditions (Table 22). About 72% of farmer's own man days are required to be spent as labourers in other farm to meet their family needs in a year.

For small farmers, maize + pigeonpea – cotton with 50 sheep gave the highest net income (Rs.40489) followed by maize + pigeonpea – carrot / chickpea – cotton + 2 buffaloes (Rs.31882). While maize + pigeonpea – cotton with 2 buffaloes gave Rs.9990 additional income over maize + pigeonpea – cotton system (Table 23). The Farming system modules under rainfed and limited irrigated conditions generate 183 mandays in agriculture and 130 mandays in livestock rearing. Under limited irrigation conditions, paddy (K) – paddy (R) – chickpea + 1 buffalo recorded the highest net income (Rs.37467) followed by paddy both seasons with chickpea system (Rs.34167).

For large farmers, paddy (K) – guinea grass – cotton – maize – chickpea in 20 ha + 3 buffaloes gave the highest net income (5,99,780) with 2.75 BC ratio followed by Cotton – maize – chickpea + 3 buffaloes (Rs.5,12,210) with 2.35 BC ratio. On an average, livestock of three buffaloes contributed 50 to 55% net income to the farming system module.

In Alfisols, a farming system module of sorghum + pigeonpea + 1 buffalo and 50 sheep recorded highest net income (Rs.28927) followed by castor with 50 sheep (Rs.26554) and maize + pigeonpea (M+PP) with 50 sheep (Rs.22,557) for marginal farmers (Table 24). For small farmers, M+PP –cotton with 1 buffalo and 50 sheep gave the highest net income (Rs.41,950) followed by maize + pigeonpea – cotton system with 1 buffalo (Rs.26,000) (Table 25). Under marginal farmers category, about 68% of their mandays are required to be used as labourers in other farms to earn their livelihood for the entire year.

Table 22. Profitability of farming system modules for marginal farmers (1 ha) in vertisols of Southern Telangana of A.P, 2006-07

Enterprise	Gross Income (Rs.)	Cost of Cultivation (Rs.)	Net Income (Rs.)	BC Ratio
M + PP (100)	17688	12719	4969	1.39
M+PP (100) + 2 Buffaloes	48675	26244	22431	1.85
M+PP (100) + 50 sheep	49163	26706	22457	1.84
M+PP-cotton (60:40)	24150	16850	7300	1.43
M+PP-cotton (60:40) +2 Buffaloes	44200	25850	18350	2.40
M+PP-cotton (60:40) +50 sheep	53300	30100	23200	1.77

M = Maize, PP = Pigeonpea

Table 23. Profitability of farming system modules for small farmers (2.0 ha) in Vertisols

Enterprise	Gross Income (Rs.)	Cost of Cultivation (Rs.)	Net Income (Rs.)	BC Ratio
Rainfed				
M+PP – cotton	45714	31575	14139	1.45
M+PP-cotton +2 LS (BF)	69014	44885	24129	1.53
M+P-cotton +50 sheep	85314	44825	40489	1.90
M+PP-cotton-S +PP-horse gram	47563	30500	17063	1.56
M+PP-cotton –S +PP-horsegram + 2 LS (BF)	70863	43810	27053	1.62
M+PP-carrot/chickpea -cotton +2 LS (BF)	87706	55824	31882	1.57
Irrigated				
Paddy (K)-cotton	54834	33592	21242	1.63
Paddy (K) – cotton +1LS (BF)	82634	50290	32344	1.64
Paddy (K)-paddy (R) – chickpea	73500	38883	34167	1.89
Paddy (K)-paddy (R) –chickpea + 1LS	83250	45783	37467	1.82
M+PP-paddy (K) – veg.	70714	55435	15279	1.28
M+PP-paddy (K) – veg + 2 (BF)	94014	70745	23269	1.33

K = Kharif, R = Rabi, LS =Livestock, BF =Buffalo

Table 24. Profitability of different farming system modules for marginal farmers (1 ha) in Alfisols (Rainfed)

Enterprise	Gross Income (Rs.)	Cost of Cultivation (Rs.)	Net Income (Rs.)	BC Ratio
M+PP	20875	11034	9841	1.89
M+PP + 50 sheep	49163	26606	22557	2.18
Castor	8250	4056	4194	2.03
Castor + 50 sheep	45750	19206	26544	2.38
Sorghum + PP	8625	4088	4537	2.10
Sorghum + PP + 1 BF	21625	9548	12077	2.26
Sorghum+PP +50 sheep + 1 (BF)	52875	23948	28927	2.21

M+PP: Maize + Pigeonpea

Table 25. Profitability of farming system modules for small farmers of Alfisols (Rainfed)

Enterprise	Gross Income (Rs.)	Cost of Cultivation (Rs.)	Net Income (Rs.)	BC Ratio
M+PP-cotton	40958	29379	11579	1.39
M+PP-cotton+ 1 BF	66550	40550	26000	1.64
M+PP-cotton + 1BF + 50 sheep	89375	47425	41950	1.88
Castor – M+PP	28333	20158	7275	1.35
Castor–M+PP + 50 sheep	53625	31217	22408	1.72
M+PP- Sorghum + PP	32550	21887	10367	1.47
M+PP –S + PP + 1 BF	42300	27887	14413	1.52
M+PP	29771	20900	8871	1.42

M+PP : Maize + Pigeonpea

2.4.6.2 On-station model at the research farm

The farming system module initiated in 1.14 ha area of a watershed in CRIDA research farm comprises arable cropping of sorghum + pigeonpea, castor + cluster bean and sole pearl millet and pigeonpea (40.9%) grasses (9.9%) agro-forestry with aonla + cowpea, pongamia + cowpea and custard apple (28.6%). Bushes of curry leaf and jatropha (9.6%) were included during this year. Henna and teak were grown along boundary of watershed area. The results during second year indicated that arable crops in different systems contributed Rs.6189 to the gross income and Rs.3728 to the net income with 2.51 BC ratio, while grasses covering 0.12 ha area gave Rs.1423 gross income and Rs.978/- net income, respectively. The agro-forestry options planted in watershed area (0.33 ha) recorded the gross and net income of Rs.3277 and Rs.1880 respectively. The horticulture component 0.10 ha area the gross income of Rs.4967 and net income Rs.3547. The bushes covering 0.11 ha gave a gross income of Rs.400/- Thus the farming system module covering crops, grasses, agro-forestry and bushes gave a total gross income of Rs.18,286 and net income of Rs.11,380 with BC ratio of 2.65 from 1.14 ha area. The biomass of 5367 kg was produced as fodder which is sufficient to feed two livestock (dairy) or 10 sheep during the entire year.

2.4.7 Refining regional level prediction of cotton yield

Infocrop model was used to estimate the cotton crop yields in Nagpur, Bharuch, Dharwad and Sirsa districts for 2006-07. Rainfall data from different rainfall stations was collected and theissen polygons were generated. Similarly, soil attribute information like soil depth, soil type (particle size distribution) was collected from soil resource maps. Crop acreage and its distribution were derived from satellite imagery. Cotton crop model was run for homogenous polygons obtained through superimposition of theissen polygons, soil attribute polygons and crop coverage imagery. Estimations were obtained for each soil type and soil depth and aggregated after accounting for the cotton cropped area under each category of soil type and depth. This integrated approach resulted in estimating the yield variability under different soil types and depths and an estimate of yield and productivity for the district (Tables 26-29).

2.4.8 Integrated Pest Management (IPM)

2.4.8.1 Isolation of effective strains of Bt

In the microbial biodiversity project, soil samples from eight dryland locations (Table 30) were screened

Table 26. Estimated yield for different polygons aggregated on soil texture and station basis

Soil type	Area (ha)	Average lint yield (kg ha^{-1})
Clay	16250	384
Coarse loamy	10271	465
Fine	1362	620
Fine loamy	36313	737
Loamy	2804	419
Loamy Skeletal	1435	343
Grand Total	68435	589
Station		
Kalmeshwar	6747	559
Kamptee	8251	745
Katol	2210	661
Kuhi	11745	689
Nagpur	7140	352
Narkhed	7099	726
Ramtek	3434	682
Saoner	16159	399
Umarer	5650	772
Grand Total	68435	589

Table 27. Estimated yield for different polygons aggregated on soil depth basis, District: Bharuch

Soil Type	Soil depth (cm)	Area (ha)	Lint (kg ha^{-1})
Clayey	40	1513	243
Clayey	90	9613	530
Clayey	120	101371	468
Loamy	120	17736	653
	Total	130233	495

Table 28. Estimated yield for different polygons aggregated on soil texture basis, District: Sirsa

Soil texture	Area	Average yield	Lint, kg ha^{-1}	Total Production (lakh tonnes)
Fine loamy	28111	1965	688	552
Coarse loamy	88416	1535	537	1356
Sandy	81589	1373	480	1120
Total	198116	1529	535	3029

Table 29. Estimated lint yield (kg ha^{-1}) for different districts for years 2005-06 and 2006-07

District	2005-06	2006-07
Nagpur	540	589
Sirsa	535	550
Dharwad	345	533
Bharuch	530-547	495-513

Table 30. Recovery of Bt colonies from dryland soil samples

Soil sample	Code	Total No. of colonies on the agar plate	Bt like colonies	Bt recovery (%)	No of crystalliferous colonies
Udaipur	Uda	160	50	31.2	11
Rajkot	Rkt	40	35	87.5	5
Bellari	Bel	35	27	77.1	4
Hisar	His	60	35	58.3	1
Bijapur	Bjp	40	20	50.0	5
Philbai	Phb	150	16	11.0	2
Solapur	Slp	150	18	12.0	3
Arjia	Arj	40	16	40.0	8

for the presence of spore forming *Bacilli*. The recovery of *Bacillus thuringiensis* ranged from 10 to 87% of the total colonies isolated from each soil sample. However, further screening through rapid staining and screening techniques revealed that a total of 39 crystalliferous isolates could be recovered and the highest recovery was with Udaipur strains of Bt.

All the confirmed Bt isolates isolated from Udaipur were tested against four insect pest species namely, *Spodoptera litura, Achaea janata, Helicoverpa armigera and Agrotis spp*. UDA 5 and 7 isolates exhibited 25-50% mortality against *S. litura.* The larval weight ranged between 2.5 and 12.5 mg as compared to control (larvae with 17.5 mg). Among the isolates that caused significant feeding cessation were Bel-26, Uda-35 and Uda-4.

The tested isolates exhibited diversity in terms of virulence to target pests. Isolates Uda 4, 5, 7, 35 and 36 were found active against all the four insect pests tested (Table 31). Uda 1 and 2 were effective against *Helicoverpa and Agrotis*. Uda 9 was effective against *Agrotis* and *Achaea* and did not show any activity against *Spodoptera*.

In another project aimed at development of suitable formulation for semilooper GV and generation of data on bio efficacy, contaminants and shelf life, 2700 LE of *Achaea janata* granulosis virus (AjGV) was produced

Mortality and feeding cessation in *Helicoverpa* larvae due to Bt isolate Uda 35

Table 31. Activity of Bt isolates against four insect species

Level of Activity against the larvae	Isolates active against *S.litura* within 72 h of treatment	Isolates active against *A.janata* within 48 h of treatment	Isolates active against *H. armigera* with in 48 h of treatment	Isolates active against *Agrotis* spp.
None	Uda 1, 2, 3, 6, 8-24, 27-34, 37-46, 47-50	Uda 1, 2, 8, 11.	Uda 3, 29.	Uda 13
Low (10-25%)	Uda 4, 26, 35, 36.	Uda 3, 10, 12	Uda 9,13, 20, 23	-
Moderate (25-50%)	Uda 5,7	Uda 5, 6, 9	Uda 4, 24	Uda 7, 9, 35.
High (50-100%)	-	Uda 4, 7	Uda 1, 2, 5, 7, 35, 36	Uda 1, 2, 4, 36

aseptically and tested for contaminant levels in the viral preparations by plating serial dilutions on suitable media. The contaminant was well below the permissible levels of 10^4 cfu mL^{-1} in all the virus preparations. Both the primary culture and formulations were free from human pathogens as per Central Insecticide Board norms. Laboratory bio-efficacy and field efficacy studies of the formulations were undertaken by RARS, Palem during *kharif* 2006 and it was found that Formulation 1 was best among the tested series .

Granulosis virus infected semilooper larva, primary culture and formulations

2.4.8.1 Development of two stage technique for mass production of aerial conidia of bio-control fungus *Metarhizium*

A two stage production technique involving an initial liquid phase followed by transfer of broth to solid medium was developed for production of aerial conidia of insect pathogenic bio-control fungus, *Metarhizium.* The complete protocol was tested for its suitability on three rice varieties (Sona, Hamsa and coarse broken rice) used as solid substrate in the second phase of production process. Two types of autoclavable bags (with and without an inbuilt filter for passive air exchange during the production cycle in solid phase) were tested and compared for maximizing spore production. Highest spore production (34 g of spore per bag, sufficient for field application in ca 1 acre) was obtained with fine rice in bags with filter (22% increase in spore yield compared to bags without in-built filter). Spore yield per g substrate, spore number per g powder and moisture content after drying were estimated for each batch of production. The ideal moisture content for shelf-storage of spore (5-10%) before field application was achieved with production on fine rice.

2.4.8.2.1 Diversity of fungal isolates for temperature tolerance – germination studies

Twelve fungal isolates (5 isolates of *Beauveria bassiana*, 5 isolates of *Nomuraea rileyi* and 2 isolates of *Metarhizium* were studied for differences in speed of germination (a parameter for higher virulence) at different temperatures (18, 25, 27 and 32^{0}C) on glass slides smeared with a thin layer of nutrient agar in an environmental test chamber (constant humidity of 65%). Results showed that all the *Beauveria* isolates showed >80% germination at 17 h and time for 100% germination of spore was uniform at 26-27 h at 25, 27 and 32^{0}C except 18^{0}C. Contrastingly, *Metarhizium* isolates showed ca 40% germination by 17 h and reached 100% germination by 25 h at higher temperatures (32^{0}C). In case of *Nomuraea* isolates even at the optimum temperature (25^{0}C), initial germination (ca 30%) was achieved only by 30 h and 100% germination by 38 h.

2.4.8.2.2 Diversity of fungal isolates for temperature tolerance – growth studies

Colony growth (diameter) of all the 12 fungal isolates was measured at 7 and 13 days after inoculation on suitable solid media in Petri dishes at 18, 25, 32 and 36^{0}C. Relative growth of isolates at higher temperatures was expressed as percent growth at the most optimum temperature (25 ^{0}C) to bring out differences in virulence. One isolate of *Beauveria* (NRRL) and both the isolates of *Metarhizium* showed >80% relative growth by 7 days. *Metarhizium* isolate (MA-HRF) was the only isolate to tolerate a temperature of 36^{0}C with a relative growth of 50% compared to its growth at 25 ^{0}C by 9 days.

2.4.8.2.3 Virulence of fungal isolates against *Helicoverpa armigera*

Twelve isolates of three entomo-pathogenic fungi were tested for their virulence. *Beaveria* isolates (Hyd, 913 and NRRL) caused 80-100% mortality in 3 days after treatment. Among the *Nomuraea* isolates, Bhongir-2 isolate caused 50% mortality in 6 days. Only one isolate of *Metarhizium* (MA-Hyd) caused 80% mortality in 4 days.

2.4.8.3 Thermal constants for insect species

In order to develop effective models for prediction of the pest incidence in dryland crops, it is essential to have thermal constants in terms of degree day requirement for the insect development. During 2006, laboratory experiments were conducted to determine larval instars of defoliators.

The greatest widths across the head capsule were measured every day from the start of hatching till pupation. Mean head capsule widths of *S. litura* were found to be 0.24, 0.50, 0.76, 1.22, 2.08 and 3.04 mm for 1st to 6th instar respectively. The same values for *A. janata*

Table 32. Morphometric measurement to determine larval instars of major defoliators

Larval stage	*Spodoptera litura*		*Achaea janata*	
	Head capsule (mm)	Body length (mm)	Head capsule (mm)	Body length (mm)
I instar				
Range	0.21-0.31	0.93-2.81	0.41-0.52	3.88-6.72
Mean ± SD	0.24 ± 0.03	1.74 ± 0.72	0.43 ± 0.03	5.62 ± 0.80
II instar				
Range	0.44 -0.56	2.50-3.51	0.62-0.78	6.46-18.10
Mean± SD	0.50± 0.03	3.96±1.00	0.69±0.05	9.97±3.47
III instar				
Range	0.69-0.81	7.50-8.44	0.93-1.24	10.86-20.68
Mean± SD	0.76±0.04	8.02±0.37	1.06±0.11	16.74±3.59
IV instar				
Range	1.00 -1.38	6.88-16.00	1.86-2.43	16.54-35.41
Mean± SD	1.22±0.08	11.90±2.20	2.08±0.13	24.59±4.32
V instar				
Range	1.88-2.63	12.18-28.75	1.96-3.36	21.20-46.53
Mean± SD	2.08 ± 0.26	19.13 ± 5.07	3.13 ± 0.20	38.25 ± 5.36
VI instar				
Range	2.81-3.25	-23.12-38.13	-	-
Mean± SD	3.04 ± 0.10	29.90	-	-

were in the order of 0.43, 0.69, 1.06, 2.08 and 3.13 mm for 1st to 5th instar respectively (Table 32). Wide ranges and high variance values were recorded in the larval lengths in all the instars for both the species. More so, larval length values overlap between instars. While the same values for head capsule widths showed least variance and there is no overlap of these values between subsequent instars. Hence the head capsule widths determined in this experiment could be used to precisely determine the larval stages of these two insect species.

2.6.8.4 Detection of pest incidence using remote sensing

In order to characterize the spectral response of crops affected by insect and diseases and study the feasibility of using space borne data in quantification of pests and disease incidence, field experiments were conducted to characterize the spectral reflectance at different wave lengths using a 16 channel multispectral radiometer (CropScan, USA) over a 450-1650 nm range. Groundnut, castor and rice were selected as test crops. Three disease levels of late leaf spot were created on potted groundnut. Field observations were recorded during severe termite incidence on groundnut and semilooper attack on castor in HRF during *kharif* season. The data on brown plant hopper infested rice were recorded during *rabi* from farmers' field. The spectral observations using radiometer were made near midday, within 2 hrs of solar noon. The measurements were taken from a height of 1.6 m above the crop canopy. Ten measurements were recorded per each treatment and the resulting data was averaged.

Higher absorption in the Near Infrared Region (NIR) between 760-1240 nm was observed for healthy plants compared to the diseased plants. In the severely affected termite plots of groundnut, the typical chlorophyll absorption bands in the visible region between 500 -710 nm were missing and in the NIR region the difference in reflectance between healthy and affected crop is minimum (Fig. 28). The spectral signatures from severely affected castor crop showed that the percent reflectance in the visible region between 560-710 nm was higher in

the defoliated crop compared to healthy and reverse is true in the NIR region between 810-1100 nm. In case of rice, spectral reflectance in the region between 760-1100 nm could differentiate the healthy and hopper affected plants. Decrease in reflectance in this region was proportional to the number of hoppers per plant. This could be due to collapse of leaf tissues due to hopper damage. The higher reflectance in the visible region (560-710 nm) was observed only when the damage was very severe (hopper burn). Different spectral indices were compared to distinguish healthy and stressed plants. NDVI was found to be useful for defoliating pests like castor semilooper. All the ratios tested were useful to differentiate sucking pests like Brown Plant Hopper (BPH) on rice and termite damage on groundnut. In case of groundnut late leaf spot disease, the differences in the spectral indices between different treatments was minimum and hence separate indices need to be developed to distinguish healthy and diseased crop.

2.4.8.5 Weather – disease relationship in groundnut

For disease development, weather at canopy level is important. However, often it is not possible to collect this data due to non-availability of infrastructure. Hence, an attempt was made to establish a functional relationship between weather from metlab and the weather at canopy level. Field trials were laid out during *kharif* 2005 and 2006 with groundnut cv. JL 24 and the crop was sown at a spacing of 45x10 cm at HRF. A sensor with data logger was placed in the field at canopy level to record temperature and relative humidity at canopy level. The field was artificially inoculated with late leaf spot pathogen by randomly transplanting the infected plants across the field. Randomly selected 100 plants were tagged and late leaf spot progression was recorded at regular interval up to harvest.

Maximum- and minimum-temperature followed logistic relationship. The R^2 was highly significant. However, for morning- and evening-relative humidity, there was a variation in relationship between *kharif* 2005 and *kharif* 2006. While in *kharif* 2005 an exponential relationship was observed for both parameters, during *kharif* 2006 a sinusoidal relationship was observed. The functional relationships for temperatures could be used for developing weather based forewarning systems. However, for relative humidity, the relationships need to be refined with further experiments.

For disease development, weather at canopy level is important. However, often it is not possible to collect

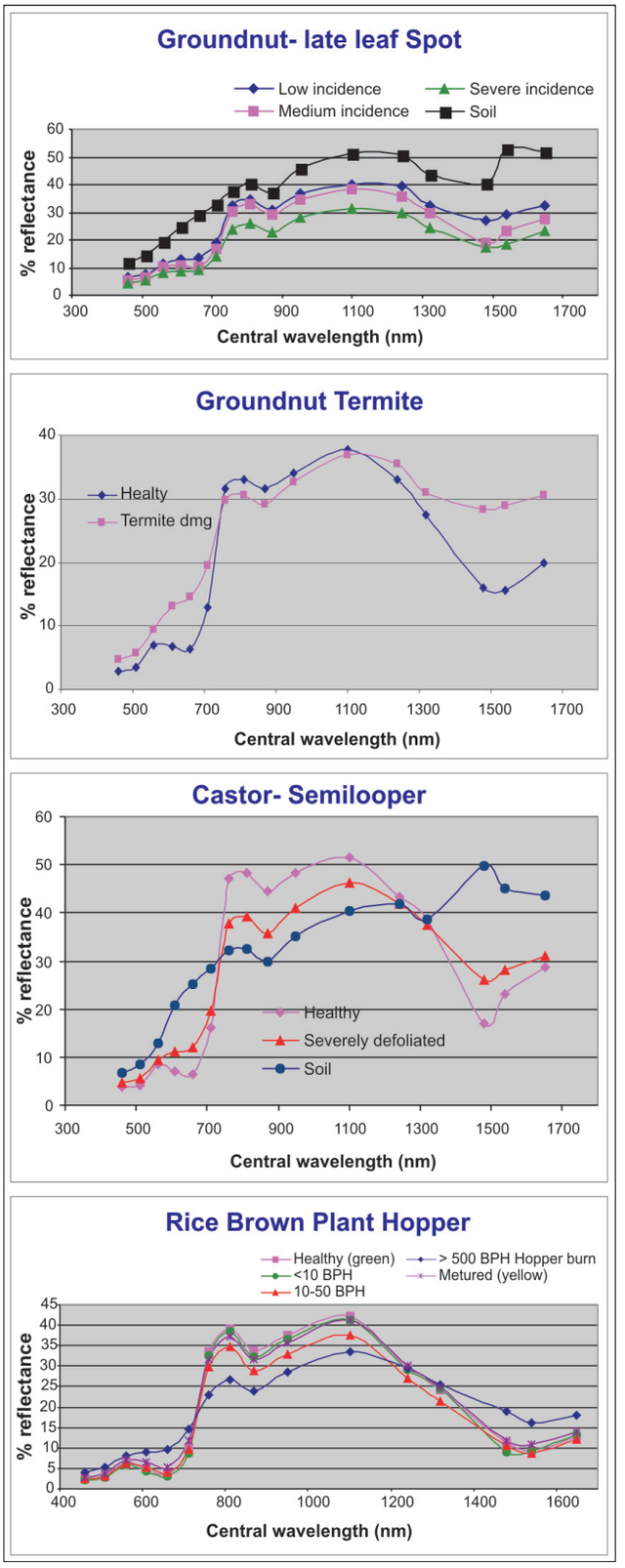


Fig. 28. Spectral reflectance of healthy and pest/disease infected crops

this data due to non-availability of infrastructure. Hence, an attempt was made to establish a functional relationship between weather from metlab and the weather at canopy level. Field trials were laid out during *kharif* 2005 and 2006 with groundnut cv. JL 24 and the crop was sown at a spacing of 45x10 cm at HRF. A sensor with data logger was placed in the field at canopy level to record temperature and relative humidity at canopy level. The field was artificially inoculated with late leaf spot pathogen by randomly transplanting the infected plants across the field. Randomly selected 100 plants were tagged and late leaf spot progression was recorded at regular interval up to harvest.

2.4.9 Sustainable agriculture through agri- horti /horti- pasture systems

Field experiments were conducted in agri-horti/horti-pasture systems in Alfisols at HRF of CRIDA.

2.4.9.1 Agri-horti system

2.4.9.1.1 Intercropping of medicinal plants in mango orchard

Medicinal plants such as *Withania somnifera* (Ashwagandha), *Cassia angustifolia* (Senna) and *Ocimum basilicum* (Tulsi), were grown in the interspaces at a row distance of 45 cm in 15 year-old mango orchards with plant spacings of 7x7 m and 8x8 m. The growth of intercrops was poor due to increasing shade of mango trees, indicating less scope for their optimum production.

2.4.9.1.2 Effect of irrigation and nutrition on tree growth in mango

The experiment was in split-plot design. Main plot treatments consisted of four irrigation levels (no irrigation, drip irrigation at 0.25, 0.5 and 0.75 Ep pan evaporation). The sub plots comprised of five nutrient management treatments: no nutrition, 75 kg FYM tree^{-1}, recommended NPK (100 g each of N, P_2O_5 & K_2O tree^{-1}year of age), 100% NPK + 75 kg FYM tree^{-1} and 50 % NPK + 37.5 kg FYM tree^{-1} to study their effect on growth, yield and quality parameters of mango.

During the off-season only nine irrigations were given to mango from February to May. The effect of only nutrition was significant, wherein broadly all the growth parameters were significantly superior by the application of nutrients. Application of 100% NPK + 75% kg FYM tree^{-1} was able to positively influence all the growth characters (Table 33).

It was observed that high rainfall received during July to September of 2006 (622 mm) reflected in excessive vegetative growth, delayed flowering (January end), low fruit set and small sized fruits. About 71% of grown up plants had inflorescence of > 50% on each tree during January, 2006. The rainfall (106.1 mm) received during March to May, 2006 resulted in excessive fruit drop.

The effect of irrigation on the weight of single fruit of mango was significantly different where in all the drip irrigation levels were significantly superior to control and

Table 33. Effect of nutrient management on growth parameters of mango tree

Treatments	Height of tree (m)		Collar diameter of tree (cm)		Canopy spread (m)			
					East-west		North-south	
	21.4.06	12.9.06	21.4.06	12.9.06	21.4.06	12.9.06	21.4.06	12.9.06
Nutrient management (N)								
N_o No nutrition	3.71	4.05	15.2	16.1	3.35	3.74	3.77	4.01
N_1 75 kg FYM/tree	4.51	4.81	20.6	21.9	4.35	5.00	4.21	5.02
N_2 Recommended NPK	4.29	4.61	18.3	19.3	3.94	4.57	3.68	4.41
N_3 100% NPK+75 kg FYM/tree	4.70	5.07	22.1	23.5	4.71	5.43	4.74	5.34
N_4 50% NPK+37.5 kg FYM/tree	4.59	4.82	20.9	21.0	4.36	4.70	4.44	4.92
SE d ±	0.230	0.246	1.73	1.75	0.330	0.334	0.346	0.362
CD (0.05)	0.461	0.489	3.44	3.48	0.657	0.664	0.688	0.720
CV %	18.3	18.2	30.8	29.8	27.6	24.7	28.8	26.4
Mean	4.36	4.67	19.4	20.4	4.14	4.69	4.16	4.74

irrigation at 0.5 Ep was superior to other levels. With regard to levels of nutrition, application of FYM alone significantly increased the yield per tree. All the nutrition treatments significantly improved the weight of single fruit, resulting in significant weight increase with application of 100% NPK.

2.4.9.2 Horti-pasture management system

As the guava trees were inter locking with 5x5 m spacing, attempts were made to moderate tree growth by pruning the top 50 or 100 cm during March 2005. Growth in pruned trees was less during 2005 as compared to unpruned controls but could put forth good growth in 2006 which was on par with control.

Pruning top branches of guava at 50 or 100 cm resulted in marginal increase in individual fruit weight and fruit yield per tree as shown in Table 34 though the increase was statistically non-significant.

Table 34. Effect of pruning on the fruit yield of guava in horti-pasture system

Treatments	Fruit Yield/tree (kg)	Weight of single fruit (g)
P_o No pruning	27.6	87
P_1 Pruning 50 cm top branches	37.8	97
P_2 Pruning 100 cm top branches	43.7	104
SED±	4.33	3.0
CD (0.05)	9.43	7.0
Mean	36.4	96

Pruning at 1 m from top

Pruning at 0.5 m from top & unpruned trees

Fresh growth on pruned trees

2.4.10 Integrated Bio Resource Centre

This is a development project wherein mass production of bio-fertilisers, bio-pesticides and planting material of multipurpose trees are to be taken up at HRF of CRIDA for supply to the farmers, organize training programmes to create awareness and promote village level entrepreneurships among youth. The progress of the work during the year is summarized below:

- 10 kg of *Trichoderma*, 15 kg of Phosphate Solubulising Bacteria (PSB) and 15 kg of *Rhizobium* were produced and distributed to chickpea farmers in a participatory mode for on-field evaluation in KVK villages of Mariapuram, Tallapalli, Machanapalli and Muthuamguda Villages in Ranga Reddy district during *rabi*. These demonstrations are aimed at generating awareness among farmers in the villages and to generate market in future.
- Viral biopesticides: 5000 LE (*Aj* GV), 3000 LE

(*Ha* NPV) and 2000 LE (*S l* NPV) were produced. All these were used for field trial to introduce the product to farmers since no registration is available.

- Tissue cultured teak and neem were produced and used for demonstration and sale. A revenue of Rs. 41,000 was generated between April 2006 and January 2007 through sale of plants.

2.4.11 Isolation of microbial cultures

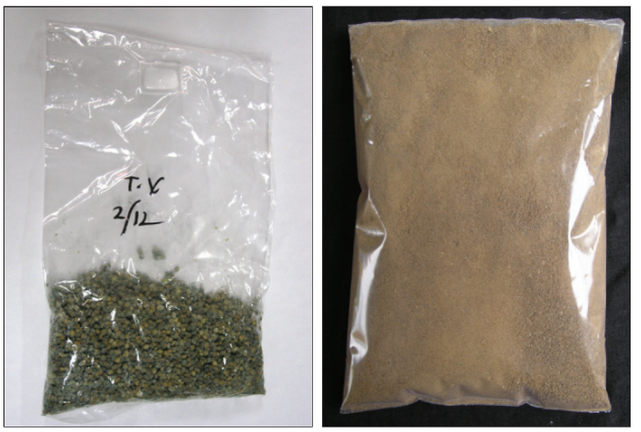
Forty each of different *Pseudomonas* spp and *Bacillus* spp. have been isolated from rhizospere of different rainfed crops with focus on abiotic stress tolerance. They were tested for their phosphate solubulizing ability and bioefficacy against 5 fungal phyto-pathogens (*Sclerotium rolfsii, A. porri, B. ricini, R. solani, and F. ricini*). Among *Pseudomonas* spp P8, P18, P19, P20, P21, P28, P36 and P39 and in *Bacillus* spp B5, B9, B 15, B18, B30, B36, B37, B 38 and B39 have shown promising antagonistic activity. This bioefficacy data is being generated in order to go for registration of these organisms in future. About 121 cultures of different beneficial microorganisms were isolated and maintained as the culture bank at CRIDA (Table 35).

Table 35. Culture collection of useful organisms maintained under IBRC

Culture	No. of isolates
Trichoderma	08
PSB	15
Azospirillum	05
Azotobacter	02
Rhizobium	11
Pseudomonas spp	40
Bacillus spp	40

2.4.12 Protocol improvement for mass production.

- A protocol for mass production and characterization of *Bt* was standardized to be used once the commercial production is taken up from 2nd year onwards. The yield of *Bt* biomass varied between 30- 40 g per bag . The toxin content was estimated in the formulation by protein assay. The toxin concentration in the 6 isolates ranged between 140 – 400 μg ml^{-1}.
- Conducted insect bioassays to test the virulence of 6 potential isolates of *Bt* on 5 days old *Helicoverpa armigera* larvae.
- Shelf life of *Trichoderma viride* was evaluated in different delivery systems, among which castor powder exhibited maximum shelf life of 2.6 x 10^8 at 80th day.
- A case study was initiated to evaluate the shelf life of biofertilizer formulations in LDPE and breather bags.
- The LDPE breather bags were found less effective than the sealed poly bags for supporting population counts of biofertilisers up to 3 months.
- Low cost medium for *Trichoderma viride* was standardized with sorghum and pearl millet meal.



Mass production of *Trichoderma viride* on sorghum grains and *Bt* (CRIDA 48b) in wheat bran

- **On farm trials/ awareness generation activities**

Four villages were adopted for the participatory on-field evaluation of biofertilizers and *Trichoderma* in chickpea. All the farmers were provided with two packages *viz*. seed treatment (10 g PSB + 10 g *Rhizobium* and 5 g of *Trichoderma*) and soil application (1 kg of *Trichoderma* + 2 kg PSB + 2 kg *Rhizobium* in 100 kg FYM) after 45 DAS were recommended. In treated plot 15% of chemical fertilizer was substituted with biofertilizers. The study of population load after 80 DAS revealed the higher load of *Trichoderma* and PSB in treated plot when compared to the control. The wilt incidence in the treated plots was reduced by 75% when compared to control plot. These results were helpful in

convincing the farmers and it is hoped that during 2007-2008 these products will be accepted and purchased by farmers in these villages.

- **Training and demonstration**

Twenty five farmers from the adopted villages were trained to use the bio-products for seed dressing, seedling treatment and on farm multiplication of *Trichoderma* with FYM. They were also enlightened about the importance of eco-friendly nature of biofertilizers and biocontrol agents.

Training the farmers in application of biofertilizers

2.5 Alternate Land Use Systems

Diversification of agriculture by incorporating appropriate crops, perennials + livestock components provides a very good ameliorative effect to the vulnerable arable crop production system in rainfed regions. Since alternative land use system provides insulation to the risk prone environments in Dryland areas, CRIDA is extensively working in developing appropriate cost effective, location specific technologies. The research efforts made during the year are discussed below.

2.5.1. Agroforestry

2.5.1.1 Nutrient management practices and agroforestry systems on soil quality in rainfed regions

From the resource management perspective, agroforestry systems are important as they are known to enhance soil quality. However, long gestation period before realizing the economic returns is an impediment to the adoption of agroforestry systems. Intercropping during the initial years is one of the options that help overcome this impediment. Therefore, during this year, agroforestry systems were studied with particular reference to nutrient management for tree species and performance of intercrops.

The experiments were conducted during 2006-2007 on aonla, tamarind and *Acacia senegal* trees planted in 1998 at a spacing of 10 X 5 m. Intercrops of Setaria (PS-4) and finger millet (GPU 28) were sown by June, 2006. Out of these two, finger millet failed, so, these plots were replanted with horse gram (local) by August, 2006. The findings are as follows:

- Setaria grain yields varied significantly due to treatments (Table 36). The three tree species were

Profusely bearing nine year old PKM-1 tamarind tree with horse gram intercrop

Setaria (PS-4) as intercrop in aonla (Anand-2)

Table 36. Crop yields with different tree species

Treatment	Grain yield (kg ha^{-1})	% of Sole	Straw yield (kg ha^{-1})	% of Sole	Harvest Index
Setaria as intercrop					
Aonla	431	46	686	23	0.386
Tamarind	437	47	849	28	0.338
A senegal	418	45	713	23	0.368
Sole crop	934	100	3043	100	0.236
SEm ±	16.3		50		0.007
CD (5%)	45		139		0.02
Horse gram as intercrop					
Aonla	434	31	1892	91	0.184
Tamarind	425	30	2152	103	0.166
A senegal	501	36	2217	106	0.195
Sole crop	1400	100	2082	100	0.388
SEm ±	27		103		0.010
CD (5%)	76		NS		0.014

on par with respect to grain yields of setaria intercrop. The moisture stress due to aberrations in rainfall during the crop-growing season resulted in competition between trees and crops leading to the grain yield reduction in the intercrops. Fodder yield of setaria also decreased similarly. The harvest index of setaria was significantly higher in the intercrops with trees.

- Grain yield of horse gram was significantly higher in sole crop compared to its performance as an intercrop. Competition for moisture was the main reason. In contrast, horse gram fodder yields did not differ significantly under those treatments, indicating that the vegetative growth was unaffected by tree competition. However the partitioning into grain was adversely affected due to moisture stress in the intercrop treatments.
- Highest fruit yields of aonla (5494 kg ha^{-1}) were harvested with application of combination of vermicompost and inorganic fertilizers, followed by castor cake and combination of FYM and inorganic fertilizers. Yields with vermicompost and inorganic fertilizers application were significantly lower than with application of castor cake. Fruit drop was higher in inorganic fertilizers and vermicompost. The fruit quality in terms of vitamin C improved with castor cake. Lowest vitamin C was observed in the fruits when FYM plus inorganic fertilizers (Table 37) were applied.

Table 37. Aonla fruit yield and quality with different treatments

Treatment	Total kg ha^{-1}	Fruit drop %	Vitamin C mg 100 g^{-1}
Vermicompost (VC)	2186	11.2	118
FYM	4164	7.5	174
Inorganic Fertilizers (IF)	3038	13	157
V C+ IF	5494	6.2	140
FYM + IF	4858	8.2	89
Castor Cake	5398	4.9	268
Sun hemp in basin	5056	10.5	137
SEm ±	825		
CD (5%)	2286		

2.5.1.2 Carbon sequestration in agroforestry systems

Efforts were made to quantify the carbon sequestration in leucaena based agroforestry systems grown under rainfed conditions and to monitor changes in soil carbon in leucaena based agroforestry systems. For quantification of above ground biomass in eucalyptus and leucaena based agroforestry systems, 173 trees of leucaena and 97 trees of eucalyptus were harvested and the biomass accumulated in the bole, bark, branch and foliage and fresh biomass was recorded. Allometric relationships were established to predict the biomass of any tree component with easily measurable characteristics like diameter at breast height and tree height. Prediction models thus developed can be used to monitor tree biomass growth for making management and harvesting decisions.

Data from *Leucaena leucocephala* cv. K-636 and eucalyptus clones plantations grown in four different locations and different spacing arrangements were used for developing the relationships. Trees used had a range of 2-18.5 m and 4-21 m in height, 2.5-18.5 cm and 3.1-15.2 cm in diameter at breast height (DBH) in leucaena and eucalyptus respectively. Regression equations developed based on DBH and tree height for both the tree species are given below in Table 38.

Table 38. Equations for calculating tree parameters from tree height and DBH

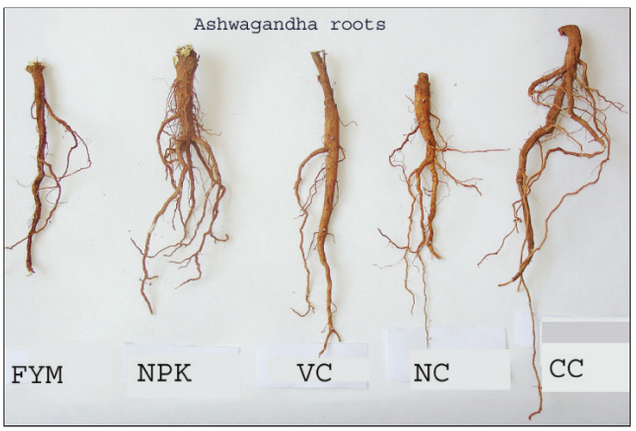
Tree/ parameters	Equations(y= kg tree^{-1}; D= DBH in cm; H= height in m)	R^2
Leucaena		
Bole	y= - 1.054 + 21.23 D - 9.29H	0.95
Branch	y= - 0.453 + 0.987D - 0.325H	0.87
Leaf	y= 0.598 + 1.505D - 0.711H	0.85
Total biomass	y= - 0.915 + 23.72D - 10.33H	0.95
Eucalyptus		
Bole	y = - 65.12 + 14.03 D – 0.431H	0.95
Bark	y= - 11.93 + 2.86 D - 0.225 H	0.93
Branch	y= -1.667 + 2.583 D – 1.01 H	0.89
Leaf	y= - 2.336 + 1.74 D – 0.538 H	0.91
Total biomass	y= - 81.07 + 21.22 D – 2.21 H	0.96

2.5.2 Medicinal and Aromatic Plants

2.5.2.1 Organic management for sustainable and profitable production of medicinal and aromatic plants

The project was initiated in 2004 to optimize the organic and inorganic sources of fertilizers to achieve higher yield and quality of medicinal and aromatic plants. The effect of application of FYM, vermicompost, castor cake, neem cake and inorganic fertilizers on yield and quality of economic product were tested in ashwagandha. The organic sources of fertilizers were applied by equating to recommended nitrogen dose; the balance P fertilizer in organic treatments was applied through rock phosphate. Major findings are as follows:

- The organics recorded higher yield in ashwagandha when compared to inorganic fertilizers. There was 52, 40 and 23% increase in root yields with neem cake, FYM, and vermicompost when compared to inorganic fertilizers.
- Providing nutrients through organic sources gave higher yield and better quality compared to inorganic fertilizers in aswagandha.



Influence of different fertilizer treatments on root growth of ashwagandha

2.5.2.2 Crop diversification for sustainability of drylands through dye yielding crops

Bixa

- The yield and bixin content was not influenced by genotype or irrigation treatment. Vermicompost application recorded higher yield (953 kg ha^{-1}) over other fertilizer treatments followed by combination of organic and inorganic fertilizers. The high yields in this treatment were due to more number of bunches tree^{-1} and seed weight when compared to other treatments. Control recorded lowest yield (328 kg ha^{-1})

- The bixa shell was composted by various methods. The decomposition was faster in vermicomposting when compared to other methods.

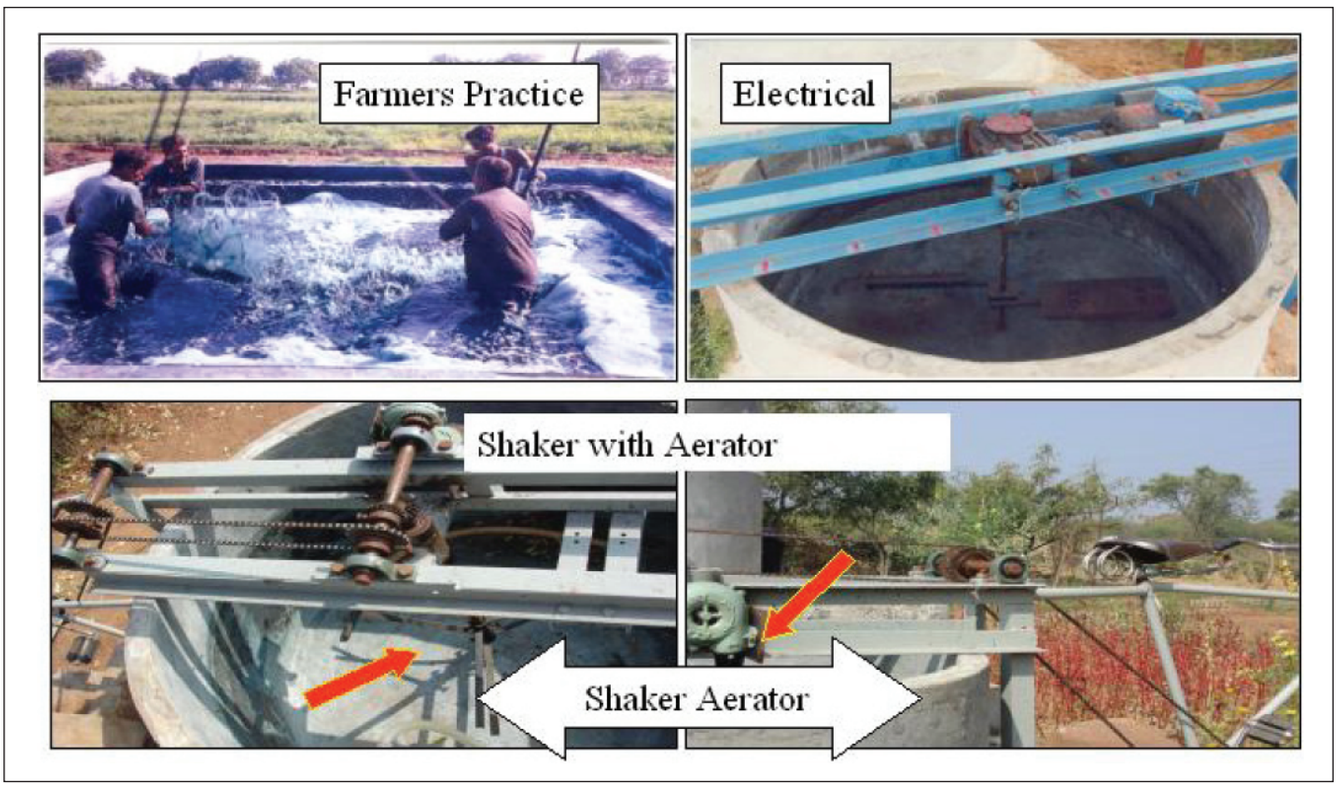
Indigo

- Highest biomass yields were recorded with FYM application (12,783 kg ha^{-1}) and vermicompost (12,301 kg ha^{-1}) over castor cake and inorganic fertilizers. Application of vermicompost increased the dye content by 70 per cent similarly with application of castor cake.
- 60 kg ha^{-1} of P_2O_5 recorded higher dye yield and indigotin content over 0, 30, 90 kg ha^{-1}.
- It was observed that indigo vermicompost had higher nutrient content than the vermicompost made of other waste materials.
- Microbial cultures added during fermentation improved the dye yield and indigotin content significantly.

The oxidation method was modified, a shaker with aerator was designed and fabricated. The aeration along with shaker saved time. The dye recovery and quality of dye was better when oxidation was done along with aerator.

Henna

- The leaf yields increased significantly with FYM application in May harvest whereas the yields were not influenced with FYM application in December harvest. No FYM application recorded significantly higher lawsone content in May cutting. Higher crop yield and lawsone content were observed with application of vermicompost.
- Application of nitrogen decreased the leaf yield and quality. The leaf stem ratio also decreased with nitrogen application. 60 kg P_2O_5 ha^{-1} recorded significantly higher yield and lawsone content over 0, 80 and 120 kg N and 0 and 30 kg P.
- In a three year old henna crop, irrigation during off season recorded significantly higher yield over rainfed crop in May cutting whereas irrigation did not influence the yields during rainy season harvest. The lawsone content was not influenced by irrigation treatments in both the cuttings.
- Various crude extracts of henna, indigo and andrographis were evaluated against 2nd instar larvae of *S.litura* under no choice conditions by following leaf dip method. The liquor of indigo after dye extraction exhibited insecticidal properties.



Shaker and aerator system for extraction of indigotin

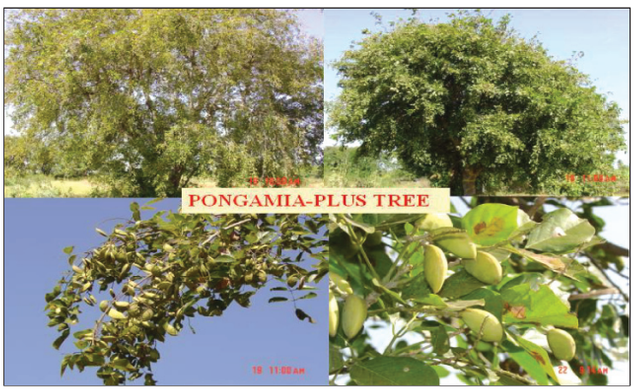
2.5.3 Biofuels

The following are the highlights of the results of studies conducted on Jatropha, Pongamia and Simarouba at HRF:

A total of 18 Jatropha and 17 Pongamia germplasms were collected from Mahabubnagar, Ranga Reddy and Nalgonda districts of Andhra Pradesh. (Table 39).

Table 39. Germplasm of collected Jatropha and Pongamia during 2006-07

District	Jatropha	Pongamia
Mahabubnagar	6	8
Rangareddy	12	1
Nalgonda	0	8
Total	18	17



Plus trees of Pongamia

- Lot of variation was found in pongamia germplasm *i.e.* from single seeded pods to triple seeded pods

Pod variability in Pongamia

- Six accessions were identified as promising out of 23 accessions evaluated in Jatropha depending on the growth and seed yield.

Fruiting in promising accession in progeny trial of Jatropha

- Pruning of Jatropha at 45 cm height resulted in enhanced seed yield compared to no pruning and pruning at 30 and 60 cm (Fig. 29). Of the three accessions evaluated, local outscored Jabua and Raipur in terms of seed yield per plant.

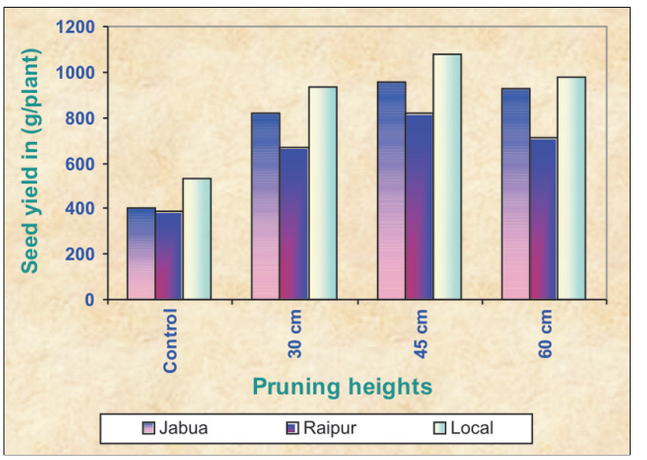


Fig. 29. Seed yield in Jatropha as influenced by pruning height in three different accessions

- At the end of the third year of plantations, it was not possible to raise intercrops in Jatropha because of the canopy spread, whereas, in Pongamia intercrops *viz.,* pigeonpea, castor, horsegram and jowar were taken up successfully without significant reduction in yield

Intercrops in Pongamia

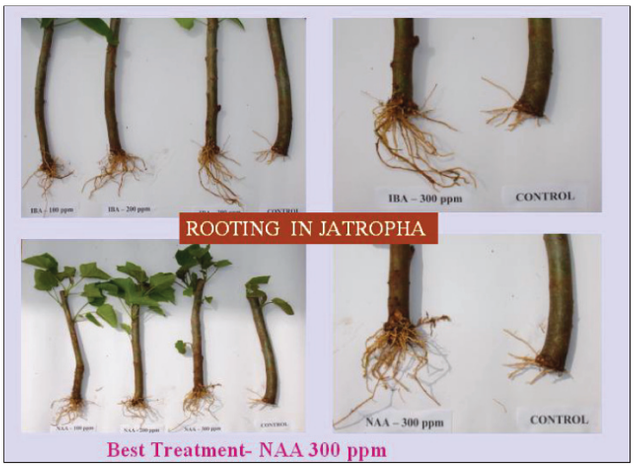
- Dipping of Jatropha cuttings in 300 ppm of NAA resulted in enhanced root initiation and growth.

Pongamia + castor

Pongamia + jowar

Pongamia + horsegram

Pongamia + pigeonpea



Effect of different growth hormones
on root initiation in cuttings of Jatropha

- Grafted plants of Pongamia flowered and yielded seeds earlier as compared to plants raised from seedlings. On an average, seed yield per plant in grafted plants at the end of the third year was 260 g plant $^{-1}$.
- Of the 23 elite germplasm accessions of Jatropha planted in multilocational trial, CRIDA-06-JJ, FRI-EL-1, RRL-MNP-0705-C-1 were identified as promising.

Elite germplasm of Jatropha at HRF

- Some of the important insect pests and diseases in Jatropha were stem borer, termites, leaf miner, powdery mildew, downy mildew, leaf and flower webber.

Leaf & inflorescence webber

Capsule borer

Leaf miner

Scale insect grubs

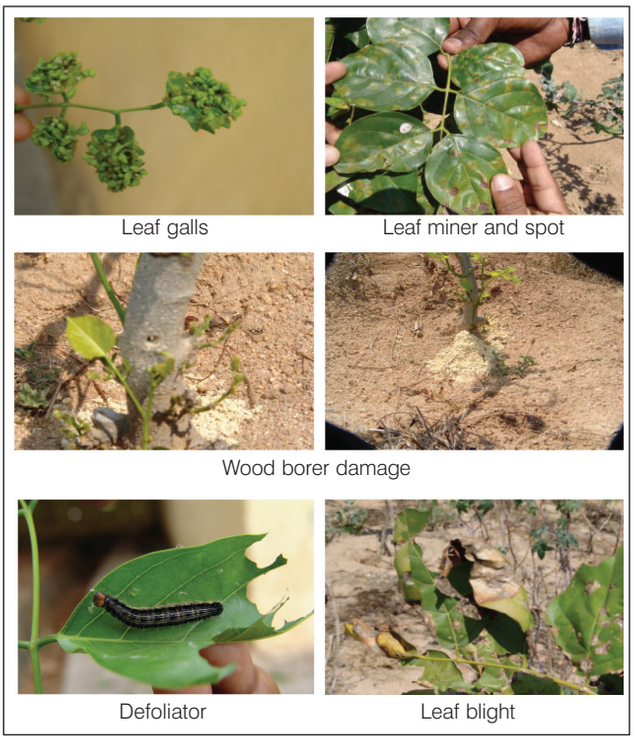
Red hairy caterpiller

Sterm borer

Round headed wood borer

- Pests and diseases of Jatropha

  The important pests and diseases noticed in Pongamia were leaf galls, stem borer, leaf spot and sooty mold.



Important pests and diseases of Pongamia

- On farm trials on Jatropha and Pongamia were continued for the 2nd year in three districts of Andhra Pradesh *viz,* Nalgonda, Anantapur and Mahabubnagar. The total area under Jatropha is 63 acres whereas Pongamia is taken up in 9 acres, in all the three districts. The main treatments comprise different levels of fertilizers, irrigation, spacing and pruning. So far, the survival of the plants under both irrigated and rainfed conditions is more than 90%. The plantation started fruiting this year.

- Fruiting was observed in Simarouba grafts planted in September 2003. The inter spaces of Simarouba could be successfully used for raising castor, cowpea and pigeonpea without any reduction in yield.

- The details on climate, soil site characters of *Jatropha curcus* locations were collected from 462 sites across 15 states viz., Andhra Pradesh, Chattisgarh, Orissa, Tamil Nadu, Punjab, Haryana, Uttar Pradesh, J&K, Gujarat, Madhya Pradesh, Maharastra, Assam, Karnataka, Jarkhand and Rajasthan.

- The range / type of climate, site and soil parameters were aggregated. In the *Jatropha curcas* growing regions, the climate- varies from arid through semi arid, subhumid, humid; rainfall- 320mm-3000mm; LGP- 60days- more than 300days; physiography- plateu to valleys: Soil orders- Entisols through Inceptisols, Aridisols, Alfisols, Vertisols, Oxisols, etc. Site characteristics in respect of depth, texture, available water content (AWC), pH, calcareousness, organic carbon, E.C, available N, P, K vary to a large extent.

2.5.4 Strategies for Sustainable Livestock Production

2.5.4.1 Livestock resources in selected watersheds

The livestock resources of the selected watersheds are presented in Table 40. Livestock population in terms of adult cattle unit ha^{-1} (ACU ha^{-1}) was highest in Pampanur and lowest in Hanjgi. The population of sheep was highest in Pampanur whereas goats dominated in Hanjgi. Buffalo was main source of milk production in Pampanur while goats and local cattle in Hanjgi. Calves of "Khillari" breed of cattle are reared in Hanjgi for draft purpose. Majority of the households in Tandpal kept pig and small ruminants for meat purpose. Keeping 4-5 poultry birds in backyard

Table 40. Livestock resources in selected watersheds

Particulars	Pampanur	Hanjgi	Tandpal
Total area, ha	849	1622	267
No. of households	287	647	137
Large ruminants	942	217	254
Small ruminants	1850	1167	85
Total Livestock	2792	1384	377
Total ACU	1375	459	287
ACU ha^{-1}*	1.62	0.28	1.07
LR ha^{-1}	1.11	0.13	1.06
SR ha^{-1}	2.18	0.72	0.32

*1 adult cattle unit (ACU): one cow/bullock; 1.2 buffalo, or 0.2 sheep/goat and 0.6 heifers/young ones; 0.4 pig

is a common practice in all the locations. Small and marginal farmers generally keep sheep and goats; whereas medium and big farmers keep large ruminants. The main purpose for rearing livestock was to "earn income and provide economic stability to the farming systems". Small ruminants have been primarily kept as mobile asset.

The livestock stocking density (ACU ha^{-1}) was three times more in Pampanur than the optimum carrying capacity recommended for Rayalseema, whereas in Hanjgi the livestock density was just half the optimum, and in Tandpal it was well within the standard carrying capacity.

- Characterization of livestock production systems

The traditional livestock production systems were complex and based on tradition and socio-economic considerations. Livestock and food production systems are closely integrated. Crops provide feed and fodder to the animals, while in return animals provide milk and meat as a source of nutrition and cash income, supply draft power and manure for crop production. A close link exists between livestock and common property resources (CPRs), with the relative importance varying depending on the cropping intensity, proximity to common lands for fodder and access to market. Poor livestock keepers depend heavily on common property resources-village pasture, forests, tanks, etc. for feeding and watering. Grazing in common forests and pastures was estimated to account for 25-35% of livestock feed consumption in selected areas. Animals of the poor depend completely on CPR during the rainy season. The grazing hours in the study area varied from 5-7 hours. However, the traditional grazing lands are being encroached upon or under faulty land distribution system. Farmers tend to ration their home grown crop residues for optimum use: large ruminants receive priority for crop residues and milking animals in addition to some amount of supplementary feeding -home-made concentrate prepared mostly on local grain residues such as rice bran, broken grains and oil cakes. Salt and mineral mixture was occasionally provided to animals. There was a very little cultivation of fodder crops in Pampanur and Hanjgi where as in Tandpal cultivation of forage crop was not at all practiced and the majority of green forage comes from the forests.

- Constraints to Livestock Production

The productivity of livestock was affected adversely by a number of causes. Most of the problems were common, which are cross cutting and feature prominently in all the centers. The major problems identified during PRA are mentioned in Table 41. The main constraint faced by the farmers across all the centers was scarcity of fodder and water in summer particularly during April to May, resulting in reduced productivity of animals and high incidence of diseases. The various reasons mentioned by the farmers for this were 1) collapse of traditional water harvesting systems created shortage of water, 2) change in cropping pattern from traditional food crops to cash crops resulted in reduced stock of crop residues-a major

Table 41. Problems identified in the selected watersheds

Pampanur	Hanjgi	Tandpal
Poor crop yields due to moisture scarcity conditions	Lack of water leading to crop failure	Lack of awareness and knowledge among farmers
Monocropping of groundnut and lack of alternative choices	Non availability of good quality seeds	Lack of improved breeds
Non-availability of appropriate crop varieties	Lack of infrastructure Lack of milk market	Inadequate quality feeds and fodders for feeding livestock
Lower profits from crop production due to high costs on seed and fertilizer	Lack of green fodder High incidence of diseases	Largely inadequate veterinary services at village level Poor economic condition of farmers
Inadequate fodder supply to milch animals		Lack of irrigation facilities Input constraints (quality seeds, fertilizer, etc).

problem in all the selected areas, and 3) shrinking of common grazing resources was another factor for scarcity of fodder to livestock. Low production potential of the native breeds, non-availability of services (veterinary, credit, seed, feed, market) in time, high incidence of diseases and high cost of maintenance were mentioned as other reasons for low productivity of livestock.

- Improved sheep management

Efforts are being made to evaluate various forage legume supplements under intensive, semi intensive and extensive systems of management for sustainable sheep production. In the year under report the growth performance of lambs under semi-intensive system was better compared to intensive and extensive system of feed management (Fig. 30).

Twenty seven lambs were born in all the three groups. The overall performance of sheep under different management systems is presented in Table 42. The overall mean birth weight was 2.90 kg ranging from 2.79 to 3.13 kg. The average birth weight of male lambs was 2.95 kg and of female lamb was 2.75 kg. Although males had more birth weight than females, differences were not significant. Significant gain in body weight was observed under semi-intensive system of management at 3, 6 and 12 months of age compared to intensive and extensive system of feeding.

Partial budget analysis was done to assess the economic advantage of different management systems. The partial budget analysis for sheep managed under different management system is given in Table 43.

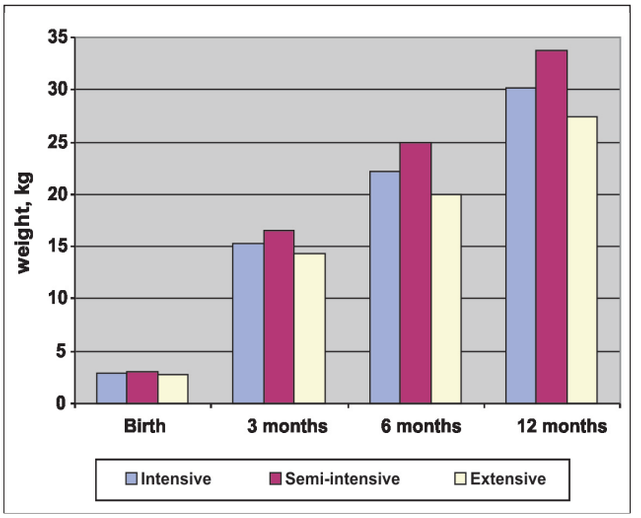


Fig. 30. Body weight of lambs under different management system

Animals reared under semi-intensive system performed better in terms of nutrient utilization, growth rate, and returned a higher profit than the animal managed under extensive or intensive system of management. However, the additional income from semi-intensive system does not justify the additional cost accompanied with it. Based on partial budget analysis, extensive system of management seems to be the only viable option for sheep rearing under farmer's conditions. However, the progressive reduction in pasture area will concomitantly increase stocking density on the grazing lands leading to further land degradation. Therefore, under this changing scenario, the rearing of small ruminants under intensive and semi-intensive system of management has wider future for commercial mutton production.

Table 42. Performance of sheep under different management system

Feeding systems/parameter	Intensive	Semi-intensive	Extensive
Adult body weight, kg	36.45 (2)	38.35 (3)	34.55 (3)
Male	28.34 (9)	34.55 (3)	27.18 (9)
Female	29.35 (10)	10	
Lambs born, Nos.	9		8
Lambing, %	100	100	89
Litter size 1.0	1.0	0.9	
Age at first lambing (months)	15.6	15.3	16.1
Lambing interval (days)	263	251	291

Feeding systems/parameter	Intensive	Semi-intensive	Extensive
Wool (greasy fleece), g h^{-1}	437	493	465
Birth weight, kg	2.88	3.03	2.79
Male	2.90	3.11	2.83
Female	2.82	2.98	2.79
Weight at 60 days, kg	12.44	13.55	11.15
Male 13.15	13.36	12.95	
Female	11.15	11.55	11.95
Weight at 90 days, kg	15.25	15.75	15.00
Male	16.53	16.85	16.37
Female	14.37	14.71	14.12
Weight at 6 months, kg	22.20	24.98	19.97
Weight at 12 months, kg	30.15	33.72	27.30
Growth rate of lambs, g day^{-1}			
0-3 months	137.44	72.22	44.17
3-6 months	128.67	62.22	40.72
6-12 months	150.07	93.89	48.56

Figures in parentheses are number of animals

Table 43. Partial budget analysis for sheep managed under different management systems

Feeding systems	Intensive	Semi-intensive	Extensive
No of lambs	6	7	6
Initial weight, kg	15.25	16.53	14.37
Final weight, kg	30.15	33.72	27.30
Weight gain, kg	14.90	17.19	12.93
Growth rate, g day^{-1}	55.18	63.67	47.89
Feed cost, Rs.	2295	1260	—
Labor cost, Rs.	1944	1512	972
Total variable cost, Rs.	4239	2772	972
Total variable cost, Rs. $animal^{-1}$	706	396	162
Gross return, Rs. $animal^{-1}$	1341	1547	1164
Net return, Rs. $animal^{-1}$	635	1151	1002

2.6 Farm Machinery and Power

2.6.1 Multipurpose self-propelled machine for dryland operations

The multipurpose self propelled machine fabricated last year was further modified this year at CRIDA, by providing double lever clutch and change of wheel design improving the machine's maneuverability. After evaluating its performance through demonstration, further modifications were suggested to the Industry regarding provision of single clutch. Keeping in view the height of some crops while doing interculture operations, it was also suggested to increase the wheel diameter to ensure more ground clearance. These modifications are being incorporated in the machine through fabrication works.

Multipurpose self propelled (5 hp) machine for dryland field operations

2.6.2 Feasibility of using Pongamia and Jatropha oils as biodiesel in CI engines

Higher oil recovery from seeds of pongamia and jatropha was obtained with modified oil expeller. Pretreatment of the seed enhanced the oil recovery from 24 to 28% in Pongamia and from 26 to 30% in Jatropha over conventional steaming process. Oil quality also improved with seed pretreatment while viscosity of oil decreased to 2.7 from 3.7 centistrokes, which is close to BIS specifications, thus contributing to higher oil recovery.

More than 94% of the biodiesel was recovered in case of jatropha oil when CRIDA process was used, which reduced the catalyst requirement when compared to the two stage process for high free fatty acid oils with biodiesel recovery of 88%. The recovery of biodiesel was around 91% in case of pongamia using CRIDA process as against 86% with normal process.

Pongamia biodiesel

Jatropha biodiesel with CRIDA process

The flash point of the CRIDA biodiesel was around 127^0 C while that of normal biodiesel was 135^0 C. This is useful in burning the fuel at lower operating temperature.

2.6.3 Performance evaluation of the biodiesel

Performance of a 5 hp water cooled engine coupled with eddy current dynamometer was tested using the B20, B40, B80, B100 biodiesel. For this, an engine test rig was used to study the engine parameters like load, fuel consumption, inlet air consumption, rpm etc. The exhaust emissions were studied using 5G gas analyzer for HC, CO_2, CO, NOx emissions. A smoke density meter was used to study the smoke opacity of the engine exhaust gases. Hydrocarbon, CO_2, CO emissions were reduced by 20% with B20 and B40 biodiesel compared to the diesel fuel. This is because of oxygen present in the oils. However, higher NOx emissions (5-10%) need to be brought down by modification in the engine or by addition of catalyst in the fuel.

Therefore, it is found that pure biodiesel can be used in stationery engines. The biodiesel made from CRIDA process, which has lower viscosity, can be substituted for diesel up to 40% without any problem.

2.6.4 Bed forming equipment

A field experiment was carried out at HRF to study the *in-situ* moisture conservation by Ridge-furrow (T1), Conservation furrows at 90 & 135 cm spacing (T2, T3), Bed and furrows at 90 & 135cm spacing (T4, T5) and a control (T6). Ridge -furrow and Bed-furrows were formed with tractor operated bed forming tools (20 cm width), whereas conservation furrows were formed with country plough. Conservation measures resulted in higher soil

moisture storage (Fig. 31), which contributed to higher yields of sorghum but not much effect on long duration pigeonpea in a 2:1 sorghum-pigeonpea intercropping system (Table 44).

2.6.5 Mechanization system for biomass incorporation

Rotavator was further modified with combination of discs and L-blades. The combined effect of these blades on chopping and incorporation efficiency of different biomass was studied. The incorporation efficiency of newly modified rotavator was 78%, a 10% increase over the earlier model. Chopping efficiency of newly modified rotavator was 62% as against 51% with the earlier model.

Table 44. Yield of sorghum+ pigeonpea intercropping system as influenced by conservation measures

Treatment	Sorghum (kg ha^{-1})		Pigeonpea grain
	Grain	Dry fodder	(kg ha^{-1})
Control	2735	5388	139
Ridge and furrow	3227	7450	78
Conservation furrow at 90 cm spacing	3074	6713	120
Bed and furrow at 90 cm spacing	3200	7485	55
Conservation furrow at 135 cm spacing	3186	7053	57
Bed and furrow at 135 cm spacing	3528	7642	61

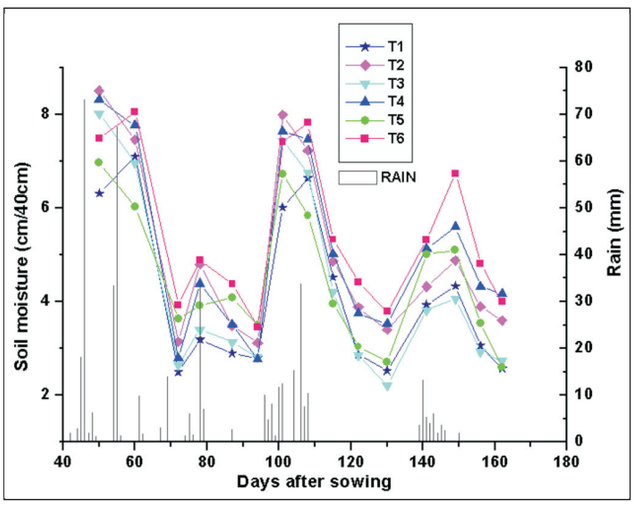


Fig. 31. Effect of different in situ conservation measures on soil moisture in sorghum+pigeonpea intercropping system

2.6.6 Herbal Dryer

The CRIDA herbal dryer developed earlier was used for studying drying performance. Drying in the herbal dryer was found to be economical with better retention of quality parameters as compared to conventional systems. The optimum drying temperature for henna, senna, curry leaf and aonla were worked using the CRIDA herbal dryer. Vitamin C content and colour of aonla, color of dried leaf in henna, senna and curry leaf, lawsone content in henna retained by drying in the herbal dryer compared to conventional drying. Sennoside content of senna was higher in herbal dryer (Table 45). Leafy vegetables, drumstick, mint, coriander, tomato and bhendi dried in herbal dryer had better color.

Table 45. Influence of different drying methods on quality of Senna

Drying method	Sennosides (%)	Color of leaf
Only leaf		
Herbal Dryer	4.423	Excellent green to light yellow
Sun drying	1.613	Brownish green
Shade drying	1.153	Light brown
Oven drying	2.48	Green
Leaf+Stem		
Herbal Dryer	3.277	Green
Sun drying	0.867	Brownish green
Shade drying	0.803	Dark brown
Oven drying	2.393	Light green
CD at 5%		
Material	0.218	
Drying methods	0.309	
Material* drying methods	0.436	

Effect of drying conditions on aonia

2.7 Socio-Economic Studies

Factors affecting technology adoption and marketing of coarse cereals were the major issues that received attention during this year. In particular, the factors that influence adoption of IPM technologies in groundnut and the marketing behaviour of farmers producing coarse cereals were studied. The major findings are presented here.

2.7.1 Adoption of different IPM components in groundnut

Different components of IPM recommended for groundnut and the frequency of adoption of each practice are given in Table 46. It can be observed that there were wide variations in adoption of different components of IPM. Application of chemical insecticides is the most adopted, with 92 % of farmers adopting it. Practices such as deep ploughing, intercropping with cowpea or black gram, growing border crop, treating the seed with insecticides or fungicides, early sowing of the crop and application of botanical insecticides such as NSKE, neem oil, etc., are among the highly adopted IPM components with more than 60% of farmers adopting each of these practice. Application of Nuclear Polyhedrosis Virus (NPV), Bacillus thuringiensis (Bt) is an important component of IPM. Its adoption was however low (2%) due to limited availability of these inputs. Keeping light traps is one of the key recommendations for managing the red hairy caterpillar in ground nut. This practice was found to be adopted by about 39% of farmers. The adoption frequencies for pheromone traps, bird perches and mechanical collection were 15.3, 14 and 11.3 % respectively. The adoption of other components of IPM was very low as many farmers were not aware of these practices.

- Extent of adoption of IPM in groundnut

In order to measure the extent of adoption, weighted scores were computed for all the IPM farmers. Of the total twenty two different components of IPM, as many as eleven were cultural practices, four were chemical, four biological and three mechanical. A farmer adopting all these twenty two practices in his or her effort to manage pests below the economic threshold levels would get a score of 5.7. The scores of the farmers were found to vary between 1.4 and 3.8 with an average score of 2.16. About 55 % of farmers scored below 2.05 (35 percentile) and were classified as low adopters (Fig. 32). Only 6 % of farmers were found to achieve high adoption scores (>2.70, the 70 percentile). The remaining 40 % of farmers were classified as medium adopters with scores between 2.05 and 2.70. Thus there was observed variation in adoption within the adopters and a majority of farmers were found to operate at low levels of IPM.

- Farm-level impact of adoption of IPM in groundnut

As mentioned earlier, the farm-level impact of IPM was observed by comparing the use of chemical insecticides, cost of cultivation, nutrient use and yields of IPM farmers with those of non-IPM farmers. As a result of adoption of IPM components, there was a steep decline in the use of chemical insecticides from about 16 L ha^{-1} in case of non IPM farmers to about 6 L ha^{-1} in case of IPM farmers (Table 47). Consequently, expenditure on plant protection chemicals fell from Rs. 3619 to Rs. 1084 ha^{-1}. It is interesting to note that IPM farmers also applied about 84 per cent more organic manures compared to the non-IPM farmers. The IPM farmers harvested about 9.8 q ha^{-1} of groundnuts compared to 9.2 q ha^{-1} in case of non-adopters. The reduced cost of cultivation and marginally higher yields together resulted in higher net returns from IPM farms (Rs. 7246 ha^{-1}) compared to non-IPM farms (Rs. 3651 ha^{-1}). Another important benefit of IPM adoption was reduction in the incidence of health hazards associated with the use of chemical insecticides. About 5% of farmers reported pesticide-related health hazards compared to 17% in case of non-IPM farmers. Such a reduction is due to the less number of chemical sprays as well as due to the relatively safer insecticides used by the IPM farmers.

Table 46. Adoption of different components of IPM in groundnut in Anantapur district, Andhra Pradesh, 2004-05 (n=180)

IPM component	Adopters (%)
Biological components	
Pheromone traps	15.3
Spraying of NSKE, neem oil etc.	62.3
Application of NPV, Bt etc.	2.0
Chemical components	
Seed treatment	67.3
Digging trenches around and application of dust	0.6
Poison baiting with monocrotophos	0.7
Insecticide spray (endosulfan or quinolphos)	92.0
Spraying on non-crop host plants	25.3
Cultural components	
Early sowing	62.7
Deep ploughing	82.0
Crop rotation	2.7
Trap crop with cucumber	0.7
Vegetative traps with Ipomoea, Calotropis etc.	0.7
Intercropping with cowpea or black gram	70.7
Mulching with rice straw	0.67
Close planting	18.0
Border crop	63.3
Erection of bird perches	14.0
Removal of congress weed	3.3
Mechanical components	
Keeping light traps	38.7
Collection and killing of adult moths	5.3
Manual collection of grubs from manure sources	6.0

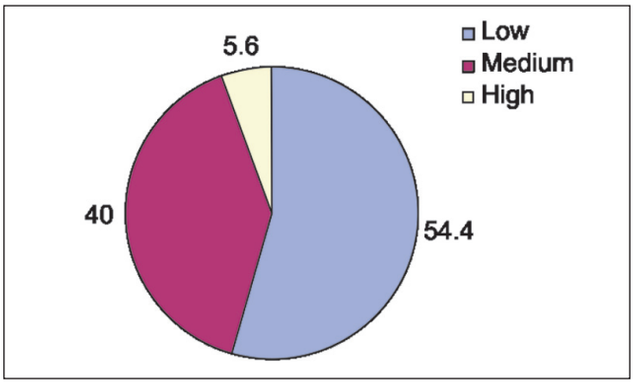


Fig. 32. Extent of adoption (%) of IPM in groundnut in Anantapur district

Table 47. Farm-level impact of adoption of IPM in groundnut in Anantapur district, Andhra Pradesh, 2004-05

Parameter	Non-IPM farms	IPM farms	Change (%)	t statistic
FYM (t ha^{-1})	10.6	19.4	83.5	2.13
Nutrients (kg ha^{-1})	88.0	77.3	-12.2	6.09
Insecticides (L ha^{-1})	15.7	5.8	-63.2	7.67
Yield (q ha^{-1})	9.2	9.8	6.4	4.04
Expenditure on insecticides (Rs ha^{-1})	3619	1084	-70.1	8.72
Cost of cultivation (Rs ha^{-1})	11791	9366	-20.6	2.34
Net returns (Rs ha^{-1})	3651	7246	98.5	2.66
Incidence of sick events (%)	16.7	5.5		5.62*

The differences were found to be statistically significant at at least 5 %
*χ^2 statistic.

2.7.2 Spatio-temporal variations in production and marketing of coarse cereals in Andhra Pradesh

The project was initiated in February 2005 in order to examine the spatio-temporal variations in production and marketing of sorghum, pearl millet and finger millet. The results with respect to marketing behaviour of sorghum in Mahabubnagar district are presented here.

Table 48 gives an outline of marketing behaviour of sorghum producers in the district. As can be seen from the table, about 53% of farmers sold the produce in the regulated market and 33% sold in unregulated markets. About 13% of the farmers who grew sorghum did not sell their produce at all. However, there were observed inter-village differences in the proportion of farmers selling their produce in regulated and unregulated markets. For example, the proportion of farmers selling in the regulated market was highest (80%) in Gangapur and Jalalpur and lowest (20%) in Chagadona as the latter was situated far from the market. It is evident that regulated markets are attracting the farmers to sell their produce. It was observed that farmers would be paid immediately for their produce when sold in a regulated market. On the other hand, they had to wait for at least 15 days if they sold in the unregulated markets. Proximity to the market is another reason for the observed difference in the proportion of farmers selling the produce in the regulated markets.

Table 49 gives the average productivity and profitability of sorghum in case of the three groups of farmers. As can be seen from the table the average productivity of sorghum in case of farmers selling in the market, whether regulated or unregulated, was found to be significantly higher (at about 13 q ha^{-1}) compared to the productivity of farmers who did not sell in the market. A look into the cost of cultivation reveals that farmers selling in the market invested more as is evident from the higher cost of cultivation for those participating in the market. Within them, the farmers selling in the regulated market spent more in cultivation of sorghum than those selling in the unregulated market. Further, participation in regulated market fetched them higher prices (Rs. 613 q^{-1}) compared to the price received in non-regulated market (Rs. 482 q^{-1}). These differences in costs, prices and yields were also reflected in the net return from sorghum cultivation for the three groups of farmers. It is also clear from the table that farmers participating in the regulated market operated larger farms (4.34 ha) and sown more area to sorghum (1.18 ha) compared to the other two groups. Farmers who did not sell any grain in the market operated only 1.48 ha of land and cultivated on an average 0.46 ha of sorghum indicating the subsistence nature of farming on a small scale.

The results of multiple logistic regression analysis of factors influencing the farmers' decision to participate in the market are presented in Table 50. The goodness of fit indicators show that the model could explain the farmers' market participation decision to the extent of about 75% as can be seen by the Negelkerke R^2. Other statistics like per cent correct classification and log likelihood values also indicate the satisfactory performance of the model. The regression coefficients indicate that all the variables included in the model except the per cent area irrigated and the dummy variable for village 4 are significantly influencing the farmers' decision to sell sorghum grain in the APMC or regulated market. For example, the effect of education was 0.378 and statistically significant at 5% which means that farmers with more education are more likely to participate in the market. Similarly the large farmers are more likely to participate in the market than the small farmers. On the other hand, as the family size increases, the probability of a farmer for selling in the market decreases significantly as can be seen from the negatively significant coefficient. This when seen in conjunction with the results presented in Table 50 reinforces the observation that small farmers grow sorghum mostly to meet household consumption needs. Since there were five villages in the study, four dummy variables were included in the model to capture the village-specific effects. Out of the four villages included, three were found to have significant regression coefficients indicating a difference as compared to the village 1. Out of the three villages whose coefficients were found to be significant, post-rainy season sorghum was found to be popular. The sorghum grain produced in the post-rainy season (*rabi*) enjoys consumer preference for its quality and hence farmers are encouraged to sell the grain in the regulated market. The third village is situated close to an APMC which is why the coefficient was found to be significant. Thus the decision to participate in the regulated market by the farmer is influenced by the farm and family size, age and education of the farmer and proximity to the market.

Table 48. Proportion of farmers selling sorghum grain in regulated and non-regulated markets in Mahabubnagar district, Andhra Pradesh

Particulars	Venkeshwaram	Village				Total
		Gangapur	Jalalpur	Boyapalle	Chagadona	
Regulated market	4(26.67)	12(80.00)	12(80.00)	9(60.00)	3(20.00)	40(53.34)
Non-regulated market	9(60.00)	3(20.00)	1(6.67)	3(20.00)	9(60.00)	25(33.33)
No sale	2(13.33)	0	2(13.33)	3(20.00)	3(20.00)	10(13.33)
Total	15 (100)	15 (100)	15 (100)	15 (100)	15 (100)	75 (100)

Note: Figures in parentheses show percentage of total

Table 49. Productivity, profitability and prices received by the farmers selling in regulated and non-regulated markets in Mahabubnagar district, Andhra Pradesh

Variable	Regulated market	Non-regulated market	No sale	Over all	*F* value	*P* value
Farm size (ha)	4.34 (2.64)	3.16 (1.67)	1.48 (0.81)	3.56 (2.37)	7.47	0.001
Area sown to sorghum (ha)	1.18 (0.59)	0.73 (0.24)	0.46 (0.26)	0.93 (0.54)	12.84	<0.001
Yield (q ha^{-1})	13.19 (4.96)	13.26 (4.97)	9.37 (2.30)	12.71 (4.83)	2.88	0.06
Price (Rs q^{-1})	613.12 (136.75)	481.80 (79.22)	523.50+* (134.62)	557.40 (133.64)	9.61	<0.001
Cost of cultivation (Rs ha^{-1})	3709 (710)	3318 (635)	2942 (460)	3477 (706)	6.52	0.002
Net Returns@ (Rs ha^{-1})	1588 (1147)	1248 (1303)	1318* (973)	1439 (1178)	0.70	0.50

Figures in parentheses are standard deviations * Average prices expected by the farmers

@ The value of sorghum stover was also included while computing net returns.

Table 50. Logistic regression results for farmers' decision to sell in the regulated market in Mahabubnagar district, Andhra Pradesh

Variable	β	SE	Wald
Constant	-12.093**	3.82	10.01
Age	0.089*	0.46	3.85
Education	0.378*	0.18	4.57
Family size	-0.739*	0.37	3.91
Farm size	0.645**	0.21	8.81
Irrigated area	-0.018	0.02	0.83
D_2	4.320**	1.69	6.55
D_3	9.095**	2.81	10.45
D_4	9.058**	3.07	8.73
D_5	27.742	79.98	0.11
Negelkerke R^2		0.75	
-2logLL[a]		38.43	
Percent correct classification[b]		86.7	
Sensitivity[c]		89.4	
Specificity[d]		82.1	

** and * indicate significant at 1 and 5 percent, respectively. a. Follows c^2 distribution with 9 df; b. Based on a 50-50 classification scheme; c. Prediction of farmers selling in the regulated market classified correctly; d. Prediction of farmers not selling in the regulated market classified correctly

2.7.3 Developing farming situation based extension in Ranga Reddy district

Different farming situations existing in Rangareddy district were studied with a view to target extension activities more effectively. The main findings are summarized below:

- Majority of farmers in black soils are illiterate (55%), middle aged (65%), with more than 15 years of farming experience, medium extension contact, medium social participation and low mass media exposure.
- Technology adoption levels were relatively higher in black soil region compared to red soil region in case of maize and cotton. However, the adoption levels did not differ significantly across categories of farmers in case of maize.
- Technology adoption of cotton crop was positively correlated with education, extension contact, social participation and mass media exposure.
- Farmers perceived high satisfaction with regard to Krishi Vignan Kendra training programmes and services more than women programmes. Women programmes were of medium satisfaction in red and mixed soils. This might be due to the fact that women take interest when soils are less productive.

2.8 Transfer of Technology

The approaches to transfer of technology are increasingly getting dependent on the use of ICTs. There is an immense scope to reduce the transaction costs of extension with use of ICT. With this in view, some of the efforts in transfer of technology by various agencies were examined for their content, effectiveness and reach. Digital documentation is one of the important back-end needs of ICT-based transfer of technology and hence it received attention.

2.8.1 Documentation of dryland technologies

Enhanced awareness of adopted technologies in drylands shall lead to informed decision making, finally paving the way for environmentally sound and economically efficient land use, including water conservation. Hence a project on "Identification and Digital Documentation of Dryland Technologies" was taken up in Nallavelli and Manmarri villages representing red and black soils respectively each with 30 farmers as sample respondents. Different dryland technologies of CRIDA were identified based on their adoption by farmers before taking up the documentation work (Table 51, 52). Criteria followed in selecting technologies for documentation was more than 50% adoption by farmers.

Dryland technologies like row ratio, intercrops, fertilizer recommendations (both red and black soils) and growing of Bt cotton (in black soils only) had maximum adoption with farmers because of less deviation from their practices.

Adoption indices were computed (Table 53) for the sample farmers based on which they were categorized into low, medium and high groups. In both red and black soils, the proportion of farmers with high adoption index was low. There was no statistically significant difference between the mean adoption indices of farmers in both red and black soils.

Table 51. Adoption of dryland technologies in Nallavelli village

S.No.	Dryland technology	Adoption %	Reasons
A.	**Technologies with high adoption (>50%)**		
1.	Sorghum + pigeonpea cropping system in 5:1 ratio	93.3	Sorghum comes handy as fodder and pigeon pea for own consumption.
2.	Late sown horse gram/ castor/ green gram	96.7	Fodder as well as consumption purpose
3.	Castor intercropped with cowpea	80	More yields
4.	Conservation furrows at 1.2 m. interval sorghum system	73.3	Helps in water retention and good aeration
5.	Recommended dose of fertilizers in sorghum system *viz.* basal & top dressing	60	Convinced of judicious application for realizing higher yields
B.	**Technologies with less adoption** (<50%)		
1.	Urea mineral molasses block feeding to cows and buffaloes	6.7	Taste not acceptable to animals
2.	Conjunctive use of inorganic N (urea) and organic N (subabul and gliricidia loppings)	10	Non availability of trees, low awareness and labour problem
3.	Dryland implements	10	Not working in undulating land and require more number of implements in the village
4.	Urea treatment of rice straw	10	Costly, labour intensive and low awareness
5.	Soil and water conservation measures (field bunds, waste weirs on field bunds, stone checks,etc.)	40	No water recharge and maintenance problem

Table 52. Adoption of dryland technologies in Manmarri village

S. No.	Dryland technologies	Adoption %	Reasons
A.	**Technologies with high adoption (>50%)**		
1.	Bt cotton cultivation	100	Convinced of the benefits like less number of chemical sprays, savings in labour and time
2.	Maize + pigeonpea cropping system in 5:1 ratio	90	Previously cultivating in 4:1 ratio, now realizing higher yields with recommended ratio
3.	Only chemical component of pest management Bt cotton especially sucking pests and for non-Bt cotton	73.3	Readily available while other management methods labour intensive
4.	Recommended dose of fertilizers in maize system *viz*., basal and top dressing	56.7	Previously applied high dose, now convinced to apply required doses at appropriate times for achieving high yields
B.	**Technologies with less adoption (<50%)**		
1.	Soil and water conservation measures like contour bunds and farm ponds	6.7	Low water recharge and maintenance problem
2.	Mulch cum manure technique with subhemp in kharif fallows	6.7	Non-availability of plant material and labourintensive
3.	Urea mineral molasses block feeding to buffaloes	6.7	Taste unacceptable to buffaloes
4.	Urea treatment of rice straw	10	Labour intensive method
5.	Dryland implements	13.3	Require more force to operate due to soil build up in case of planter, weeder. Inadequate availability and require at least one implement for five persons.

Table 53. Adoption indices for dryland technologies

Adoption Category/Statistic	Nallavelli (Red soils)	Manmarri (Black soils)
Low adoption	14	11
Medium adoption	15	11
High adoption	1	8
Mean value	62.78	61.94
Standard Deviation	8.22	10.16

2.8.2 ICTs as a tool of technology dissemination in rainfed agriculture

The project attempted to assess the impact created by ICTs *viz.,* eSagu (IIIT), weather based agro advisory services (Crop weather outlook, CRIDA), Ikisan (Nagarjuna Group), Kisan Call Centers (Govt of India, MANAGE as state level center) which are used as alternative tools of agricultural extension. Content validity and reliability of the data collection instrument for different items was measured by pretesting with ICT eAQUA. Based on the pretesting, suitable modifications were made and data collection instrument was finalized with variables like awareness, nature of content, access, timely

update, language, capacity building, maintenance, partnership, affordability and sustenance.

The main findings of the study are summarized below

- e-Sagu has provided a cost-effective and affordable opportunity to the farmers in the rural areas to have access to the best and latest technological developments in the field of agriculture for improving the productivity and profitability.
- The profit due to reduced use of fertilisers ranged from Rs.751 acre^{-1} in case of chilli, Rs.419 acre^{-1} in case of cotton and on an average Rs. 443 acre^{-1} for all crops (cotton, chilli, paddy, redgram, groundnut, castor *etc*.), the profit due to reduced use of pesticide application is Rs. 1140 acre^{-1} in case of cotton and Rs. 1093 acre^{-1} in case of chilli and an average gain of Rs. 928 acre^{-1} is observed for all crops.
- The response time for advise delivery ranged from 24-36 hrs. Nearly 60% of the farmers were able to follow the advices recommended by eSagu. Results show that the farmers participation is increased by 42% with local language advice than earlier eSagu advice which was received in English offering scope for further expansion of the technology.
- More than 70 per cent advices are repetitive, which shows that system can be scalable following cluster-based approach.
- High cost of maintenance, frequent repairs of infrastructure (computers, software and hardware), frequent change of trained personnel, scarcity of skilled ICT labour force, farmers' resistance to change, were some of the hindrances observed in the study.

2.8.3 Capacity building of ORPs in rainfed agroecosystem

The project started in January 2005 with the objectives of redefining the concept of ORPs in the changing scenario of rainfed agriculture, building the capacity of ORP for meeting the changing needs of integrating NRM research and livelihood issues and institutionalizing a process to enhance the effectiveness of ORP. The study areas encompass 8 ORPs in AICRPDA network viz., Anantapur (ANGRAU), Arjia (MPUA&T), Ballowal-Saunkhri (PAU), Banglore (UAS, B), Hisar (CCSHAU), Indore (JNKVV), Ranchi (BAU) and Solapur (MPKV). The progress was in two phases *i.e*., capacity building phase and action research phase.

- Capacity building phase- the scientists from 8 ORPs continuously interacted upon the modification and implementation of technical programmes on NRM and farming system based modules. For technologies that are adopted by the ORP farmers and other farmers a participatory extension plan was designed for which policy research and support services with the help of CBOs, SHGs, PRIs *etc*., was suggested. For the technologies that are adopted by ORP farmers and not by other farmers and also the technologies that are not adopted by ORP farmers and other farmers, a participatory research plan was suggested in a participatory technology development process mode.
- The ORP scientists identified 166 technologies that were adopted by ORP farmers and diffused to other farmers (Type I), 47 technologies (Type II) that were adopted by ORP farmers and not diffused to others and 20 technologies (Type III) that were neither adopted by ORP farmers nor by others.
- The participatory process also brought out the support system required for adoption of Type II and III technologies
- Participatory need assessment and participatory action plan development processes carried out in ORP Solapur at village Hanjagi revealed that livestock integration into cropping required a strong support system for collection of milk and veterinary care.

3 Technologies Assessed and Transferred

3.1 Krishi Vigyan Kendra (KVK)

3.1.1 Capacity building

The KVK of the institute organized 78 need-based, skill oriented training programmes on various aspects of traditional and upcoming novel dryland technologies. There were 2940 clientele comprising practicing farmers, women farmers, rural youth and field level functionaries (Table 54).

Table 54 : Details of various theme based training programmes conducted by the KVK

Discipline	Number of programmes			Number of participants		
	On-station	Off-station	Total	Male	Female	Total
Agronomy	04	04	08	218	046	264
Horticulture	01	05	06	173	048	221
Plant protection	03	11	14	470	074	544
Home Science	08	15	23	181	417	598
Agricultural Engineering / Soil Conservation	02	05	07	222	052	274
Animal Science & Agricultural Extension	01	01	02	055	005	060
Others*	02	16	18	662	317	979
Total	21	57	78	1981	959	2940

* Includes various sponsored programmes

3.1.2 Extension activities

Following extension activities were undertaken by KVK, CRIDA during the year:

Activity	Period	Venue
Exhibitions showing dryland technologies	May 2, 3, 6, 2006	Manchala, Tandur and Ibrahimpatnam in Ranga Reddy district
Radio talk: NPV preparation and its uses and limitations	July 25, 2006	AIR, Hyderabad
Field Days on Organic Farming	August-September, 2006	In all KVK villages
Two Field Days on Sorghum and Cotton protection	August 24 and 28, 2006	Muddemguda and Mariapuram villages of Ranga Reddy district
National Nutrition Week	September 7, 2006	Tallapally and Machanapally villages of Ranga Reddy District.
Parthenium Awareness Week	September 12, 2006	Muddemguda, Bobbiligam and Mariapuram of Ranga Reddy district

Activity	Period	Venue
Farmers' Day	September 16, 2006	Farmers from villages of Ranga Reddy district and other neighbouring districts
Field Day on Maize	September 28, 2006	Machanapally village of Ranga Reddy district
Two Study tour – cum – exposure visits	October 11-15, 2006 and October 27-31, 2006	Coastal Andhra and Rayalaseema regions of Andhra Pradesh
Exhibition on the occasion of National Conference of KVKs-2006	November 26-28, 2006	ANGRAU, Hyderabad
Exhibition on the occasion of National Seminar on Oilseeds	January 29-31, 2007	DOR, Hyderabad
Knowledge empowerment through *Rytu Samakhya* of Ranga Reddy district	Monthly meetings and trainings on 1st Monday of every month at CRIDA and in other places of Ranga Reddy district	CRIDA and places like Dharur, Vikarabad, etc. in Ranga Reddy district

Training women in candle making at Muddemguda

Training women in Agro techniques on sorghum and cotton

To improve the nutritional security and assured additional income for the resource poor farmer families, three hundred units (each consisting of three female and one male birds of 4-week age of coloured birds) were supplied to 300 families in five villages adopted by KVK. This activity was supported by the Project Directorate on Poultry, ICAR.

The KVK has added turkey birds, guinea fowl birds, colour love birds and goats to its livestock demonstration unit. Nine hundred horticulture and other plants including mango, fig, lime, sapota, aonla, custard apple, karonda,

Distribution of poultry for backyard

teak and jatropha were planted on KVK instructional farm during the season.

3.1.3 Development of website of KVK

To provide easy accessibility of information to the stake holders, KVK has launched its website. Dr. Y.S. Ramakrishna, Director, CRIDA inaugurated it on 9.10.06. This website has been developed by the KVK and is hosted on the CRIDA website by following link: http://www.crida.ernet.in/kvk/kvkhomepage.htm. The KVK website provides all the information about the KVK, its activities, linkages, training programmes, package of practices, market information, weather report, online newsletters, etc.

3.1.4 Frontline Demonstrations

The KVK conducted 1292 frontline demonstrations (FLDs) in an area of 517 ha covering important oilseeds, pulses, cereals and other crops, viz., castor (32), niger (25), pigeonpea (30), soybean (15), sorghum (45), maize (950), cotton (100) and paddy (38). The programme has been taken up in different villages of Ranga Reddy district. The improved production technologies were demonstrated to the farmers with their active involvement. Spot guidance/advice/training/exposure visits were also arranged by the KVK scientists. The various collaborating agencies in the FLD programme are DMR, NRC for Soybean, DRR, NRC for Sorghum, CICR, etc. Through FLDs it was possible to demonstrate that the adoption of improved technologies can enhance crop productivity and profitability (Table 55).

3.2 ORPs of AICRPDA

All India Coordinated Research Project on Dryland Agriculture carried out dissemination of improved technologies generated at various research institutes/ centers on farmers fields through ORPs & FLDs across the country. A total of 122 trials were conducted under various themes at the eight ORP centers located at Bangalore, Hisar, Ananthpur, Indore, Solapur, Arjia, Ranchi and Ballowal Saunkri.

There were 17, 34, 11, 11, 23, 15 and 11 trials in rice, maize, soybean, groundnut, fingermillet, foxtail millet and *rabi* sorghum based production systems, respectively. Among the practices themes cropping systems, plant protection, crop improvement, integrated nutrient management, rainwater management, energy management, alternate land use system, there were 32, 5, 13, 24, 12, 11 and 8 trials, respectively. There were also 5 trials on integrated farming systems and 12 other on demonstration of different combinations of package of practices and other related themes. Salient achievements are listed in Table 56

3.2.1 Front Line Demonstrations on Pulses

There are 97 Front Line Demonstrations (FLD) on different pulses under on-farm conditions at AICRPDA centers. Out of these FLDs, 12(12.4%) were on pigeonpea, 19(19.8%) were on chickpea, 58 (59.8%) were on green gram, 7(7.2%) were on black gram and 1(1%) was on lentil. A maximum of 50 FLDs were organized at

Table 55. Details about the frontline demonstrations conducted by the KVK during 2006-07

Crop	No. of farmers	Area (ha)	Average yield (kg ha^{-1})		Average increased yield over local practice %	Average additional profit (Rs)
			Improved practice	Farmers' practice		
Maize	950	380	6562	4368	50.23	14058
Sorghum	45	18	2023	1010	100.29	4542
Cotton	100	40	2000	1500	33.33	10500
Paddy	95	38	4580	3250	40.92	5747
Pigeonpea	30	12	1958	1533	27.72	8640
Soybean	15	06	1400	1100	27.72	2363
Castor	32	13	660	341	93.55	3309
Niger	25	10	913	424	115	4083

FLDs conducted in collaboration with commodity Institutes/ Directorates/ NRCs / AICRPS.

Table 56. Salient findings of ORP under on-farm condition

Center	Crop (Variety)	Promising practice/ Salient finding
Rain Water Management		
Anantapur	Groundnut (TMV-2)	10 mm water during dry spell
Arjia	Maize (Navjot) + blackgram (RBU-38) (2:2)	Supplemental irrigation at 55 DAS
Arjia	Groundnut (JL-24) + Sesame (RT-125) (6:2)	Supplemental irrigation at 45 DAS for maximum maize equivalent yield
Arjia	Maize (Navjot)	Deep tillage + 100% RDF (FYM & inorganic fertilizer)
B.Saunkhri	Maize (JH-3459)	Chiseling + mulching
Ranchi	Linseed (T-397)	Inter-culturing at 25 DAS
Ranchi	Linseed (T-397)	Dust mulching + mulching with ipomea leaves
Solapur	Sorghum (M-35-1)	Two protective irrigations at 35 & 65 DAS
Integrated Nutrient Management		
Anantapur	Groundnut (TMV-2)	Soil test based fertilizer application
Arjia	Maize (Navjot) + Blackgram (RBU-38)	50% N (organic) + 50% N (inorganic) for maize under maize + balckgram
B.Saunkhri	Maize (JH-3459)	50% N (FYM) + 50% N (inorganic)
Bangalore	Fingermillet (GPU-28)	50% NPK (FYM) + 50% NPK (inorganic)
Hisar	Pearlmillet (HHB-67) &Mustard (RH-30)	40 kg N ha^{-1}
Indore	Soybean (JS-335)	100% RDF (50 kg N + 60 kg P/ha) + sulphur @ 20 kg/ha
Ranchi	Upland rice (Vandana)	20 kg N + 20 kg P ha^{-1} (basal)
	Rice (Birsa Dhan-109)	40 kg K ha^{-1}
Solapur	Sorghum Pearlmillet (Shradha)	50 kg N + 25 kg P ha^{-1} 50 kg N + 25 kg P + 25 kg K ha^{-1}
Energy Management		
Anantapur	Groundnut (TMV-2)	Tractor drawn mechanical seed drill
B.Saunkhri	Wheat (PBW-175) Chickpea (PBG-5)	Seed – cum – fertilizer drill
Ranchi	Rice (Vanadana)	Weeding by grubber

Center	Crop (Variety)	Promising practice/ Salient finding
Cropping System		
Anantapur	Groundnut + pigeonpea	Normal sowing with TMV-2 variety of groundnut & LRG-30 of pigeonpea
Arjia	Maize + blackgram	Navjot of maize & RBU-38 variety of blackgram in 2:2 ratio
B.Saunkhri	Maize + blackgram	JH-3459 of maize & MASH-338 variety of blackgram in 10:1 ratio
Bangalore	Maize + cowpea	South African of maize & C-152 variety of Cowpea in 3:1 ratio
	Finger millet + pigeonpea	L-5 of finger millet & TTB-7 variety of pigeonpea in 10:2 ratio
Hisar	Chickpea + chinese cabbage	H-208 of chickpea with Chinese cabbage for fodder after 70 DAS
Ranchi	Pigeonpea + rice	Bahar variety of pigeonpea & Vandana variety of rice in 1:3 ratio
	Pigeonpea + groundnut	Bahar variety of pigeonpea & BAU-20 variety of groundnut in 1:2 ratio
Solapur	Maize – berseem	African tall variety of maize in *kharif* & vardhan variety of berseem for green fodder in *rabi*
	Sunflower – berseem	SS-2083 variety of sunflower with sowing on 11th August & vardhan variety for green fodder with sowing on 10th November
	Castor + clusterbean	CK-06 of castor & G-15 variety of clusterbean in 1:2 ratio
Crop Improvement		
Arjia	Maize	Navjot
	Groundnut	TAG-24
B.Saunkhri	Maize	JH-3459
	Groundnut	SG-99
	Wheat	PBW-527
Bangalore	Fingermillet	L-5
	Pigeonpea	BRG-1
	Green Chilli	Samrudhi
	Cowpea	IT-38956
	Horsegram	PHG-9
Hisar	Pearlmillet	HHB-67-2
	Mustard	RH-9304
	Barley	BH-393
Indore	Soybean	JS-9305
Ranchi	Rice	Vandana
	Niger	Birsa niger-1
Solapur	Pigeon pea	BSMR-853
	Pearlmillet	Shradha
	Sunflower	SS-56

Center	Crop (Variety)	Promising practice/ Salient finding
	Sunflower	MSFH-17
	Maize	MPQ
Integrated Weed Management		
B.Saunkhri	Groundnut (M-37)	One hoeing at 21 DAS
Hisar	Pearlmillet (HHB-67) Mustard ((RH-9304)	Weeding with kasola at 20 & 30 DAS
Indore	Soybean ((JS-335)	Weed-free treatment
Ranchi	Rice (Vandana)	Removal of weeds with grubber
Alternate Land Use		
B.Saunkhri	Groundnut (M-37) Groundnut (SG-99) – lentil (LL-699)	Dhek + groundnut system Guava + groundnut - lental Peach + groundnut - lentil
Package of Practices		
Anantapur	Groundnut (TMV-2) Pigeonpea (LRG-30)	Improved package of practices for groundnut + pigeonpea with small seed of groundnut
Arjia	Maize (Navjot) Groundnut (JL-24) Sesame (RT-125) Blackgram (RBV-38)	Improved package of practices for maize + blackgram ; groundnut + sesame
B.Saunkhri	Wheat (PBW-175) Barley (PL-419) Raya (RLM-619)	Recommended practice for wheat & complete package of barley. Improved package of practices for raya; taramira ·
	Taramira (TMLC-2) Maize (JH-3459) Groundnut (SG-99) Fodder pearlmillet (PCB-15)	Improved package of practices for maize; groundnut; fodder pearlmillet; wheat; barley; chickpea; raya; taramira
Hisar	Green gram (Asha) Moth bean (RMO-40) Cluster bean (HG-365) Chickpea (H-208)	Improved package of practices for green gram; moth bean; cluster bean and sesame. Complete package of practices for chickpea
Solapur	Sorghum (M35-1) Maize (MPQ-13) Chickpea (Vijay) Sunflower (SS-2038) Safflower (Bhima)	Improved package of practices for sorghum; maize; chickpea; sunflower and safflower

Phulbani, followed by 24 at Agra, 14 at Kovilpatti and 5 at Rewa (Table 57).

3.2.2 Front Line Demonstrations on Oilseeds

Out of a total of 94 FLDs, 20 (21.3%) were on castor, 5 (5.3%) were on soybean, 51 (54.2%) were on groundnut and 18(19.1%) were organized on mustard at various ORP centers. Phulbani center organized 50 followed by Dantiwada 20, Agra 12 and Rewa 10 FLDs.

Through organizations of various FLDs it was possible to demonstrate that the pulse and oilseed yields in rainfed areas can be enhanced to the tune of 21 to 56 and 13 to 48%, respectively over farmers practices by adopting the improved package of practices.

FLD on chickpea

Table 57.Highlights of the FLDs on pulses

Centre	Crop (Variety)	Mean yield(Improved Practice)	Increase (%)
Phulbani	Green gram (OUM-115)	466	44.8
Agra	Chickpea (RGS-44)	917	25.5
Solapur	Pigeonpea (BSMR-853)	1219	29.9
	Chickpea (Vijay)	1071	23.2
Kovilpatti	Blackgram (Co-5)	795	21.4
	Greengram (Co-6)	831	22.9
Faizabad	Pigeonpea (Narendra Arhar-1)	2216	33.4
	Chickpea (Awrodhi)	2023	35.0
B.Saunkhri	Lentil (LL-699)	213	52.6
Rewa	Chickpea (JG-315)	173	52.6
Varanasi	Pigeonpea (Bahar)	1540	44.8
	Greengram (HUM-12)	850	38.8
	Chickpea (BG-1)	1275	41.2

Table 58. Performance of oilseeds in FLDs

Centre	Crop(Variety)	Mean yield (Improved practice)	% increase over Farmer'spractice
Phulbani	Groundnut (Smruti)	1290	47.9
Agra	Mustard (Pusa Jaikisan)	1618	14.6
Solapur	Sunflower (Bhanu SS-2038)	1084	30.4
	Safflower (EC-68414)	1221	36.6
Faizabad	Mustard (NDR-1)	1346	23.7
Dantiwada	Castor (GCH-7)	585	19.9
	Cowpea (Guj.Cowpea-4)	321	23.9
	Greengram (GM-4)	580	13.3
Rewa	Linseed (2 K-0106)	556	19.8
Varanasi	Linseed (T-397)	1300	30.8

4 Education and Training

4.1 Education

Apart from research, the expertise available at CRIDA coupled with modern infrastructure facilities is also utilized to impart research and education to PG students of different institutions.

4.1.1 Post graduate research

The following scientists are guiding/training post-graduate students of different universities :

Supervisor	Student/s	Discipline	University
Dr. B. Venkateswarlu	Sri Abdul Rasul	Microbiology	OU, Hyderabad
	Sri Sk. Z. Ali	Microbiology	OU, Hyderabad
Dr. M. Maheswari	Ms. Varalakshmi	Genetics	OU,Hyderabad
	Ms. Vijaya Lakshmi	Genetics	OU, Hyderabad
	Ms. Suchitra	Genetics	OU, Hyderabad
Dr. S.Desai	Sri M.H. Ahmed	Microbiology	OU, Hyderabad
	Sri G. Pravin Kumar	Microbiology	OU, Hyderabad
Dr. Y.G.Prasad	Ms. Mannava Chithanada Laxmi	Microbiology	OU, Hyderabad
	Ms. A. Phanidhara	Microbiology	OU, Hyderabad
Dr. S.K. Yadav	Sri M. Gopal Krishna	Genetics	OU, Hyderabad
Dr.M.Srinivasa Rao	Ms. Sunita Devi	Entomology	ANGRAU, Hyderabad
Dr. M.Vanaja	Ms. P. Vagheera	Genetics	OU,Hyderabad
	Sri N. Sunil	Genetics	OU, Hyderabad
	Sri Babu Abraham	Genetics	OU, Hyderabad
Dr. M. Prabhakar	Sri Raj Kumar	Biotechnology	Bangalore University, Bangalore
Dr. K.V. Rao	Sri I. Bhaskara Rao	Soil and Water Conservation	IGAU, Raipur
	Ms. Bharathi	Soil and Water Conservation	IGAU, Raipur
Dr. K.L. Sharma	Ms. Kusuma Grace	Environmental Sciences	JNTU, Hyderabad
	Ms. Usha Rani	Environmental Sciences	JNTU, Hyderabad
Dr. G.R. Maruthi Sankar	Ms. A.Girija	Statistics	JNTU, Hyderabad

4.1.2 Higher studies

The following scientists/technical officers were deputed for pursuing Ph.D. studies

Scientists	University
Ms. Sreedevi Shankar, Scientist	ANGRAU, Hyderabad
Er. I. Srinivas, Scientist (Selection Grade)	JNTU, Hyderabad
Er. Ravikanth Adake, Scientist (Sr. Scale)	JNTU, Hyderabad
Ms. A. Girija, T6	JNTU, Hyderabad
Ms. K. Usha Rani, T5	JNTU, Hyderabad
Ms. V. Anantha Rao, T.6	ANGRAU, Hyderabad

Sri D.B.V.Ramana, Scientist attained Ph.D (Livestock Production & Management) from Sri Venkateswara Veterinary University, Tirupati on 28.03.2007

4.2 Training

The following scientists and technical officers acquired need-based training during 2006-07

4.2.1 Deputation within the country

Name	Title	Venue	Duration
Sri R. Joseph	Evaluation of capacity building for rural resource management	IARI, New Delhi	April 11-16, 2006
Sri B. Narasimlu	Management skills for Technical Officers	ISTM, New Delhi	May 22-26, 2006
K. Ravi Shankar	Summer School on Advances in Agricultural Research Project Management	NAARM, Hyderabad	June 1-21, 2006
Ms. A. Vidyadhari	Draping techniques of apparel designing	College of Home Science, ANGRAU, Hyderabad	July 19-28, 2006
Sri S.M.Vidyasekhar	Orientation programme for newly selected Programme Coordinators and Subject Matter Specialists	ZC Unit, Zone-V, Hyderabad	July 26-27, 2006
Dr. G. Ravindra Chary	Harmonization of database for land use and evaluation	NRSA, Hyderabad	July 28-29, 2006
Dr. B. Venkateswarlu	WTO and TRIPS impact on Indian Agriculture	ASCI, Hyderabad	July 31- August 4, 2006
Dr. G. Ravindra Chary	GIS Application in Land Resource Management	ICRISAT Hyderabad	July 31- August 4, 2006
Sri P.K. Mathad	FLDs and OFTS : Concepts and Impact Analysis	ZC Unit, Zone-V, Hyderabad	August 18-19, 2006

Name	Title	Venue	Duration
Sri R. Joseph	Evaluation of capacity building for rural resource management	IARI, New Delhi	August 19-26, 2006
Sri R. Joseph	IPR Training	ZC Unit, CRIDA, Hyderabad	August 30-31, 2006
Sri R. Joseph	Impact analysis of KVK activities	ZC Unit, Zone-V, Hyderabad	September 7-8, 2006
Sri R. Joseph	Sensitization of agricultural knowledge at KVK	KVK, Trivandrum, Kerala	September 13-16, 2006
Ms. A.Vidyadhari	Drudgery reduction, Nutrition Food & Empowerment of Women farmers	KVK, CTRI, Rajahmundry	October 16-17, 2006
Dr. A.K. Mishra	Course on Planning, Monitoring and Evaluation of Livestock Development	NIRD, Hyderabad	December 4-9 2006
Sri R.Joseph	Video production technology	NAARM, Hyderabad	December 11-23, 2006
Dr. K. Ravi Shankar	DUS Testing – Principles and Procedures	ANGRAU, Hyderabad	December 12-18,2006
Ms. A. Vidyadhari	Innovative methods of extension	KVK, Ahmednagar	December 15-16, 2006
Sri P.K. Mathad	Mechanization and management of FLD on improved agricultural machinery for major oilseed and pulse crops	CIAE, Bhopal	December 18-28, 2006
Ms. A.Sambrajyamma Dr. P.R. Singh Sri P.K. Mathad Sri R. Joseph Sri R.D.R. Reddy Ms. A.Vidyadhari	Training programme on gender sensitization – modules of the functionaries of agriculture and allied sectors	MANAGE, Hyderabad	January 9-12, 2007
Dr. G. Ravindra Chary	National Symposium on Application of Space Technologies for Agricultural Development	APSRAC	January 19, 2007
M. Osman G. Pratibha	International training course on Agricultural Water Management for Enhancing Water Productivity jointly organized by ANGRAU and Alterra-ILRI	January 22-11 February,'07	ANGRAU, Hyderabad

Name	Title	Venue	Duration
Dr. S. Desai	WTO and IPR related issues	ASCI, Hyderabad	January 23-27, 2007
Ms. A. Vidyadhari	Winter school on computer aided residential and commercial interior design	ANGRAU, Hyderabad	January 17 - February 6, 2007
Sri R.D.R. Reddy	Advances in plant protection techniques	PDKV, Akola	February 2-3, 2007
Sri S.M. Vidyasekhar	Hybrid purity analysis by using molecular techniques	DOR, Hyderabad	February 12-19, 2007
Sri P.K. Mathad	Agricultural Engg. technologies for drudgery reduction and soil & water management	KKV, Dapoli	March 1-2, 2007
Dr. Uttam Kumar Mandal	GIS based decision support systems for sustainable agriculture	NAARM, Hyderabad	March 1-21, 2007
Sri B. Narasimlu	Advanced Irrigation Systems for Intensive Crop Production	IARI, New Delhi	March 15-25, 2007
Dr. A.K. Mishra	Training on Technology Commercialization for Senior Scientists	ASCI, Hyderabad	March 26 - April 6, 2007

*Eight scientists and 18 other officials attended the Off-campus training programme on Enhancement of Research and Administration Management Capabilities of Personnel conducted by NAARM at CRIDA,Hyderabad. From March 12-17, 2007

4.2.2 Deputation abroad

Name	Title	Country	Period
Dr. Y.S. Ramakrishna	GEF meeting on Combating Desertification in South Asia	Dubai	June 6-9, 2006
Dr. Y.S. Ramakrishna	To explore the possible options of support in the field of agriculture on behalf of Govt. of India	Niger	June 15-30, 2006
Dr. M. Vanaja	Commonwealth Academic Staff Fellowship, 2006	UK	October 2, 2006- April 1, 2007

5 Women in Agriculture

Farm women are the most important and productive work force in the economy of India. In the overall farm production, women's average contribution is estimated at 55 to 66% of the total labour with percentages much higher in certain regions. Since agriculture is a family enterprise and women have an important role, there is a need to take into account their requirement for improved knowledge and skill. They have to be made aware of the technologies by which they can improve the productivity of their land.

5.1 Farm women

KVK under CRIDA, carried out many activities for empowerment of farmwomen. These included training programmes for skill development and exposure visits.

- Seventy eight training programmes under KVK were conducted including 18 sponsored programmes in which nine hundred and fifty nine women were provided with need-based, skill oriented training in various aspects of agricultural development

Farm women visiting demonstration on Organic Farming

- To improve the nutritional security and assured additional income about 300 families were trained in backyard poultry
- Field days on Organic Farming were conducted for farm women in all KVK villages
- In Tallapally and Machanapally villages of Ranga Reddy district, National Nutritional Week was celebrated to enlighten them about the health and nutrition
- Training to 59 women and 57 men farmers and extension workers on Jatropha and Pongamia cultivation in rainfed areas at Kalwakurthy of Mahabubnagar district on December 21-22, 2006 was imparted.

Farmers (women) training programme at Kalwakurthy, Mahabubnagar district

5.1.1 Study tours-cum-exposure visits

Two Study tours were organised to coastal Andhra and Rayalaseema regions of A.P. during October 11-15 and 27-31, 2006. About 100 farm women were benefited from these tours.

Exposure visit to Anakapally

5.2 Women in CRIDA

CRIDA has a fair representation of women in all spheres. There are nine women in the scientific, eight in the technical, fourteen in administrative and fifteen in supporting staff categories. They are actively involved in carrying out the research and extension as per the mandate besides other institute building activities. Women scientists undertake both institute and externally funded projects and contribute liberally to scientific literature. They have also been instrumental in attracting funds from several funding agencies. Besides carrying out the research activities, they are active in institute committees like RAC, IMC, IJSC, Grievance and Vigilance.

It is a matter of pride to the institute to report that Dr. (Mrs.) M. Maheswari, Senior Scientist (Plant Physiology) was bestowed with the prestigious Punjabrao Deshmukh Women Agricultural Scientist Award 2005 by ICAR. Dr. G. Pratibha, Senior Scientist (Agronomy) received the second best oral presentation award at the National symposium on Production Processing and Marketing of Medicinal Aromatic and Dye Yielding Crops organized by UAS Dharwad and NMPB at Arabhavi.

5.2.1 Projects handled by women scientists

A number of institute and externally funded projects are handled by women scientists. Research results emanating from these are reported through this annual report.

S.No.	Project title	P.I.
	Externally funded	
1.	Enhancing tolerance of sorghum to abiotic stress through genetic manipulation	M. Maheswari
2	Nitrate uptake and assimilation in crop plants under elevated CO_2	N. Jyothi Lakshmi
3.	Impact of elevated CO_2 on important rainfed crops	M.Vanaja
4.	Assessment of Sustainability of Treated / Developed Watersheds in Rainfed Agro-Eco-Sub Regions of Peninsular India using GIS and Remote Sensing	Kausalya Ramachandran
	Institute funded	
5.	Organic management for sustainable production of medicinal and aromatic plants	G.Pratibha
6.	Crop diversification for sustainability of drylands through dye yielding crops	G.Pratibha
7.	Mechanism of drought tolerance in rainfed short duration pluses	N.Jyothi Lakshmi
8.	Studies on root characteristics of greengram and horsegram crops in relation to resource use	V. Maruthi
9.	ICTs as a tool of agricultural extension for technology dissemination – a critical analysis	K. Nagasree
10.	Development of farming situation-based extension for Ranga Reddy district	G.Nirmala
11.	Gender analysis in watershed development programmes of Andhra Pradesh	G. Nirmala
12.	Studies on Enrichment of Quality & utilization of Palmyra fruit	K. Sreedevi Shankar

5.2.2 Human resource development

Two women scientists attained international training. Four woman technical officers and one woman Administrative Officer underwent need-based trainings in the fields of their specializations within the country. Two women technical officers are pursuing Ph.D studies (cf chapter 4).

- Dr.(Mrs.) M. Vanaja, Senior Scientist (Plant Physiology) was selected for the prestigious Commonwealth Academic Staff Fellowship. Under this programme, Dr. Vanaja underwent a six-month training at University of Essex, U.K.

5.2.3 Participation in scientific gatherings

All the women scientists actively participated in seminars, symposia, conferences and workshops conducted by prestigious scientific organizations spread across India (cf chapter 13).

5.2.4 Radio / TV talks

- NPV preparation and its uses and limitations was broadcast on July 25, 2006 by AIR, Hyderabad
- A talk on Post harvest processing and value addition and Production techniques of henna to ETV.

5.3 Women's Cell

There is an active women's cell in the Institute, which looks after the welfare of the women staff. It has the following members.

Dr. G. Pratibha (Scientific)

Ms. V. Savithri (Technical)

Ms. K.V. Manikyam (Administration)

Ms. K. Rajamani (Supporting)

5.4 Women's Day

International Women's day was celebrated on March 8, 2007 at CRIDA. Dr. (Mrs.) Vijaya Khader Ex-Dean (Home Science) ANGRAU, Hyderabad, was the Chief Guest. Dr. Y.S. Ramakrishna, Director, CRIDA chaired the function. There was a discussion on the Role of Urban and Rural Women in the Development of Society. Many women participants highlighted the role of urban and rural women in the development of the society. Dr. (Mrs.) Vijay Khader in her address underlined the problems of working women in balancing her dual role at home and office. She also urged the working women to keep in pace with the changing scenario of the society.

Women's day celebrations at the Institute

6 Awards and Recognition

6.1 Awards

- Dr. Y.S. Ramakrishna, Director, CRIDA was awarded *Shiksha Shiromani Award 2006* by Bharatiya Sanskriti Nirman Parishad and Rachnatmak Sahityik avam Saikshanik Parishad, Hyderabad on October 8, 2006 for implementing the Official Language.

Shiksha Shiromani Award 2006 conferred to Dr Y.S.Ramakrishna

- Dr. M. Maheshwari, Senior Scientist (Plant Physiology) was awarded the Punjabrao Deshmukh Women Agril. Scientist Award 2005 by ICAR

Dr. M. Maheshwari receiving the award from Shri Kantilal Bhuria, Hon'ble Minister of State, Agriculture

- Dr.(Mrs.) M. Vanaja, Senior Scientist (Plant Physiology) was selected for the prestigious Commonwealth Academic Staff Fellowship.

- CRIDA's Two Row Planter manufactured by Rohit Steel Industries received best invention award for the year 2006 at a Mechanical Engineering exhibition held at Jalgaon, Maharashtra.
- CRIDA Orchard Sprayer was selected for Prominent Innovation Award by the TRADE TRENDS magazine for the year 2006
- Shri S.R. Yadav, Asstt. Director (OL), CRIDA was awarded with *Rashtra Bharati Award 2006*, by Bharatiya Sanskriti Nirman Parishad and Rachnatmak Sahityik avam Saikshanik Parishad, Hyderabad on October 8, 2006

- Second best poster presentation Award for the paper by Ravindrachary G. Vittal K.P.R, Sai Reddy, C Vasanta R Mahender Kumar, R, G.R. Maruthi Shankar, Pratibha, G, Rao, K.V, Prasaad, J.V.N.S, Rama Krishna,Y.S, Sreeramulu, L, Srijaya, T and Udaybhanu Sri for enhancing the land productivity in rainfed rice based farming systems paper presented in National symposium on System of rice intensification organized by DRR, and ANGRAU, Hyderabad during November 17-18, 2006.

- Dr. V.S. Rao, Principal Scientist (Horticulture) was awarded second prize in the area of fruits and vegetables for the poster on studies on processing of Aonla presented at ICFOST 2006, 18th Indian Convention of Food Scientists and Technologies November 16-17, 2006

- Second best Oral presentation award was bagged by Pratibha G, Korwar GR, Srinivas I and Ramakrishna Y S for their by paper on "Production potential of *Indigofera tinctoria* in rainfed SAT regions" presented in National symposium on Production Processing and Marketing of Medicinal Aromatic and Dye Yielding Crops, organized by UAS Dharwad and NMPB at Arabhavi, February 22-23 2007

- Award for best performance in implementation the official Language (Hindi) policy of the union among The Central Government Offices in twin cities from Town Official Language Implementation Committee (TOLIC), Hyderabad-Secunderabad. The Shield was received by Director, Dr.Y.S.Ramakrishna from the GM of South Central Railway, Rail Nilayam in a function which was held on 27.2.2007 at Rail Nilayam, Secunderabad.

- CRIDA was awarded two First prizes, one Second prize and one Third prize in different categories of Annual Rose Show, 2006 organized by Hyderabad Rose Society on December 9 & 10, 2006 at Hyderabad

6.2 Recognition

- Dr. M. Osman, Senior Scientist (Agronomy) empanelled as Facilitator Cum Evaluator (FCE) with Council for Advancement of People's Action and Rural Technology (CAPART), Ministry of Rural Development, Government of India, New Delhi

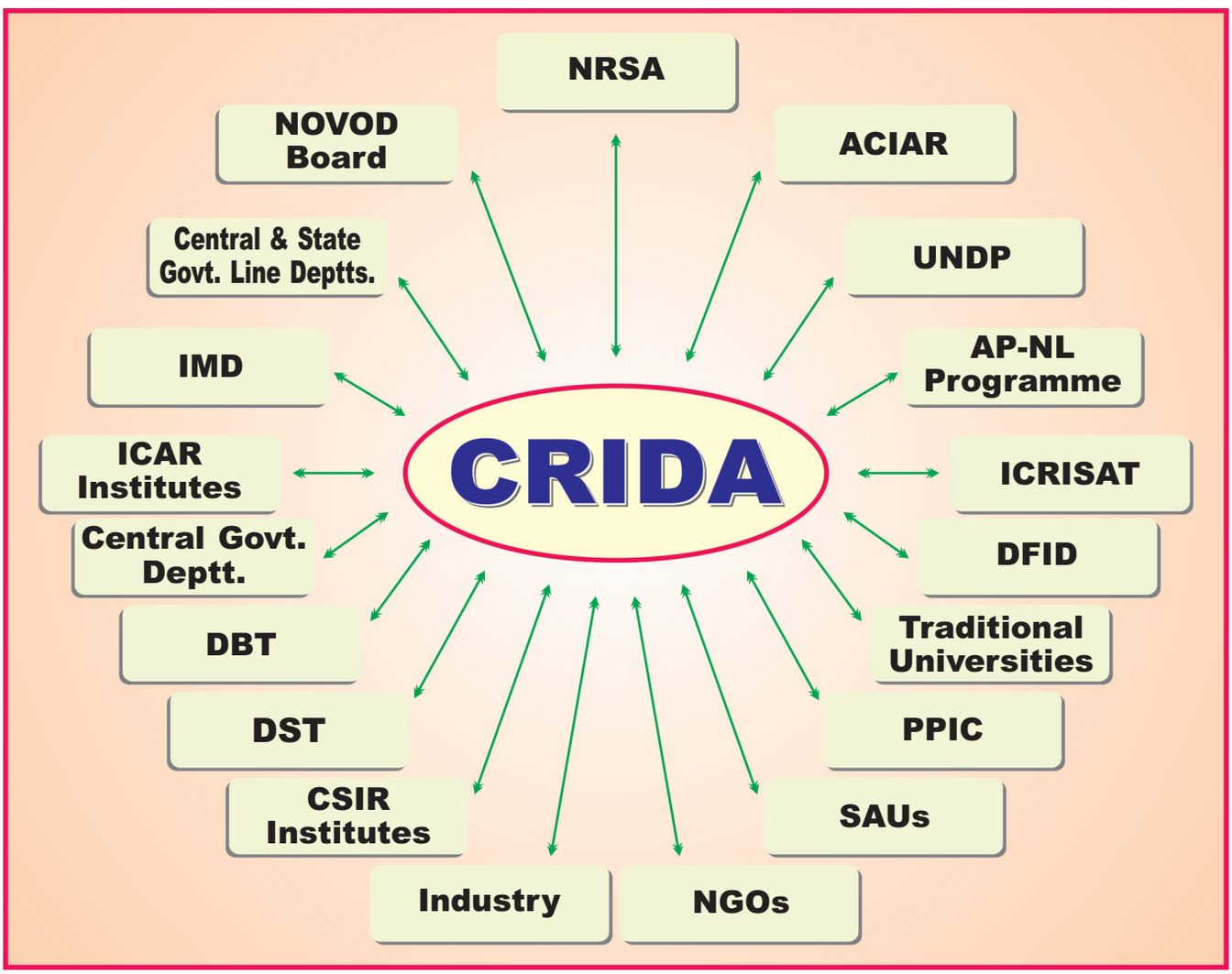
- Dr. B. Venkateswarlu, Head, DCS was nominated to the Board of Studies of Microbiology, Osmania University and also as technical committee member of Sri Ramanadha Tirtha Institute of Rural Development.

- Dr. S.K. Yadav, Senior Scientist (Biochemistry) was nominated as Fellow of Indian Society of Agricultural Biochemists, Kanpur.

7 Linkages and Collaborations

Keeping in pace with the changing scenario of agricultural research and development, CRIDA has been renewing existing linkages and establishing new partners with all the stake holders. CRIDA promotes action oriented research in public – private partnership mode through consortium approach. It has strong collaboration with ICRISAT, ILRI, IWMI, ANGRAU and other SAUs, JNTU, University of Delhi, Osmania and other Universities and NGOs for developing and refining the technologies for improving the profitability in rainfed agriculture. CRIDA also plays a role in advising agencies such as central/ state line departments to develop suitable policies for implementing the programmes on rainfed agriculture.

The Institute undertakes specific research programmes fulfilling mandates of both CRIDA and the donar to delve into basic, applied, strategic and anticipatory research. The partners in this mode include ACIAR, DFID, UNDP, CSIR, DBT, DST, NOVOD Board, PPIC, Govt. of Andhra Pradesh and the like. CRIDA also undertakes consultancy programmes for specific tasks from Govt. of Andhra Pradesh, Madhra Pradesh, WWF etc. CRIDA takes inputs from IMD, NCMRWF and generates value added outputs for the benefit of the rainfed farmers.



8 AICRP/Coordination Units

8.1 All India Coordinated Research Project for Dryland Agriculture

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) has a network of 25 centers representing arid, semi-arid, sub-humid and per-humid climates with diverse biophysical and socio-economic settings of the rainfed agro-ecologies of the country. The project has the mandate to generate location specific technologies, their evaluation through on-station and on-farm research. This year, 469 experiments were conducted at the participating centers under following themes: rain water management (66), integrated nutrient management (107), energy management (54), cropping systems (60), crop improvement (119), crop management (28) and alternative land use (35), in rainfed rice, maize, oilseeds (soybean and groundnut), cotton and nutritious cereals (finger millet, pearl millet and sorghum) based production systems.

8.1.1 Salient findings under on- station condition

The salient findings emerged at different centers under various themes are highlighted below:

Centre	Test Crop/ Cropping system	Salient finding/ promising technology
Rain water management		
Agra	Mustard (Pusa Jaikisan)	4 cm irrigation each at 50% flowering and 50% silique formation stage
Akola	Cotton (AHH-84635) Soybean (JS-335)	Soil mulch with application of 20 kg K ha^{-1} for cotton + soybean
Arjia	Sorghum (CSH-14) + Cowpea (C-152) Maize (Navjot) + Blackgram (RBU-38) Groundnut (JL-24) + Sesame (RT-125)	Sorghum + cowpea (fodder); supplemental irrigation for maize + blackgram; groundnut + sesame; ridges & furrows for maize
B.Saunkhri	Maize (JH-3459)	Sugarcane thrash mulch
Bangalore	Chilli (Samrudhi) Horse gram (PHG-9)	Pond water for green forage & chilli minimum runoff of 83 mm under natural vegetation & khus live barrier
Bijapur	*Rabi* sorghum (M35-1) Chickpea (A-1) Sunflower (KBSH-1)	Seed hardening with $CaCl_2$ (2%) for 8 hours for *rabi* sorghum & chickpea; sand mulch of 10 cm depth for sunflower
Dantiwada	Castor (GCH-7)	Crop residue mulch of castor together with kaolin @ 5% as an anti-transparent for castor
Faizabad	Pigeonpea (Narendra Arhar)	Ridges & furrows
Indore	Rosha grass + Soybean (JS-335)	Sowing across the slope + vegetative barriers with rosha grass; ridge and furrows system with 45 cm & polythene mulching for soybean

Centre	Test Crop/ Cropping system	Salient finding/ promising technology
Kovilpatti	Cotton (KC-2) + maize (COHM-4)	Coir pith as mulch @ 5t ha^{-1} for cotton + maize
Pharbani	Sorghum (CSH-9) + pigeonpea (BSMR-853)	Opening furrow after every 4 rows for sorghum + pigeonpea in (4:2) ratio
Phulbani	Tomato (Vaisali)	Lined pond with soil-cement plaster (6:1) of 8 cm thickness with tomato
Rajkot	Groundnut (GG-2)	30 cm distance between rows having 3 rows on broad bed of 90 cm & furrow of 45 cm
Ranchi	Upland rice (Vandana)	Hoeing by Dutch Hoe between rows together with leaf & straw mulch
Rewa	Soybean (JS-335) Rice (Vandana) Lentil (JLS-1)	Use of harvested rain water for soybean, rice in lower zone and lentil in upper zone
Solapur	Pearl millet (Shradha)	Mechanical bunds + vertical plastic mulch
Varanasi	Rice (NDR-97)	Straw mulch for early sown rice, life saving irrigation for late sown rice
Cropping systems		
Agra	Pigeonpea (Upas-120) + cluster bean (HGS-365)	Pigeonpea + cluster bean in (1:1) ratio
Akola	Soybean (JS-335) – chickpea (PKV-KAB-2) Cotton + pigeonpea (C-11)	Soybean – chickpea crop sequence Cotton + pigeonpea inter cropping
Arjia	Maize (Navjot) – blackgram (RBU-38)	Maize – blcakgram crop sequence
B. Saunkhri	Maize (JH-3459) (50 cm) + blackgram (MASH-338)	Maize (50 cm) + blackgram (1:1) ratio inter cropping
Bijapur	Chilli (Byagadi dabba) + onion (local)	Chilli + onion (2:4) ratio inter cropping
Dantiwada	Greengram (HM-4) Green gram (GH-4) + castor(GCH-7)	Paired row sowing of greengram (30-60 cm) between 2 pairs under green gram + castor relay cropping
Faizabad	Pigeonpea (Narendra Arhar) + Okra, Maize (Naveen)	Pigeonpea + okra for maize equivalent yield
Hisar	Greengram (Asha) Castor (DCH-7)	60:120 cm x 60 cm + 2 rows of greengram for maximum castor equivalent yield (910kg ha^{-1})
Indore	Pigeonpea (Asha) + soybean (JS-335)	Pigeonpea + soybean (1:2) ratio intercropping

Centre	Test Crop/ Cropping system	Salient finding/ promising technology
Jorhat	Rice (Basundhara)-niger (NG-1)	Rice-niger sequence
Parbhani	Sorghum (CSH-9) + pigeonpea (BSMR-853)	Sorghum + pigeonpea in 3:3 ratio
Phulbani	Groundnut (OG-52-1) + pigeonpea (Asha ICPL-87119)	Groundnut + pigeonpea
Solapur	Pearlmillet (Shradha) + pigeonpea (BSMR-853)	Pearlmillet + pigeonpea in 2:1 ratio; Sunflower + pigeonpea in 6:3 ratio
Varanasi	Rice (NDR-97) pigeonpea (Malviya Arhar)	Paired planting of 3 rows of rice in 2 pairs of pigeonpea (50 & 100 cm)
Alternate Land Use		
Agra	Aonla (Balwant) *Stylosanthes hamata* Pearlmillet (MBH-163)	Vetiveria (khus) for maximum survival (97%), Aonla + *stylosanthes hamata* & aonla+pearl
Akola	Ber + greengram (kopargaon)	Ber + greengram for maximum gross monetary returns Rs.7120 ha^{-1}
Anantapur	Tamarind	Tamarind was superior for maximum stem girth under drip and without drip irrigation
Arjia	*Acacia tortilis*	*Acacia tortilis* + bunding under silvi-pasture system for maximum dry grass yield and pumpkin under agri-horti system
B. Saunkhri	Lemon grass *(Citronella)*	45 x 30 cm spacing & mulching @ 6t ha^{-1} for lemon grass fresh yield
Bangalore	*Solanum viarum*	*Solanum viarum* (Alkaloid solanum)
Bijapur	Sorghum (MM-351)	Tractor drawn seed-cum-fertilizer drill was superior for sorghum
Dantiwada	*Dicanthium annulatum* Pearlmillet (GCB-1)	*Dicanthium annulatum* + pearl millet for maximum pearl millet equivalent yield under ley farming
Indore	Drumstick + soybean (JS-335) + pigeonpea (ICPL-87)	Drumstick + soybean + pigeonpea (4:2) for for maximum soybean equivalent yield
Solapur	Pigeonpea (BSMR-8537)	Fluchloralin @ 1 kg a.i. ha^{-1} as a pre-emergence dose + one hoeing at 45 DAS
Crop Management		
Agra	Mustard (Pusa Jaikisan)	Sowing of mustard during 11-20th October

Centre	Test Crop/ Cropping system	Salient finding/ promising technology
Anantapur	Groundnut (TMV-2) Sorghum (VJJH-540) Sunflower (VSH-475) Pigeonpea (LRG-41) Castor (Kranthi) Cluster bean (REC-1035)	Normal DOS (July 1st fortnight) for groundnut; sorghum; sunflower; pigeonpea; castor; and cluster bean
Indore	Soybean (JS-335) Pigeonpea (JA-4) Sunflower (Jwala mukhi) Cowpea (Pusa komal) Pigeonpea (JA-4) Soybean (JS-335)	Sowing on 7th July for soybean and pigeonpea under sole and soybean + pigeonpea as inter cropping Sowing on 17th July for sunflower & cowpea; sunflower + pigeonpea; cowpea + pigeonpea; and soybean + sunflower
Rajkot	Pearlmillet (GHB-558) Black gram (T-9) Bunch groundnut (JSSP-29) Sesame (Guj-Til-1) Castor (GACH-1) Cotton (HY-8) Pigeonpea (GT-100) Groundnut (GG-2)	Normal sowing for pearl millet; black gram & bunch groundnut ; while 15 days after onset of duration crops, sowing with on set of monsoon (normal) for castor; cotton; pigeonpea spreading monsoon (29th June) for sesame Incase of long groundnut
Solapur	Sorghum (M-35-1)	45 x 25 cm spacing & 75 kg N + 37.5 kg P ha^{-1}
Integrated Nutrient Management		
Agra	Pearlmillet (MBH-163) + Cluster bean (HGS-365)	60 kg N ha^{-1} (inorganic) under pearl millet + cluster bean system
Akola	Cotton (AHH-84635) + greengram (Kopargaon) Sorghum (CSH-9) + pigeonpea C-11)	25 kg N + 25 kg P + 25 kg N ha^{-1} (FYM) for cotton + greengram (1:1); 15 kg N (compost) + 25 kg N (inorganic) for sorghum + pigeonpea
Anantapur	Groundnut (TMV-2)	10 kg N + 20 kg P + 20 kg K ha^{-1} + FYM @ 4 t ha^{-1}
Arjia	Maize (Navjot) + blackgram (RBU-38)	15 kg N (compost) + 10 kg N (urea) for maize + blackgram
B. Saunkhri	Maize (JH-3459) + blackgram (MASH-338)	100% RDF for maize + blackgram
Bangalore	Soybean (KB-79) Groundnut (JL-24) Fingermillet (GPU-28)	FYM to supply rec. N + 50% NPK for soybean; FYM @ 10 t ha^{-1} + 50% RDF NPK for groundnut; and 50% N through (green leaf) + 50% NPK for finger millet
Bellary	Sorghum (M35-1) +	15 kg N (green leaf) + 20 kg N (urea) for sorghum + chickpea (Annigeri-1) chickpea

Centre	Test Crop/ Cropping system	Salient finding/ promising technology
Bijapur	Sorghum (M-35-1) + chickpea (A-1)	100% recommended N
Dantiwada	Castor (GCH-7) Cluster bean (Gujarat cluster bean-1)	50% N (inorganic) + 50% N (FYM) for castor & 100% recommended N for cluster bean under *simarouba glauca*
Faizabad	Maize (Naveen) + pigeonpea (Narendra Arhar)	100% recommended N for maize+pigeonpea
Hisar	Green gram (Asha) Chickpea (H-208)	10 kg N + 20 kg P ha^{-1} + inoculation of seed with phosphorus solubilizing bacteria for green gram; and20 kg N + 40 kg ha^{-1} for chickpea
Indore	Maize (IVM-421)	50% RDF + earthing at 25 DAS for maize
Jagadalpur	Rice (Poornima)	60 kg N + 50 kg P + 30 kg K ha^{-1} + blue green algae
Jorhat	Rice (Basundhara)	50% N (urea) + 50% N (organic)
Kovilpatti	Cotton (KC-2) + blackgram (Co-5)	FYM @ 40 kg N ha^{-1} for cotton + blackgram
Parbhani	Sorghum (CSH-9) + pigeonpea (BSMR-853) Soybean (MAUS-7) + pigeonpea (BSMR-853) Greengram (BPMR-145) – *rabi* sorghum	100% RDF for sorghum + pigeonpea; soybean + pigeonpea; cotton + blackgram & greengram – rabi sorghum
Phulbani	Pigeonpea (Asha) + rice (JHU 11-26) Yam(Hatikhoja) + Maize (Nirmal -51) Rice (JHU 11-26) +	20 kg N (FYM) + 25 kg N (urea) for pigeonpea + rice; 50% N (urea) + 50% N (FYM) for yam + maize; 15 kg N (FYM) + 20 kg N ha^{-1} (urea) for rice + black gram and lime @ 20% of lime requirement + FYM @ 5 t ha^{-1} for green gram
Rewa	Rice (Vandana) - wheat (GW-173) Blackgram (DU-4) - chickpea (JG-315) Wheat (GW-173) – chickpea ((JG-315) Mustard (Varuna)	100% recommended N (compost) rice-wheat; blackgram-chickpea & wheat-chickpea rotation; and 40 kg N ha^{-1} for mustard 100% NPK + secondary & micro nutrient for rice;
Solapur	Sorghum (M35-1) Chickpea (Vijay)	25 kg N ha^{-1} (crop residue) + 25 kg N ha^{-1} (leucaena) for sorghum & chickpea
Varanasi	Rice (NDR-97) – lentil (T-397) Rice (NDR-97) + green gram (Narendra moong -1)	50% N (urea) + 50% N (FYM) for rice – lentil; 15 kg N (green leaf) + 20 kg N ha^{-1} (urea) for rice + green gram

Centre	Test Crop/ Cropping system	Salient finding/ promising technology
Energy Management		
Akola	Sorghum (CSH-9)	Low tillage + herbicide + 50% inorganic + 50% organic fertilizer
Anantapur	Groundnut (TMV-2)	Intercultivation with tractor drawn implement twice at 25 & 40 DAS at 30 x 10 cm spacing
Arjia	Blackgram (RBU-39)	Conventional tillage + 2 interculture + 50% inorganic + 50% organic fertilizer
B. Saunkhri	Maize (JH-3459)	Conventional till + interculture + 100% inorganic
Bellary	Sorghum (M35-1)	Conventional tillage + one hand weeding + 100 N (inorganic)
Dantiwada	Cluster bean (Gujarat cluster bean -1)	Low tillage + interculture together + 50% inorganic + 50% organic fertilizer
Faizabad	Lentil	Pantnagar zero till drill
Hisar	Pearl millet (HHB 67) Mustard (RH-30) Chickpea (H-208)	Tractor drawn ridger seeder for pearl millet; 2-row ridger seeder for mustard; & bullock drawn desi plough for chickpea
Indore	Soybean (JS-335)	Low tillage+straw @ 4t ha^{-1}+hand weeding Sowing with CRIDA planter
Jagdalpur	Rice (Poornima)	Summer ploughing + line seeding by Indira seed drill + 100 kg ha^{-1} of seed + herbicide + sunhemp green manure
Parbhani	Cotton (PH-348) + soybean (MAU-71) Sorghum (CSH-9) Soybean (MAU-71)	Conventional tillage + interculture for cotton + soybean; minimum tillage for sorghum and mechanical tillage for soybean
R. Dhiansar	Maize (Kanchan-517) – wheat (Raj-3077)	Low tillage + interculture + 100% inorganic fertilizer for maize – wheat
Ranchi	Rice (Vandana) Linseed (T-397) Groundnut (BAU-20)	Low tillage + twice hand weeding for rice & linseed; sowing with Dutch Hoe for groundnut
Rewa	Soybean (JS-335)	Low tillage + weedicide + 50% organic + 50% inorganic fertilizer
Solapur	Pearlmillet (Shradha) Sorghum (M35-1)	Low tillage + 50% organic + 50% inorganic for pearl millet; conventional tillage + 25 kg N (urea) + 25 kg N (organic) + 12.5 kg P ha-1 for sorghum
Bangalore	Fingermillet (GPU-28)	Conventional tillage + interculture + 50% N (organic) + 50% N (inorganic)

Under crop improvement theme some promising varieties/genotypes were identified at various AICRP centers which yielded 25-40% above the prevalent varieties. The promising crops alongwith the identified genotypes are given as under :

Centre	Promising Varieties
Agra	Sesame (OS-sel-117), Niger (JNS-27), Cluster bean (HGS-02-1)
Arjia	Sesame (RT-334), Maize (Pratap early), Horsegram (Mekka-3), Blackgram (HG-1), Taramira (ST-1-2), (PTM-1)
B.Saunkhri	Maize (PMH-2)
Bangalore	Chilli (PBC-613), Maize (NAH-2049), Cowpea (PKB-4), Soybean (KB-280), Blackgram (BDU-4), Greengram (2KM-137), Rice (Doddabirenellu), Castor (CK-05-IHT-35)
Bijapur	Horsegram (GPM-6 of), Mulberry (S-1635), Spreading groundnut (GPM-425), Bunch groundnut (DH-103), Foxtail millet (FMLT-11), Barnyard millet (BMLT-10), Little millet (LMLT-5), Cotton (Jayadhar)
Dantiwada	Mustard (Bio-902), Castor (JHB-887), Pearlmillet (GHB-558), Cotton (G-cot-21)
Hisar	Pearlmillet (HHB-67-2), Cowpea (HC-98-96), Cluster bean (HG-563), Greengram (K-851), Mustard (RH-819), Barley (HB-393), Chickpea (H-208)
Indore	Pigeonpea (ICP-8863), Soybean (JS-9305), Niger (JNS-27)
Kovilpatti	*Arboreum cotton* (KWA-23), *Hirsutum cotton* (L-763), Sunflower (AHT-8)
Phulbani	Pigeonpea (V-41)
Ranchi	Upland rice (Birsa Dhan-109), Groundnut (BAU-20), Sesame (Kanke white), Pigeonpea (Bahar (local red))
Rewa	Chickpea (JG-315), Lentil (RWl-4), Linseed (2K-0106), Greengram (TJM-15),Blackgram (IU-83-5)
Solapur	Horse gram (HG-1), Castor (CK-05-AHT-41), Cluster bean (G-5), Moth bean (MB-3)
Varanasi	Sesame (TC-25), Pigeonpea (Malviya Arhar-6), Lentil (L-345 (small seed)), Lentil (L-436 (bold seed))

8.1.2 Workshops/group meetings

- A one day Brainstorming session was organized on July 9, 2006 at CRIDA to find the means of continuing the capacity building and start action research phase based on the progress made during the previous year.

- A two-day technical workshop on Participatory Action Plan Development was organized at ORP Village Hanjagi in Solapur district on February 8-9, 2007 to identify the issues of priority through participatory situation analysis to include into ORP technical programme.

- Three-day Technical Workshop on Action Research, Impact analysis and Participatory Technology Assessment was organized at CRIDA, Hyderabad during March1-3, 2007.

8.2 All India Coordinated Research Project on Agrometeorology

The All India coordinated Research Project on Agrometeorology (AICRPAM) has a network of 25 centres encompassing various agro-ecological regions and covered by 25 SAUs. As in the past, this year too research activities were carried out on all the mandated crops, at all the centers, on the themes of agro-climatic characterization, crop-weather relationships, crop growth modeling, and the effect of weather on pests and diseases. The highlights of the activities are summarized below:

8.2.1. Agroclimatic Characterization :

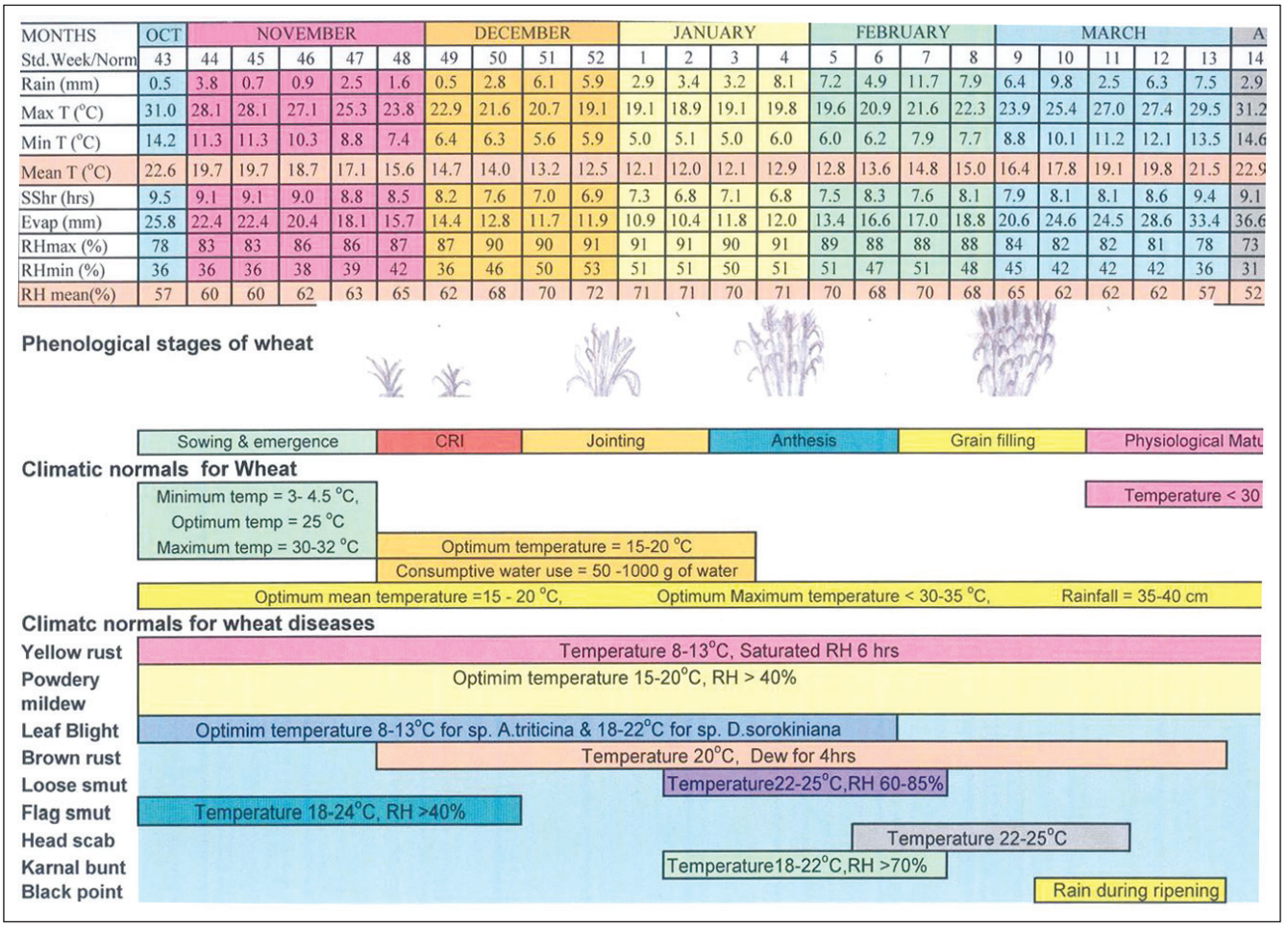
- At Thrissur, rainfall analysis of Kerala state for a period of 136 years (1871-2006) showed that the mean annual rainfall of the state was 2819 ± 405 mm and the coefficient of variation (CV) was 14.4 percent indicating nature of the rainfall that was highly stable and dependable.

- At Udaipur 46 years of rainfall data (1961-2006) was analyzed with respect to trend factors and no definite trend was found in annual rainfall values. However, 10-year moving average showed decreasing trend from 1986 onwards.

- Crop-weather calendars were prepared by Ludhiana centre using the historical weather data, phenology of the crops and pest/disease information for the major crops, *viz*., wheat, mustard and sunflower in Agroclimatic Zone-3 (Central Plains) of Punjab. These calendars can be effectively used in issuing Agro Advisory Services for the farmers of the region. The critical stages of the crop and congenial conditions of peak pest infestation can be obtained from this calendar.

- Long-term trend analysis of temperature in respect of Gwalior (1960-2005) and Indore (1970-2005) was carried out by Jabalpur and was found that the minimum temperature range (5-10°C) at Gwalior was showing an increasing trend while it was a decreasing trend at Indore.

MONTHS	OCT	NOVEMBER					DECEMBER				JANUARY				FEBRUARY				MARCH					A
Std.Week/Norm	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rain (mm)	0.5	3.8	0.7	0.9	2.5	1.6	0.5	2.8	6.1	5.9	2.9	3.4	3.2	8.1	7.2	4.9	11.7	7.9	6.4	9.8	2.5	6.3	7.5	2.9
Max T (°C)	31.0	28.1	28.1	27.1	25.3	23.8	22.9	21.6	20.7	19.1	19.1	18.9	19.1	19.8	19.6	20.9	21.6	22.3	23.9	25.4	27.0	27.4	29.5	31.2
Min T (°C)	14.2	11.3	11.3	10.3	8.8	7.4	6.4	6.3	5.6	5.9	5.0	5.1	5.0	6.0	6.0	6.2	7.9	7.7	8.8	10.1	11.2	12.1	13.5	14.6
Mean T (°C)	22.6	19.7	19.7	18.7	17.1	15.6	14.7	14.0	13.2	12.5	12.1	12.0	12.1	12.9	12.8	13.6	14.8	15.0	16.4	17.8	19.1	19.8	21.5	22.9
SShr (hrs)	9.5	9.1	9.1	9.0	8.8	8.5	8.2	7.6	7.0	6.9	7.3	6.8	7.1	6.8	7.5	8.3	7.6	8.1	7.9	8.1	8.1	8.6	9.4	9.1
Evap (mm)	25.8	22.4	22.4	20.4	18.1	15.7	14.4	12.8	11.7	11.9	10.9	10.4	11.8	12.0	13.4	16.6	17.0	18.8	20.6	24.6	24.5	28.6	33.4	36.6
RHmax (%)	78	83	83	86	86	87	87	90	90	91	91	91	90	91	89	88	88	88	84	82	82	81	78	73
RHmin (%)	36	36	36	38	39	42	36	46	50	53	51	51	50	51	51	47	51	48	45	42	42	42	36	31
RH mean(%)	57	60	60	62	63	65	62	68	70	72	71	71	70	71	70	68	70	68	65	62	62	62	57	52



Crop-weather-disease calendar for Wheat

- Long-term daily rainfall data analysis was carried out to study the impact of pre-monsoon rainfall activities in different parts of Chhattisgarh by Raipur centre. A strong relationship was found between the monsoon and the pre-monsoon rainfall over Ambikapur.

$$Y = 1024.78 + 1.66\,X_1 + 17.18\,X_2 + 1.00\,X_3 \qquad R^2 = 0.25^{**}$$

  Where Y=Southwest monsoon rainfall, X_1 = Premonsoon rainfall; X_2 = No. of thunderstorms; X_3 = First thunderstorm date,**significant at 1% level.

- Three Agroclimatic Zones of Chhattisgarh were further delineated into 40 Agro-ecological Regions based on rainfall, surface soil type, soil depth/slope, land use by Raipur centre and thematic maps were prepared. This information is useful for improving the agricultural crop planning in the State.

8.2.2. Crop Weather Relationships :

Rabi

Wheat

- Temperature during flowering stage is critical in determining the final grain yield. It was found that increase in maximum temperature beyond 27°C during flowering stage reduced the yield at Faizabad.

- At Udaipur it was found that the higher mean temperature beyond 24°C during milking to maturity causes significant reduction in grain yield.

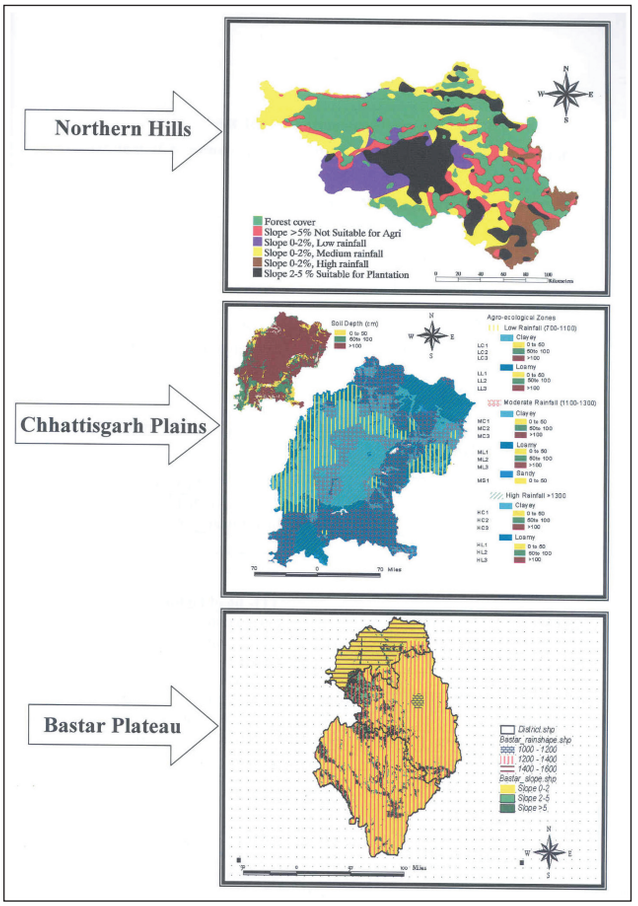


Fig.2: Agro-Ecological regions of Chhattisgarh

- The following Simple linear regression models were developed at Palampur between cumulative biomass (BM) (kg/ha) of wheat and accumulated values of growing degree-days (AGDD), evaporation (AEVP) and rainfall (ARF) explains about 77 to 95% variation in biomass

  BM = -3709.469 + 5.284 AGDD $R^2 = 0.92$

  BM = -3122.517 + 16.160 AEVP $R^2 = 0.95$

  BM = -4901.032 + 40.440 ARF $R^2 = 0.77$

Maize

- At Chatha, the conversion efficiency to produce dry matter from absorbed photo synthetically active radiation was higher in sole maize crop by 4 % compared to intercropping with moong as well as moong sole crop.
- Light use efficiency (LUE) in sole maize varied from 0.47 to 1.53 (g MJ^{-1}) where as in intercropping with moong, it varied from 0.69 to 1.47 (g MJ^{-1}) and in sole moong it varied from 0.4 to 0.7 (g MJ^{-1}).
- At Samastipur, study on Heat units (HU) and growth of maize showed that among the varieties, Deoki variety used only 2152 HU and produced higher grain yield among the maize varieties in all the three different dates of sowing .

Cotton

- At Kovilpatti, a significant positive relationship was observed between bacterial blight (Y) and weather parameters rainfall (Rf) and morning RH (%) of 10 day intervals. The following linear regression model was developed for use in Agro Advisory Services.

  $Y = 0.205 + 0.705\ (Rf) + 0.472\ RH\ (m)$

  $R^2 = 0.78$

Chickpea

- On the basis of three-year experimental data of Chickpea crop (Desi variety), a strong negative relationship found between maximum temperatures (X) during flowering to physiological maturity and seed yield (Y) at Jabalpur.

  $Y = -195.29\ x + 7158.3$ $R^2 = 0.89$

- It was observed at Faizabad that the cumulative PAR was higher in the genotype K-850 over Awarodhi and also produced better yields at the same locations, the east-west sowing of chickpea was found to be more efficient in light interception by 9%.

Mustard

- A strong relation between accumulated heat units and dry matter was observed in mustard crop at physiological maturity in the mid-October sown crop at Hisar.

  $Y = 6026.5 - 4.1246\ X$ $R^2 = 0.82$

  A technology developed by the Hisar center was that the lower leaves removed for fodder purpose from the late sown mustard crop at Hisar , was not only compartmented the seed yields but also provided the green fodder for animals.

- At Chatha, Jammu, a linear relationship was observed between Vapour Pressure Deficit (VPD) and transpiration (Y), Which explains 94% variations in transpiration

  $Y = 0.31 (VPD) + 0.17$ $R^2 = 0.94$

Groundnut

- At Anantapur, prediction of phenophases in groundnut crop were carried out using growing degree-days and validated with actual data of last week of July sown crop. It was found that predicted and actual values were within the acceptable limits.

  Flowering - $Y = 0.0604 X – 2.3237$

  Pod initiation - $Y = 0.0526 X + 3.5424$

  Maturity - $Y = 0.0353 X + 39.716$

  Where - Y = phenological event and X =Growing degree days

Blackgram

- At Kovilpatti, experimental data analysis showed that the optimum time of sowing for blackgram was during 40th and 41st week were registered increased growth and yield.

Ragi

- Evapotranspiration (ET) measured with weighing lysimeter in ragi crop was higher during transplanting to maturity phase at Ranchi and it was found to be 104.6 mm.

Soybean

- At Akola, among soybean varieties viz., PK-472 and JS-335, recorded the highest mean thermal use efficiency of 0.53 kg ha^{-1} $^0C^{-1}$ during the crop-growing period.

Vegetables

Cabbage

- The total GDD requirement of cabbage reduced from 2404 to 2164 °C with delay in sowing by one month i.e. from 15th October to 15th November respectively at Dapoli. The regression analysis indicated a strong relationship ($R^2 = 0.62$) between yield (Y) and accumulated growing degree days (AGDD) during entire growth period of the crop. The equation is as follows:

  $Y = 1478.0 – m\ 0.636\ AGDD$

Field bean (Wal)

- The analysis of weather data in Dapoli region indicated reduction in crop yield during 2005-06. This may be mainly due to lower minimum temperature (8.8°C) and higher maximum temperature (35.1°C) than the normal. Lower bright sunshine hours during flowering to fruit set also affected the crop yield.

Kharif

Rice

- At Mohanpur, a linear relationship between grain yield and agrometeorological parameters was developed to predict grain yield (Y) of rice:

  $Y = -9376.16 – 25.1741\ \Sigma\ E_0\ P_1 + 2.209263\ \Sigma\ Rf\ P_2 + 8.108382\ \Sigma\ GDD\ P_4$ $R^2=0.92^{**}$

  Whereas P_1 = Transplanting to pod initiation;

  P_2 = Transplanting to first Anthesis;

  P_4 = Transplanting to physiological maturity;

  E_0 = Evaporation; Rf = Rainfall, and GDD = Growing degree-days

- At Raipur, the evapotranspiration (ET) measured using Lysimeter in rice during vegetative, reproductive and maturity stages were recorded as 211,175 and 122 mm respectively which were higher than the open pan evaporation.

8.2.3. Crop Growth Modelling:

Rabi

Wheat

- At Ludhiana, Modeling equations were developed with the pooled data of three date of sowings from rabi season in different crop years (1986-87 to 2003-04) on Accumulated growing degree days (AGDD) were derived for predicting the onset of a particular phenophase in different cultivars of the wheat crop. These regression models indicate that AGDD accounts for 95 % variation in the onset of phenophases in all the cultivars.

Cultivar	Model equation	R^2
WL1562	Y=0.089*AGDD-0.207	0.95
HD2329	Y=0.088*AGDD-1.093	0.95
WH542	Y=0.087*AGDD-0.789	0.95
PBW343	Y=0.089*AGDD-0.665	0.95

Kharif

Rice

- A linear regression model equation was developed with the pooled data of two different dates of sowing from four consecutive *kharif* seasons (1999-2002) on temperature (AGDD) were derived for predicting the onset of a particular phenophase (Y) in rice crop at Ludhiana.

  Y= 0.0489*AGDD+0.1921 R^2=0.99

Maize

At Chatha, Jammu, genetic coefficients of maize crop were derived and CERES Maize model was simulated. The grain yield was showed a permissible deviation from the simulated (2848 $kgha^{-1}$) and observed (2806 $kgha^{-1}$)

8.2.4. Weather Effects on Pests and Diseases:

Rabi

Wheat

- Evening RH and Minimum temperature were observed to be congenial for leaf blight in wheat at Faizabad.

Rice

- The peak rice hispa activity of the pest was associated with Tmax - 33.5 to 34.3°C; Tmin – 23.8 to 26.6°C; RH (morning) – 98-99 percent and RH (evening) – 68-94 % during mid-August coincided with active tillering phase.

Ber

- Multiple regression models developed for the Mundia ber variety at Anantapur using maximum and minimum temperature and PDI of powdery mildew indicating the negative effect of max T and Min T.

  PDI = 66.74 – 14.0 MaxT – 8.,1 MinT R^2 = 0.79

Cotton

- A simple regression model was developed using data of Alternaria leaf blight (Y) of cotton crop and the corresponding weather variables at Kovilpatti.

  Y = 0.213 + 0.625 Rf + 0.417 RH (m)
  R^2 = 0.78

- At Parbhani, weather data prevailed in one week prior to the outbreak of bollworm (Y) was used in development of regression equations for prediction purposes. The following equation could explain the variability up to 65 percent. .

  $Y = 0.37 + 0.67\ Tmin_1 + 0.63\ RH_1 - 3.72\ BSS - 1.73\ BSS_{1(post\ one\ week)}$ R^2 = 0.65

- The mean weather condition for the variables involved in causing outbreak are as below:

  $Tmin_1$ = >17.6°C; RH_1 = >83%; BSS=<8.4 hr; $BSS_{1(post\ one\ week)}$ = <8.3 hr

9 Publications

9.1 Research papers

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10 Ongoing Projects

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
DIVISION OF RESOURCE MANAGEMENT				
1. RM/LU/12	Low till farming strategies and integrated plant nutrient supply for rainfed semi-arid tropics	**K.L. Sharma** K. Srinivas Y.S. Ramakrishna G.R.Korwar B.Venkateswarlu G.R. Maruthi Sankar V.Maruthi K.V.Rao U.K.Mandal	1998	2008
2. RM/FM/02	Mechanical incorporation of biomass for soil fertility improvement	**R.K.Adake** V.M.Mayande I.Srinivas U.K.Mandal A.L.Pharande M.Prabhakar	2004	2008
3. RM/ALU/01	Organic management for sustainable production of medicinal and aromatic plants	**G.Pratibha** G.R.Korwar K.Srinivas S.K.Yadav I.Srinivas B.Venkateswarlu	2004	2009
4. RM/ALU/03	Crop diversification for sustainability of drylands through dye yielding crops	**G.Pratibha** G.R.Korwar M.Srinivasa Rao S.K.Yadav B.Venkateswarlu	2006	2008
5. RM/FM/04	Feasibility of using Pongamia/ Jatropha oils as a biodiesel in compression ignition engines	**I. Srinivas** R. V. Adake S.K. Yadav	2004	2008
6. RM/FM/05	Development of a tractor drawn bed forming machine for rainfed crops	**B. Sanjeeva Reddy** G.R. Korwar R.V. Adake U.K. Mandal	2005	2008

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
7. RM/FM/06	Design and development of self propelled multi purpose machine for small farm mechanization in drylands	**C.R. Thyagaraj** I. Srinivas B. Sanjeeva Reddy	2005	2008
8. RM/NM/2	Feasibility of organic production of pigeonpea and sorghum in drylands	**K. Srinivas** M. Srinivasa Rao K.L. Sharma	2005	2009
9. RM/ALU/02	Effect of different nutrient management practices and agroforestry systems on productivity and soil quality in rainfed regions	**G.R. Korwar** G. Pratibha K. Srinivas	2005	2007
10. RM/RM/02	Watershed based NRM strategies for rainfed area of Prakasam district in Andhra Pradesh	**M. Osman** K.V.Rao	2006	2008
11. RM/RM/03	Standardization of agri-techniques of perennial castor	**M. Osman** M. Vanaja P.R. Reddy	2006	2010
12. RM/NM/01	Development of field kit for estimating labile carbon to assess the soil quality under different land use system	**U.K. Mandal** K.L. Sharma S.K. Yadav	2004	2008
13. ICAR (Lal Bahadur Shastri Young Scientist Award)	Assessment and improvement of soil quality and resilience in a watershed under rainfed agroecosystem using GIS and remote sensing	**U.K. Mandal**	2006	2009
14. Externally Funded (NOVOD)	National Network project on integrated development of Jatropha and Pongamia	**G.Rajeswar Rao** G.R. Korwar M. Prabhakar	2004	2008
15. Externally Funded (CSIR)	Genetic improvement of Jatropha for oil yield and adaptability	**G. Rajeswar Rao** G.Ravindra Chary Y.G. Prasad D.P. Dubey M.P. Jain P.R. Reddy	2005	2010

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
16. Externally funded (Govt. of A.P.)	Collection and evaluation of germplasm, standardization of agro-techniques and pilot demonstration of *Jatropha curcas* in rain shadow districts of A.P.	**G. Rajeswar Rao** **J.V. Rao** K.V. Rao	2005	2010
17. Externally Funded (Ministry of Water Resources,GOI)	Rainfall-runoff-ground water dynamics in semi-arid regions	**K.V. Rao** U.K. Mandal	2004	2007
18. Externally (AP-Cess)	Assessing soil quality key in dicator for development of soil quality index under predominant management practices in rainfed agro-ecology	**K.L. Sharma** U.K. Mandal G.R. Maruthi Sankar G. Ravindra Chary K. Srinivas Kausalya Ramachandran S.K. Yadav Ch. Srinivas Rao	2005	2008
DIVISION OF CROP SCIENCE				
19. AP-NL project	Enhancing tolerance of sorghum to abiotic stress through genetic manipulation	**M. Maheswari** S.K.Yadav B. Venkateswarlu M. Vanaja N. Jyothi Lakshmi	2001	2007
20. CS/CP/09	Genetic transformation of greengram for enhancing abiotic stress tolerance	**S.K.Yadav** M.Maheswari R.Reddy B.Venkateswarlu. M.Vanaja N.Jyothi Lakshmi	2004	2009
21. CS/CP/O7	Mechanism of drought tolerance in rainfed short duration pulses	**N.Jyothi Lakshmi** M.Maheswari M.Vanaja S.K.Yadav B.Venkateswarlu G.Subba Reddy	2004	2008
22. DST project	Nitrate uptake and assimilation in crop plants under elevated CO_2	**N. Jyothi Lakshmi**	2006	2009

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
23. ICAR network project (NPCC)	Impact of elevated CO_2 on important rainfed crops	**M.Vanaja** M.Maheswari P.R.Reddy S.K.Yadav N.Jyothi Lakshmi B.Venkateswarlu G.Subba Reddy	2004	2008
24. CS/CP/15	Germplasm enhancement and evaluation for elite material in bio-fuels	**P.R. Reddy** G. Ravindra Chary G. Rajeswar Rao M. Vanaja B.M.K. Reddy	2006	2010
25.CS/CP/11	Farming system model for marginal and small farmers in Southern Telangana Zone of Andhra Pradesh	**G.Subba Reddy** C.A.Rama Rao S.S.Balloli	2004 2004	2008 2007
26.CS/CP/12	Drought management practices in castor	**S.Venkateswarlu** G.Subba Reddy		
27. CS/ALU/04	Assessment of forage species and varieties for drought tolerance	**G. Jayaram Reddy** G. Subba Reddy M.Osman B.M.K. Reddy	2005	2008
28. CS/SS/02	Management of soil fertility-related constraints for higher productivity and profitability in KVK adopted villages of CRIDA	**S.S. Balloli** M.S. Prasad K.L. Sharma G. Nirmala	2006	2008
29. CS/CP/14	Impact of INM on productivity of niger	**B.M.K. Reddy** G.R. Maruthi Sankar K. Srinivas	2005	2008
30. Externally funded (APNL)	Generation of data for registration of Achaea janata Baculovirus (AP-NL)	**Y.G. Prasad** M. Prabhakar B. Venkateswarlu	2005	2007
31. Externally funded (WWF)	Sustainable Cotton Initiative in Warangal district of Andhra Pradesh	**Y.G. Prasad** K.V. Rao M. Prabhakar	2006	2009

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
32. CS/CP/13	Organic farming in rainfed production systems	**B. Venkateswarlu** G. Subba Reddy G.R. Maruthi Sankar Y.G. Prasad S. Venkateswarlu S. Desai	2005	2009
33. ICAR Net work project	Application of micro organisms in Agriculture and allied sectors (AMAAS)	**B. Venkateswarlu** S. Desai S.K.Yadav	2006	2008
34. CS/PP/10	Integrated disease management in groundnut based production systems	**S. Desai**	2005	2010
35. DST Project	Threshold temperatures, thermal constants and development models for major pests of dryland crops	**M. Prabhakar**	2005	2007
36. NABARD project	Production and promotion of quality bio-pesticides for eco-friendly management of pests in dryland crops	**M. Prabhakar** Y.G. Prasad M. Srinivasa Rao	2005	2007
37. ISRO project	Detection of pests and diseases for precision crop management using remote sensing techniques	**M. Prabhakar** Y.S. Ramakrishna Y.G. Prasad M. Srinivasa Rao N.N. Srivastava U.K. Mandal	2005	2008
38. NPCC project	Impact of elevated CO_2 and temperature on host herbivore interaction	**M.Srinivasa Rao** K.Srinivas M.Vanaja	2004	2008
39.CS/Horti/07	Vegetable cultivation as a source of livelihood option in watershed areas of Ranga Reddy District	**N.N. Reddy** G. Nirmala M. Srinivasa Rao C.A. Rama Rao V.S. Rao K. Sreedevi Shankar	2006	2011
40. CS/Horti/06	Studies on tree-tree interactions in conjunction with water management in fruit crops	**N.N. Reddy** J.V. Rao V.S. Rao M.V. Padmanabhan	2005	2010

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
41. CS/Horti/04	Productivity enhancement in existing fruit orchards in drought prone areas	**V.S. Rao** N.N. Reddy K. Srinivas Reddy	2006	2008
42. RSAD (J) MBNR	Collection, evaluation of standardization of agrotechniques and pilot demonstrations of Jatropha & Pongamia	**J.V.Rao** G.R.Rao	2005	2008
SECTION OF TRANSFER OF TECHNOLOGY				
43. TOT/RM/1	A critical evaluation of conservation furrows in semi arid Alfisols	**M.V.Padmanabhan** U.K.Mandal G.Pratibha K.V.Rao	2004	2008
44. TOT/LM/1	Performance of sheep reared under different management systems	**D.B.V. Ramana** G.R. Rao K.V. Subrahmaniam A.R. Sen	2005	2008
45. TOT/LM/2	Development of strategies for sustainable livestock production in the rainfed regions of India	**D.B.V. Ramana** G. Ravindra Chary G. Subba Reddy K. Ravi Shankar C.A.Rama Rao K.V. Subrahmanian Scientist from ACIRPDA Centres of Jagadalpur, Anantapur, Solapur	2006	2009
46. TOT/AE/22	Identification and Digital Documentation of Dryland Technologies	**K. Ravi Sankar** K.V. Subrahmanyam G.Subba Reddy G.R. Maruthi Sankar	2006	2009
47. TOT/AE/23	ICTs as a tool of agricultural extension for technology dissemination – a critical analysis	**K. Nagasree** K.V. Subrahmanyam G.G.S.N. Rao Y.G. Prasad	2006	2009
SECTION OF DESIGN & ANALYSIS				
48. DA/AE/02	Development of farming situation-based extension for Ranga Reddy district	**G.Nirmala** M.S.Prasad V. Maruthi	2004	2007

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
AICRPDA				
49. DR/ALU/01	Development of climate and soil site suitability criteria for *Jatropha curcas* in rainfed regions of India	**G. Ravindra Chary** G. Rajeswara Rao G.R. Maruthi Sankar A.V.M. Subba Rao K.V. Rao K.S. Vara Prasad L.G.K. Naidu, Scientists from AICRPDA Centres	2006	2008
50. Externally Funded (AP-Cess)	Capacity building of Operational Research Projects (ORP) in rainfed agro ecosystems - an action research project	**G. Ravindra Chary** S. Dixit G.R. Maruthi Sankar G. Subba Reddy	2005	2008
51. Externally Funded (AP-Cess)	Organic carbon assessment and its maintenance under rainfed production system	**G. Ravindra Chary** Ch. Srinivas Rao J.V.N.S. Prasad B. Venkateshwarlu K.L. Sharma G.R. Maruthi Sankar	2005	2008
AICRPAM				
52. Externally Funded (ICAR)	Network Project on impact, adaptation and vulnerability of Indian Agriculture to climate change	**G.G.S.N. Rao** Y.S. Ramakrishna V.U.M. Rao M. Srinivasa Rao M. Vanaja A.V.M. Subba Rao	2004	2008
NATIONAL FELLOW				
53. Externally Funded (ICAR National Fellow Scheme)	Assessment of Sustainability of Treated/ Developed Watersheds in Rainfed Agro-Eco-Sub Regions of Peninsular India using GIS and Remote Sensing	**Kausalya Ramachandran**	2005	2010
54. Externally Funded (ICAR National Fellow Scheme)	Restoration of soil quality through conservation agricultural management practices and its monitoring using Integrated Soil Quality Index approach in rainfed production system(s)	**K.L. Sharma**	2005	2010

11 Consultancy, Patents and Commercialization

11.1 Consultancy

Following projects are currently in operation:

- Drought studies in Krishna basin area of Andhra Pradesh, Karnataka and Maharashtra
- Sustainable Cotton Initiative with emphasis on water management and pest management being implemented in Warangal district of Andhra Pradesh in association with a NGO, 'MARI'.
- Water productivity improvements in rainfed agriculture in Indian river basins/states, future potential and contributive factors in collaboration with International Water Management Institute (IWMI), New Delhi

11.2 Commercialization

- A combined income of Rs. 6,10,826/- was generated through sale of farm produce from HRF and GRF.
- Soil and plant analytical services worth Rs. 94,227/- were provided to farmers, NGOs, ICAR institutes, SAUs and the like.
- Micro propagated neem and teak plants worth Rs. 19,340/- were sold to farmers and NGOs.
- An income of Rs. 4,15,000/- was generated by selling 2,4,6 and 9-row planters, drill ploughs, castor shellers, orchard sprayers, groundnut strippers, paddy reapers, maize shellers and fruit and vegetable preservators.
- In all, Rs. 12,93,000/- was generated from consultancies, externally funded projects, commercialization and the like.

12 QRT, RAC, Management Committee, SRC

12.1 Quinquennial Review Team (QRT)

Fifth QRT for the period 2001-2005 was constituted vide ICAR letter F.No. 4-10/2005-IA.II dated 29.11.2005. The composition of the committee was as under:

Chairman

Dr. Maharaj Singh, Ex. DDG (Edn.), ICAR

Members

Dr. R.P. Dhir, Ex. Director, CAZRI

Dr. S.P. Bhardwaj, Ex. Head, CSWCR&TI

Dr. D.N. Jha, Ex. Director, NCAP

Dr. Hardeep Singh Sur, Ex. Regional Director, PAU

Dr. P. Joshi, Ex. Director of Research, RAU

Dr. K.P.R. Vittal, PC (AICRPDA) and Member Secretary

The first introductory meeting was held on March 9-10, 2006. Dr.Y.S.Ramakrishna, Director, CRIDA presented an overview of various programmes undertaken by CRIDA, AICRPDA and AICRPAM including the institute's involvement in preparation of the first report by the National Commission of Farmers. Subsequent meetings were held on July 16-17, 2006, December 12-14, 2006 and January 11-12, 2007 under the Chairmanship of Dr. Maharaj Singh. The QRT team visited research laboratories, research farms, AICRPDA and AICRPAM centres, and interacted with scientists and reviewed the work.

QRT members reviewing the CRIDA programmes

Based on its observations and analysis of information received, the QRT made the recommendations aimed at enhancing the output and effectiveness of the CRIDA, AIRCPDA and AICRPAM system in the service of rainfed farming in the country and submitted the QRT report to ICAR


QRT team visiting Farm Machinery Workshop at HRF

12.2 Research Advisory Committee (RAC)

- Fifteenth Research Advisory Meeting was held on April 13, 2006 under the Chairmanship of Dr. N.N. Goswami, Ex-Vice Chancellor, CASUA&T, Kanpur.

The meeting was attended by the following members :

Dr. A. Padma Raju, Director of Research (Retd.), ANGRAU, Hyderabad

Dr. S.R. Verma, Ex-Dean, College of Agril. Engg, PAU, Ludhiana

Dr. P.S.N. Sastry, Principal Scientist (Retd., IARI), Hyderabad

Dr. H.H. Khajuria, Dean,

Post Graduate Studies, SKUAS&T, Jammu

Besides Dr. Y.S. Ramakrishna, Director CRIDA, Dr. J.V. Rao, Member Secretary, Dr. V.M. Mayande, Zonal Coordinator, Special invitees from CRIDA attended the meeting.

The following were the major recommendations made by the Committee:

- To give more focus on organic farming and development of wastelands and watersheds with perennials and bio-mass yielding trees and conducting of R&D programmes preferably on on-farm, collectively along with development agency extensioneries and NGOs.
- Research also to be focused on meeting the livestock and fodder available in rainfed areas.
- Sixteenth RAC meeting was held on 12.02.2007 under the chairmanship of Dr. N.N. Goswami, Ex-Vice Chancellor, CASUA&T, Kanpur.

RAC meeting in progress

The meeting was attended by the following members :

Dr. A. Padma Raju, Director of Research (Retd), ANGRAU, Hyderbaad

Dr. Rajendra Prasad, INSA Senior Scientist, Division of Agronomy, IARI, New Delhi

Dr. S.R. Verma, Ex-Dean, College of Agril. Engg., PAU, Ludiana

Dr. P.S.N. Sastry, Principal Scientist (Retd.), IARI

Dr. H. N. Khajuria, Professor Forestry, PAU, Ludhiana (Punjab)

Shri Rajendra D. Pawar, Chairman, Agri. Dev. Trust, Baramati Dist, Pune

Shri D. Ramakrishna Reddy, Federation of Farmers Association, AC Guards, Hyd

Dr. A.K. Gogoi, Asst. Director General (Agronomy), NRM Division, IARI Campus, New Delhi

Besides Dr. Y.S. Ramakrishna, Director CRIDA, Dr. J.V. Rao, Member Secretary, Dr. V.M. Mayande, Zonal Coordinator, special invitees from CRIDA attended the meeting.

The following were the major recommendations made by the Committee:

- The term 'dryland' to be renamed as 'rainfed'
- The status of proposed Institute to be considered as 'deemed university'.
- Rainwater harvesting and recycling using Farm Pond Technology need to be given impetus
- The area required for meeting nutrient i*n-situ* from bio-mass needs to be standardized for different cropping systems

12.3 Institute Management Committee (IMC)

Chairman

Dr. Y.S. Ramakrishna, Director, CRIDA

Members

Dr. A.L. Pharande, ADR-cum-Chief Scientist, Solapur

Sri Rajendra D. Pawar, Pune, Maharashtra
(Non-official member)

Sri D. Ramakrishna Reddy, Hyderabad
(Non-official member) ADG (Agronomy), ICAR, New Delhi

Dr. V.S. Subramanian, F&AO, NAARM, Hyderabad

Dr. V.M. Mayande, Principal Scientist (FM&P), CRIDA, Hyderabad

Dr. B. Venkateswarlu, Principal Scientist

Dr. Kausalya Ramachandran, National Fellow, CRIDA, Hyderabad

Dr. G. Pratibha, Sr. Scientist (Agronomy), CRIDA, Hyderabad

Dr. G.R. Korwar, Head, DRM & SAO i/c.

The IMC was held on 13.02.2007 and the following are the major recommendations :

- Policy paper on Role & Responsibility of various Institutions on Watershed to be brought out by organizing Brain Storming Session and study the gaps in terms of policy and scientific issues
- Technology need o be location specific as there is a vide diversity in bio-physical resources
- CRIDA much carry out strategic research which should support directly to the Institutions working in different locations
- Strengthening of AICRPDA cell

12.4 Staff Research Council (SRC)

The Staff Research Council Meeting was held on May 6,8,9,11,16 and 18, 2006 under the chairmanship of Dr. Y.S. Ramakrishna, Director, CRIDA. It reviewed 11 new proposals, four from Resource Management, three from Crop Sciences, three from TOT, and one from AICRPDA) and four extension proposals from Resource Management and D&A. All except two were approved with major/minor modifications. In addition, 8 concept notes on National Funding for Basic and Strategic Research were also discussed. In all six institute funded projects were closed since their objectives were met.

The following are the major recommendations:

- To form think tanks, take up the challenge and meet the earmarked targets.
- Need for increasing the visibility of the Institute by writing more research papers, technical bulletins, books/book chapters and the like.
- The importance of organic farming, soil health, IPM and economic issues vis-à-vis rainfed agriculture were highlighted. Concerned groups to bring out policy briefs and come out with plans to tackle the issues head on.
- To generate path breaking ideas and formulate all encompassing projects.

12.5 Scientific Advisory Committee Meeting of KVK

The SAC meeting of KVK was held on May 27, 2006 and December 13, 2006 at Hayathnagar Research Farm under the chairmanship of Dr. Y.S. Ramakrishna, Director, CRIDA. The meeting was attended by Scientists from CRIDA and ZC Unit, KVK Staff besides officials of the line departments, representatives from ANGRAU, bank, mass and electronic media and farmer representatives. The meeting reviewed the progress made and planned for the future programmes to be taken up by KVK.

Scientific Advisory Committee meeting of KVK in progress

13 Participation of Scientists in Conferences, Meetings, Workshops and Symposia

Name of the Scientist	Topic	Period	Venue
M.S. Prasad A.K. Mishra	Workshop on Action Plan preparation of KVKs for the year 2006-07 (AP)	April 12-13, 2006	ZC Unit, Zone-V, Hyderabad
J.V.N.S. Prasad	Carbon Emission: An Environmental Trading Mechanism	April 20, 2006	FICCI, Bombay
A.K. Mishra	Review Workshop of KVK Action Plan of Vidarbh and Konkan Region of Mahrashtra	April 21-22, 2006	ZC Unit, Hyderabad
M.S. Prasad	ZREAC for Southern Telangana Zone *(Kharif*, 2006)	April 24-25, 2006	Zilla Parishad Office, Mahabubnagar
G. R. Rao	Workshop on Rainfed Area Network in Biofuels	April 24-25, 2006	CRIDA, Hyderabad
G.G.S.N. Rao	Meeting on Technical Committee on main findings/ recommendations \ of Parthasarathy Committee Report and future Plan of Action for identification of blocks	May 10, 2006	Krishi Bhawan, New Delhi
G. R. Rao	AICRPAF Group Meeting (Brain storming session on biofuel cultivation)	May 15-17, 2006	UAS, Dharwad
G.G.S.N. Rao	Meeting on Preparation of Project Proposals of National Agricultural Scientific and Technical Intelligence System for funding under NAIP	May 19-20, 2006	New Delhi
G.G.S.N. Rao	1st Group Monitoring Workshop on Earth and Atmospheric Sciences-cum-2nd Meeting of the Subject Expert Committee (SEC)	May 22, 2006	Indian Institute of Geomagnetism, Navi Mumbai
G.G.S.N. Rao	Meeting on Formulating the Indian proposal on Water Management, part of US-India Knowledge Initiative in Agriculture	May 26, 2006	WTC, IARI, New Delhi
K. Ravi Shankar	Workshop on Relevance of Ancient Wisdom on Weather Forecasting for improving Agro-advisories	May 29, 2006	CRIDA, Hyderabad

Name of the Scientist	Topic	Period	Venue
G.G.S.N.Rao	National Seminar on Agro meteorological Services for Crop and Location-specific Advisories conducted by	June 20, 2006	IMD, Pune
K. Nagasree	Mainstreaming Gender Concerns in agriculture	June 26-29, 2006	MANAGE, Hyderabad
G.G.S.N.Rao	Meeting of the Core Group on "Role of Scientific and Technical Institutions in Disaster Management"	June 27, 2006	New Delhi
G.G.S.N. Rao	Working Group Meeting on National Programs of Watershed Development	June 28, 2006	Krishi Bhavan, New Delhi
Shaik Haffiz	Seminar on Role of Indian Agro-Industry in Rural Economic Development – A perspective	July 28, 2006	Suryapet, Nalgonda
G.Ravindra Chary	Participated in two day Workshop on Harmonization of Database for Land Use and Evaluation	July 28 - 29, 2006	NRSA, Hyderabad
M. Osman	National Workshop on Rejuvenating Tanks for Sustainable Livelihoods – Emerging Trends, Organized by WWF and ICRISAT	August 3-4, 2006	ICRISAT, Patancheru
J.V.N.S. Prasad	Annual Workshop on Network project on Climate Change	August 10-12, 2006	NDRI, Karnal
G.G.S.N.Rao	3rd Annual Workshop of the ICAR Network Project on Impacts, Adaptation and Vulnerability of Indian Agriculture to Climate Change	August 10-11, 2006	National Dairy Research Institute, Karnal
M. Osman J.V. Rao	National Symposium on Improving Input Use Efficiency in Horticulture organized by Society for Promotion of Horticulture, Banagalore and Indian Institute of Horticultural Research	August 9-11, 2006	IIHR., Bangalore
K. Nagasree K. Ravi Shankar	Sensitization Workshop for Developing ICT Sub-projects under NAIP	September 4-5, 2006	NAARM, Hyderabad
G. R Korwar	First meeting of the subcommittee for More crop and Income per rain drop of water	September 9, 2006	Seva Bhavan, New Delhi
G. Subba Reddy	Seminar on bringing in a Second Green Revolution – Dryland Development through Organic Farming and Water Conservation	September 10, 2006	Sastriya Vignana Samithi, Kakinada
G. Subba Reddy	Farming systems research in rainfed agriculture	September 16, 2006	ANGRAU, Tirupathi

Name of the Scientist	Topic	Period	Venue
Y.S. Ramakrishna	National Conference on Role of Soil & Water Conservation in Rural Employment (RSWCRE-2006),	September 19-21, 2006	IGAU, Chattisgarh
C.A. Rama Rao	14th Annual Conference of Agricultural Economics Association (India)	September 27-28, 2006	CABM, GBPUAT, Pantnagar
G. R Korwar	Second meeting of the subcommittee for More crop and Income per drop of water	September 29, 2006	ICAR, New Delhi
G. Subba Reddy	New Dimensions in Integrated Nutrient Management of field crops for sustainable production	October 5-25, 2006	DOR, Hyderabad
K.L. Sharma	Twentieth Biennial Workshop of All India Coordinated Research project on Dryland Agriculture	October 17-22, 2006	CRIDA, Hyderabad.
G.G.S.N.Rao	International Workshop on Agrometeorological Risk Management	October 25-27, 2006	New Delhi
G. Subba Reddy	National Symposium on Conservation Agriculture and Environment,	October 26-28, 2006	BHU, Varanasi
J. V. N. S. Prasad	Wastelands: Review and Options for Development and Enhancing of Livelihood Southern India at NIRD	October 31- November 1, 2006	Society for Promotion of opportunities in Wasteland Development (SPWD), New Delhi
S. Dixit	Annual Workshop of KVKs of A.P.	November 1-3, 2006	ZC Unit, Zone-V, Hyderabad
K. V. Rao	Finalizing the best bet practices of Indo German Programme for replication in watershed programme	November 2-3, 2006	NABARD, Pune
G. R. Rao	Agroforestry for Wasteland Development	November 6-11, 2006	NIRD, Hyderabad
G. R Korwar	Fifth Conference of Asian Federation for Information Technology in Agriculture (AFITA 2006)	November 9-11, 2006	I.I.S.C., Bangalore
S.S. Desai	Biodiversity and biotechnology: Research and development needs in edible mushrooms and crop disease management	November 9-11 2006	GBPUA&T, Pantnagar
S.S. Balloli	71st Annual Convention of Indian Society of Soil Science	November 10-13 2006	OUAT, Bhubaneswar

Name of the Scientist	Topic	Period	Venue
Kausalya Ramachandran M. Prabhakar U. K. Mandal	SPIE Asia-Pacific Remote Sensing Symposium	November 13-17, 2006	Marriott Hotel, Panjim
V.S. Rao	18th Indian Convention of Food Scientists and Technologists	November 16-17, 2006	ANGRAU, Hyderabad
G. Pratibha G. Ravindra Chary	National Symposium on System of Rice Intensification	November 17-18, 2006	ANGRAU, Hyderabad
K. V. Rao	Project formulation meeting	November 20, 2006	INCID, MoWR
S.S. Balloli	International Conference on Balanced Fertilization for Sustainable Production	November 22-24 2006	PAU, Ludhiana
M.S. Prasad	Second National Conference of KVKs, 2006	November 26-28, 2006	ANGRAU, Hyderabad
K. Ravi Shankar	National Seminar on Extension Strategies for fostering Knowledge centric Agricultural Growth	December 2-3, 2006	Pondicherry
G. R Korwar	Second meeting of working group on "Natural Resource Management (NRM) for XI Five Year Plan	December 07, 2006	Krishi Bhawan, New Delhi
G. R. Rao J. V. N. S. Prasad	National Symposium on Agroforestry for Livelihood Security, Environment Protection and Biofuel Production	December 16-18, 2006	National Research Center on Agroforestry, Jhansi
G. R Korwar A.K. Mishra S.S. Balloli K. Srinivas	Regional conference on Natural Resource Conservation, Use and Sustainability in Drylands	December 18-20, 2006	GIDE, Bhuj
G.G.S.N.Rao	Fourth Meeting of Agromet Advisory Services	December 21, 2006	Agromet Division IMD, Pune
G.R. Maruthi Shankar	International Conference on "Statistics & Informatics in Agricultural Research	December 26-30, 2006	NASC, New Delhi
K. Nagasree	National Seminar on Information and Communication Technology: Opportunities and challenges for revitalizing extension system	December 27-29, 2006,	GAU, Navsari
M. Osman	Regional workshop on Deserts and Desertification organized by Ministry of Environment & Forests, (GoI) and Rural Development Department (GoAP)	December 29-30, 2006	NAARM, Hyderabad

Name of the Scientist	Topic	Period	Venue
G. R Korwar	One-day workshop on "Technology Development, Extension & Training (TDET) Scheme by Department of Land Resources (MORD) and SIRDI Foundation	January 07, 2007	Osmania University, Hyderabad
M. Osman	Review meeting of TATA –ICRISAT project for Combating Land Degradation and Increasing Productivity in Madhya Pradesh and East Rajasthan	January 10-11, 2007	ICRISAT, Patancheru
G. Ravindra Chary	Participated in one day National Symposium on Application of Space Technologies for Agricultural Development	January 19, 2007	Federation of farmers Association in Association with APSRAC
G.G.S.N.Rao	Meeting on screening the Concept Notes of Network Project on Climate Change	January 25, 2007	IARI, New Delhi
B. Venkateswarlu S. Venkateswarlu V. Maruthi	National Seminar on Changing Global vegetable oils scenario: issues and challenges before India	January 29-31, 2007	Directorate of Oilseeds Research, Hyderabad
G. R. Rao	4th International Biofuels Conference	February 1-2, 2007	Winrock International India, New Delhi
G.G.S.N. Rao	International Workshop on Monsoon Climate Variability and Change and their Impacts on Water, Food and Health in Western India	February 5-7, 2007	Nirma University of Technology, Ahmedabad
Dr. G.R. Maruthi Sankar Md. Osman G. Ravindra Chary Y.S. Ramakrishna	National Training-cum-Workshop on Bio-informatics & Statistics in Aquaculture	February 7-10, 2007	CIFA, Bhubaneswar
G. Subba Reddy, V. Maruthi	National Seminar on Drought adaptations for sustainable agriculture and livelihood in dryland areas - problems, prospects and policies	February 15-16, 2006	Palem, Mahabubnagar
S. Desai	Minimizing aflatoxin risk in peanuts	February 21-22, Pattancheru	ICRISAT,
G. Pratibha G. Ravindra Chary	National Symposium on Production Processing and Marketing of medicinal aromatic and dye yielding crops	February 22-23, 2007	NMPB, Arabhavi, UAS Dharwad
G. R. Rao	National Consultative Meeting on DUS testing of trees	February 27-28, 2007	Forest College & Research Institute, Mettupalayam, Coimbatore

Name of the Scientist	Topic	Period	Venue
K. V. Rao	Annual Project Review Workshop of INCID-MoWR	February 26-27, 2007	NERI-WALM, Tezpur
G. R Korwar	National Consultative Meeting on DUS testing of trees	February 27-28, 2007	TNAU, Coimbatore
M.S. Prasad	National Seminar on Extension strategies to promote agri-business enterprises	March 1-3, 2007	College of Agriculture, Pune
D.B.V. Ramana	Action Research, Impact Analysis and Participatory Technology Assessment	March 1-3, 2007	NRC on Meat, Hyderabad
U. K. Mandal	GIS Based Decision Support Systems for Sustainable Agriculture	March 1-21, 2007	NAARM Hyderabad
K. V. Rao	Project Review Workshops of TMC-MMD-1	March 5-6, 2007	CICR, Nagpur
G. Ravindra Chary G.R. Maruthi Sankar	National Seminar on Emerging Issues and Development Strategies for Dryland Agriculture and Wasteland Management	March 6-7, 2007	CRIDA, Hyderabad
K. V. Rao	Brianstorming session on Guidelines for Watershed Management	March 7, 2007	Ministry of Rural Development New Delhi
K. Nagasree	ICT solutions for Socio Economic Development	March 12-13, 2007	CDAC, Bangalore
G. R Korwar	International Conference on 21st Century Challenges to Sustainable Agri-Food Systems, Biotechnology, Environment, Nutrition, Trade and Policy	March 15-17, 2007	Hotel Atria, Bangalore
G. Rajeshwar Rao	Survey, Collection, Evaluation and Multiplication of elite germplasm of Pongamia and Jatropha. Proc. of All India Coordinated Research Project on Agroforestry	March 15-17, 2007	UAS, Dharwad
G.G.S.N. Rao	Final Workshop of Network Project on Climate Change	March 19-21, 2007	CMFRI, Cochin
M.S. Prasad	District level coordination committee meeting of DAATTC, Ranga Reddy (ANGRAU) for *kharif*, 2007	March 20, 2007	DAATTC, Agro market Yard Gudamalkapur, Mehdipatnam, Hyderabad
G. Pratibha	National Symposium on Management of medicinal and aromatic plants in farming systems	March 20-22, 2007	CSAUA & T, Kanpur
J.V. Rao	Bio-fuels: Production, Methodologies, Utilization Techniques and Challenges Ahead"	March 22-23, 2007	MER & DO, Ludhiana

14 Workshops, Seminars, Summer Institutes, Farmers' Day etc., organized by the Institute

14.1 Workshops, Seminars, Summer Institutes, Farmers' Day etc., organized by the Institute

Programme	Period	Venue
Brain Storming Session on Crop Planning for *kharif* season, 2006	April 4, 2006	CRIDA, Hyderabad
Dr. Upender Singh, Sr. Scientist International Fertilizer Development Centre, Alabama, USA delivered a talk on 'Decision Support Tools for Integrated Nutrient Management'	April 12, 2006	CRIDA, Hyderabad
State Level Workshop for Validation of the Findings of Disaster management Plan in Respect of Drought Project by CRIDA in Collaboration with IIT, Delhi	May 4, 2006	CRIDA, Hyderabad
Scientific Advisory Committee (SAC) Meeting of KVK, Ranga Reddy district.	May 27, 2006	KVK, Hyderabad
Three interactive meetings were held to discuss the base paper for livelihood consortium project for sub-mission to NAIP for funding. The meeting was attended by National Coordinator (NAIP), representatives from ICRISAT, ANGRAU, MPUAT, Udaipur, Project team members from CRIDA and NGP partners.	June 13, 22 and 27, 2006	CRIDA, Hyderabad
A two day training on Farm mechanization and Soil Conservation in which 40 farmers from Mahaboobnagar district participated	July 18-19, 2006	KVK, CRIDA
Two sub-group meetings on Climate Change, Risk and Disaster Management of XI Plan	July 18 and S September 28, 2006	CRIDA, Hyderabad
First Meeting of Working Group on Rainfed Areas for the 11th Five Year Plan Sub-group 1(b)-Statistical Review :	August 18, 2006	CRIDA, Hyderabad
Dr. Samad Madar, Principal Researcher, IWMI delivered a seminar on Mapping Indicators of Water-land-poverty nexus – results from AP	August 21, 2006	CRIDA, Hyderabad

Programme	Period	Venue
Hands on training to the officials of Andhra Pradesh State Disaster Mitigation Society (APSDMS), Planning Department, Govt. of AP for operationalization of Drought Management Software	September 11, 2006	AP Secretariat, Hyderabad
A hands on training for the officials of Andhra Pradesh State Disaster Mitigation Society (APSDMS) was organized	September 11, 2006	AP Secretariat, Hyderabad
Model Training Course on Livelihood Enhancement through Improved Natural Resource Management in Semi-Arid Areas	September 12-19 2006	CRIDA, Hyderabad
Fourth SERC School on Agricultural Drought: Aspects of Micrometeorology (Department of Science and Technology, Govt. of India)	Sept. 25-October14, 2006	CRIDA, Hyderabad
Scoping Workshop on Climate and Disease Risk Management and International Initiative in Asia Pacific Region	November 6-8, 2006	CRIDA, Hyderabad
National Nutrition Week	November 07, 2006	Tallapally/ Machanapaly villages of Ranga Reddy district
Condensed Translation Training Course in Hindi	November 20-24, 2006	CRIDA, Hyderabad
Sub-Group Meeting of XI Plan Working Group on Rainfed agriculture Research and Education for Semi-arid areas	December 4, 2006	CRIDA, Hyderabad
Scientific Advisory Committee (SAC) Meeting of KVK, Ranga Reddy district	December 13, 2006	KVK, Hyderabad
Farmers Training Programmes on Bio-fuel Plantations in drylands Kalwakurthy, Mahabubnagar district	December 21 and 22, 2006	DWMA Office,
Two training programmes on prospects of bio-fuel plantations in rainfed areas	January 3-5, 2007 and March 28-30, 2007	CRIDA, Hyderabad.
Training Programme on Modern Managemental Practices for Higher Profitability from Small Ruminants	January 24-25, 2006	KVK adopted villages
Training Programme on Dryland Horticulture and Horticultural-based cropping systems	February 1-7, 2007	CRIDA, Hyderabad

Programme	Period	Venue
Training programme on Dryland Horticulture and Horticulture based cropping systems for Horticultural Officers, Agril. Officers and other staff working at ITDAs in AP	February 12-18, 2007	CRIDA, Hyderabad
Ten Agricultural Engineering Undergraduates from UAS, Dharwad, Raichur Campus were trained on farm implements	February 22-March 23, 2007	CRIDA, Hyderabad
Dr. S.M. Ilyas, Director, NAARM delivered lecture entitled "WTO and its Implications on Research"	March 24, 2007	CRIDA, Hyderabad
A district level Training cum Awareness programme on biodiesel plantations in dry lands	March 5-7, 12-13 and 24, 2007	CRIDA, Hyderabad

14.2 CRIDA Foundation Day

The 21st CRIDA Foundation day was celebrated on April 12, 2006 at CRIDA. Shri S. Parthasarathy, IAS (Retd.) and Chairman, Watershed Technical Committee, Ministry of Rural Development presided over the function. Shri E. Venkat Ramanaiah, President, Youth for Action (NGO) was guest of honour. The Foundation day lecture was delivered by Dr. N.N. Goswami, Former Vice Chancellor, CSAUA&T, Kanpur and Chairman, RAC, CRIDA. The function was attended by representatives from ICAR Sister Institutes, ICRISAT, ANGRAU and staff of the Institute. Dr.Y.S.Ramakrishna, Director, CRIDA highlighted the achievements of the Institute's activities inimproving the livelihoods of resource poor farmers in dryland areas. Shri Venkat Ramanaiah emphasized the need to adopt corporate approach with the participation of all institutions involved in R&D in rainfed agriculture. He also complimented the role played by scientists of CRIDA in enhancing the quality of life of resource poor farmers of rainfed regions of the country by providing location specific and cost effective improved technologies. Dr. N.N.Goswami in his Foundation Day Lecture on "Rainfed Agriculture – Future Challenges". He stressed the role of soil quality in sustaining the productivity of rainfed areas and urged the CRIDA scientists to take up initiatives and leadership in improving the efficiencies of the natural resources for higher profitability and sustainability. Mr. Parthasarathy stressed the need for structural reorgansation of departments or funds working on watersheds/wastelands.

14.3 Hindi Day

Hindi fortnight was celebrated from September 14-29, 2006. During this period, several competitions on

Foundation Day celebrations


Bilingual newsletter released by Director, CRIDA on Hindi Day

Hindi-English Technical Terminology, Hindi Noting & Drafting, Essay Writing for Hindi speaking and non-Hindi speaking employees, Hindi Elocution and Hindi Quiz were conducted. Dr.Y.S. Ramakrishna, Director, CRIDA chaired the Valedictory function which was organized on September 30, 2006. The winners of different events were awarded cash prizes. On this occasion, Director, CRIDA also released the Bilingual (Hindi-English) newsletter for the period Jan-June, 2006.

14.5 Farmers' Day

The Farmers' Day was organized on September 16, 2006 at Hayathnagar Research Farm, CRIDA. Shri V.S. Sampath, IAS, Director General, National Institute of Rural Development (NIRD), Hyderabad was the Chief Guest and Shri L. Prem Chandra Reddy, IAS and Collector, RR District presided over the function. The Farmers Day was attended by more than 1000 farmers from the neighbouring villages of Ranga Reddy and neighbouring districts. On this occasion, the farmers were taken around various experiments and trials, exposing them to modern and scientific ways of sustaining agriculture in dryland areas. Dr.Y.S. Ramakrishna, Director, CRIDA while welcoming the guests briefed the highlights of achievements of the Institute.

Chief guest addressing the farmers

Shri Sampth complimented the CRIDA scientists for the excellent work in the area of rainfed agriculture. He called upon the scientists to intensify their efforts for further improving the incomes of the farmers in rainfed areas and make dryland agriculture a profitable and sustainable profession.

Shri Prem Chandra Reddy in his presidential address emphasized the need for adopting an integrated approach to manage water, insect pests, nutrients to improve the productivity of rainfed regions.

14.6 Vigilance Awareness Week

Vigilance week was observed at CRIDA from November 6-10, 2006. Mrs. Malabika G. Mohan, Dy. Chief Vigilance Officer of South Central Railway educated the staff of the institute on the means and ways to maintain high integrity on November 7, 2007.


Mrs. Malabika G. Mohan during Vigilance week celebrations

14.7 National Science Day

National Science Day was celebrated at CRIDA on February 28, 2007. Around 150 students from 10 different schools visited CRIDA and shown different laboratories and explained about the scientific activities carried out by the institute tin inculcate scientific temper among children. On this occasion, a Science Quiz was organized for the school children. Dr.Y.S. Ramakrishna, Director, CRIDA gave away prizes to the winners.

Dr Y.S. Ramakrishna addressing school children

15 Distinguished Visitors

15.1 Individual

- Dr. P. Das, DDG (Agril. Extn.), ICAR visited KVK, HRF on August 5, 2006.
- Dr. Mangala Rai, Secretary DARE and Director General, ICAR visited CRIDA Farm on November 25, 2006

DG interacting with scientists at HRF

15.2 Group

- Visit of 20 farmers to CRIDA from the Council of Agricultural Research and Policy, Sri Lanka to learn about the farming practices of Indian farmers

Lankan farmers delegation

- AO's /F&AOs of ICAR institutes
- Progressive Farmers of Mahabubnagar, A.P.
- Farmers Educational Study tour of Amravati, Maharashtra
- Farmers of Nagpur, Maharashtra
- Graduate Assistants of CSWCRTI, Regional Centre, Kota,Rajasthan
- Farmers of Command Area Development Authority, Thrissur, Kerala
- Progressive farmers of Thanjavur, Tamil Nadu
- Women farmers of Mahabubnagar, A.P.
- Delegates from Nigeria & UK visited field trails at HRF on 19.06.2006

Delegates from Nigeria & UK visiting Nursery of tree-born oilseeds

- Thirteen member delegates from Mangolia Vietnam visited CRIDA on 15.06.2006 as a part of their tour to India to study agricultural insurance

Delegates from Mangolia & Vietnam interacting with CRIDA/Scientists

- Dr. Christian Roth, Programme Manager, SMCN of Australian Centre for International Agril. Research (ACIAR) along with Dr. Kuhu Chattarjee, Regional Manager, ACIAR- South Asia, and New Delhi visited CRIDA on July 19, 2006 and explored the possibilities of collaborative research with CRIDA officials.
- Dr. K. Ramesh Reddy, Professor (Soil & Water Sciences) accompanied by Drs. Sabine Grunwald, Associate Professor and Distance Education Coordinator, Soil and Water Sciences, University of Florida and had a discussion with the Director and staff of and CRIDA on August 10, 2006 to explore the possible areas of collaborative research between CRIDA and University of Florida.

Parliamentary Standing Committee on Agriculture interacting with CRIDA officials

- On the Spot Study Visit by Parliamentary Standing Committee on Agriculture consisting of 12 Hon'ble Members of Lok Sabha and Rajya Sabha of Govt. of India under the Chairmanship of Prof. Ramgopal Yadav, Hon'ble Member of Lok Sabha visited CRIDA on November 15, 2006 to review the farmers issues in rainfed areas and research carried out by CRIDA on dryland agriculture. The Parliamentary committee complimented CRIDA on its research thrusts in meeting the challenges of the rainfed areas.
- Forty-seven members from Cornell University, College of Agriculture and Life Sciences, Panjagutta, Hyderabad visited CRIDA on 10th January, 2007.

Students and family of Cornell University visiting CRIDA

- The Members of Science Council (CGIAR, NARS, ANGRAU, DOR, BAIF, ICRISAT and others) visited CRIDA on 27.03.2007 to discuss on ICAR – ICRISAT collaborative programme.
- Trainee Officials from SAMETI, Hyderabad

15.3 Students

Students of Agriculture, Horticulture, Veterinary, Forestry, Dairy and Engineering disciplines belonging to various SAUs/Institutions viz., KAU, TNAU, UAS, Bangalore, UAS, Dharward, ANGRAU, RAU, SKUA&T, YSPUA&T, JNKVV, Loyala academy of Degree & P.G. College, Secunderabad, Abhyasa Residential Public School, Medak, Thanthai Roever Institute of Agriculture & Rural Development, Perambalur, Shardabai Pawar Mahila College, Baramati, Academy of Management & Information Technology, Bhubaneswar visited the institute during the year. Young visitors were shown the state of art facilities existing at CRIDA and were educated about the recent developments in rainfed agriculture.

16 Personnel

(As on March 31, 2007)

Dr. Y.S. Ramakrishna	**Director**

Division of Resource Management

Dr. G.R.Korwar	**Principal Scientist (Agronomy) & Head, DRM**
Dr. K.D. Sharma@	Principal Scientist (S&WCE)
Sri. N.N.Srivastava	Principal Scientist (Ag. Meteorology)
Sri N.N.Nimbole	Principal Scientist (Agronomy) (voluntary retirement on 31.08.06)
Dr. C.R.Thyagaraj	Principal Scientist (FM&P)
Dr. K.L.Sharma	Senior Scientist (Soil Science) & ICAR National Fellow
Dr. M. Osman	Senior Scientist (Agronomy)
Dr. G. Rajeshwara Rao	Senior Scientist (Forestry)
Dr. Sreenath Dixit**	Senior Scientist (Ag. Extension)
Dr. Ch. Srinivasa Rao*	Senior Scientist (Soil Science)
Dr. G.Pratibha	Senior Scientist (Agronomy)
Dr. K.Srinivas	Senior Scientist (Soil Science)
Dr. K.V. Rao	Senior Scientist (S&WCE)
Dr. J.V.N.S.Prasad	Senior Scientist (Agronomy)
Er. I.Srinivas	Scientist (Selection Grade) (FM&P)
Dr. B.Sanjeeva Reddy	Scientist (Senior Scale) (FM&P)
Dr. U.K.Mandal	Scientist (Senior Scale) (Soil Physics)
Er. Ravikanth V. Adake	Scientist (Senior Scale)(FM&P)
Dr. V.Ramesh	Scientist (Senior Scale)(Soil Physics) (transferred to CPTCRI, Tiruvananthapuram on 12.10.2006)
Sri I. Ramamohan	Technical Officer (T-7/8)
Sri V. Sree Ramulu	Technical Officer (T-6)
Sri B. Narsimlu	Technical Officer (T-6)
Sri J. B. Ramappa	Technical Officer (T-6)
Smt. K. Usha Rani	Technical Officer (T-6)
Sri K Venkanna	Technical Officer (T-5)

Division of Crop Sciences

Dr. B.Venkateswarlu	**Principal Scientist (Microbiology) & Head, DCS**
Dr. J.V.Rao	Principal Scientist (Agronomy) & Head, Agroforestry Cell
Dr. P.Raghuram Reddy	Principal Scientist (Plant Breeding)
Dr. V.S.Rao	Principal Scientist (Horticulture)
Dr. Y.G.Prasad	Senior Scientist (Entomology)
Dr. S. Desai	Senior Scientist (Plant Pathology)
Dr. N.N.Reddy	Senior Scientist (Horticulture)
Dr. S.K.Yadav	Senior Scientist (Biochemistry)

Dr. M. Maheshwari	Senior Scientist (Plant Physiology)
Dr. M.Vanaja	Senior Scientist (Plant Physiology)
Dr. S.S. Balloli	Senior Scientist (Soil Science)
Dr. B.M.K.Reddy	Senior Scientist (Agronomy)
Dr. M.Srinivasa Rao	Senior Scientist (Entomology)
Dr. V.Maruthi	Senior Scientist (Agronomy)
Dr. S.Venkateswarlu	Senior Scientist (Agronomy)
Dr. M.Prabhakar	Senior Scientist (Entomology)
Dr. Arun Kumar Shankar	Senior Scientist (Plant Physiology) (joined CRIDA on request transfer from NRC on Agroforestry, Jhansi on 4.9.2006)
Dr. G.Jayaram Reddy	Scientist (Senior Scale) (Agronomy)
Dr. N.Jyothi Lakshmi	Scientist (Senior Scale) (Plant Physiology)
Smt. P. Anantha Kumari	Technical Officer (T-6)
Sri T. Madhusudhan Swamy	Technical Officer (T-6)
Smt. D. Renuka	Technical Officer (T-6)
Smt. P. Lakshminarasama	Technical Officer (T-6)
Sri G. Prem Kumar	Technical Officer (T-6)
Sri Jainender	Technical Officer (T-5)
Smt. M. Pushpalata	Technical Officer (T-5)
Sri P. Yadagiri	Technical Officer (T-5)

Section of Design and Analysis & KVK

Dr. Y.V.R.Reddy	**Principal Scientist (Ag. Economics) & Head & OIC, KVK**
Dr. M.S.Prasad	Principal Scientist (Ag. Extension)
Dr. C.A.Rama Rao	Senior Scientist (Ag. Economics)
Dr. G.Nirmala	Senior Scientist (Ag. Extension)
Smt. Sreedevi Shankar	Scientist (Food & Nutrition)
Smt. A Sambrajyamma	Technical Officer (T-9)
Sri R. Joseph	Technical Officer (T-9)
Sri P. K. Mathad	Technical Officer (T-8)
Sri Pukh Raj Singh	Technical Officer (T-8)
Sri R. Dasaratha Rami Reddy	Technical Officer (T-7/8)
Sri S.M. Vidyasekhar	Technical Officer (T-7/8) (joined CRIDA on promotion from IARI, New Delhi on May 18, 2006)
Smt. A. Vidyadhari	Technical Officer (T-6)

Section of Transfer of Technology

Dr. K.V. Subrahmanyam	**Principal Scientist (Ag. Economics) & Head**
Dr. M.V. Padmanabhan	Principal Scientist (S&WCE)
Dr. A.K. Mishra	Senior Scientist (LP&M)
Sri K.Ravi Shankar	Scientist (Senior Scale) (Ag. Extn.)
Dr. K.Nagasree	Scientist (Senior Scale)(Ag. Extn.)
Dr. D.B.V.Ramana	Scientist (Senior Scale) (LP& M)
Sri K. Surender Rao	Technical Officer (T-6)

Sri K.V.G.K. Murthy	Technical Officer (T-6)
Shi B. Dhanunjaya	Technical Officer (T-5)

All India Coordinated Research Project for Dryland Agriculture

Dr. K.P.R.Vittal	**Project Coordinator (appointed as Director, CAZRI on 27.12.06)**
Dr. G.Subba Reddy	**Project Coordinator (appointed as PC (R) since 01.01.2007)**
Dr. G.R.Maruthi Sankar	Principal Scientist (Ag. Statistics)
Dr. G.Ravindra Chary	Senior Scientist (Agronomy)
Smt. A. Prema Kumari	Asst. Administrative Officer
Sri S.R. Meena	Asst. Administrative Officer (joined CRIDA on transfer from NRCS on 28.6.2006)
Smt. A. Girija	Technical Officer (T-6)
Sri R.V.S.G. Krishnam Raju	Technical Officer (T-6)
Sri L. Sree Ramulu	Technical Officer (T-5)

All India Coordinated Research Project on Agrometeorology

Dr. G.G.S.N.Rao	**Principal Scientist (Ag. Meteorology) & Project Coordinator**
Dr. U.S.Victor	Principal Scientist (Ag. Meteorology) (Retired from service on 30.09.2006)
Dr. V.U.M. Rao	Principal Scientist (Ag. Meteorology)
Dr. Kausalya Ramachandran	Senior Scientist (Geography) & ICAR National Fellow
Dr. A.V.M. Subba Rao	Scientist (Senior Scale) (Ag. Meteorology)
Sri I. R. Khandgonda	Technical Officer (T-5)

Research Coordination and Management Unit

Dr. M. Osman	**Senior Scientist (Agronomy) & Officer-in-Charge**
Dr. S. Desai	Senior Scientist (Plant Pathology)
Dr. Y.G. Prasad	Senior Scientist (Entomology)
Dr. K. Srinivas	Senior Scientist (Soil Science)
Dr. S.S.Balloli	Senior Scientist (Soil Science)
Dr. J.V.N.S. Prasad	Senior Scientist (Agronomy)
Er. I. Srinivas	Scientist (Selection Grade) (FM&P)
Dr. Shaik Haffis	Technical Officer (T-6)

ARIS CELL

Dr. K.V.Rao	**Senior Scientist (S&WCE) & Officer-in-Charge**
Shri P. Chandrasekhar	Technical Officer (T-6)

Library

A.K. Mishra	**Senior Scientist (LP&M) & Officer-in-Charge (upto 26.09.2006)**
M. Maheswari	**Senior Scientist (Plant Physiology) & Officer-in-Charge (from 27.09.2006)**
Sri A. Malla Reddy	Technical Officer (T-6)

Sri I. Syam Prasad	Technical Officer (T-6)
Sri K. Bazar Raju	Technical Officer (T-5)

Hayatnagar Research Farm

Dr G. Rajeswar Rao	**Senior Scientist (Forestry) & Officer-in-Charge**
Sri B.Chandra Mohan Reddy	Technical Officer (T-7/8)
Sri Ganesh Ramji Hedau	Technical Officer (T-6)
Sri S. Srinivasa Reddy	Technical Officer (T-6)
Sri Y. Venkatesha Reddy	Technical Officer (T-6)
Sri B. Narasing Rao	Technical Officer (T-5) (voluntary retirement w.e.f. 01.02.07)
Sri M. Arokia Swamy	Technical officer (T-5)
Sri J.B. Swamy	Technical Officer (T-5)
Sri M. Ramulu	Technical Officer (T-5)
Sri M. Yadaiah	Technical Officer (T-5)
Sri P. Yadaiah	Technical Officer (T-5)

Gunegal Research Farm

Dr. M. Srinivasa Rao	**Senior Scientist (Entomology) & Officer-in-Charge**

Administration

Sri Ashish Roy	**Senior Administrative Officer (transferred to DOR w.e.f. 17.01.2007)**
Sri P.Balabrahmaiah	**Finance and Accounts Officer**
Sri R.K.Shukla	Asst. Administrative Officer
Sri V.Govardhan	Asst. Administrative Officer
Sri G. Lakshminarayana	Asst. Administrative Officer
Sri K. Ramakrishnaiah	Technical Officer T-5

Vehicles

Sri E. Ravindranath	Technical Officer (T-5)
Sri P. Nagender Rao	Technical Officer (T-5) (Driver)
Sri P. Yadi Reddy	Technical Officer (T-5) (Driver)
Sri T. Ravi Kumar	Technical Officer (T-5) (Driver)

Hindi Cell

Dr. G.G.S.N. Rao	Project coordinator (Ag. Met.) & Officer-in-Charge (Official Language)
Sri S.R.Yadav	Asst. Director (OL) and Public Relations Officer

Works

Dr. M.V. Padmanabhan	Principal Scientist (S&WCE) & Officer-in-Charge (Works)
Sri D. Srinivas	Technical Officer (T-5)

* on deputation to ICRISAT for 3 years from 1 January 2006
** on deputation to ICRISAT for a period of 9 months from 30 November, 2005 to 29.09.2006
@ on deputation to NIH, Roorkee

17 Infrastructure Development

17.1 At CRIDA Campus

- 380 KVA Diesel Generator and Generator Room
- Recarpeting of roads in main complex
- Solar water heating system at IGH
- Upgradation/renovation of Soil Physics laboratory
- Upgradation/renovation of Plant Pathology laboratory
- Vehicle shed with approach road
- RCC shelves with wooden shutters for AICRPDA wing
- Roofed passage from TTC Hostel to IGH
- Renovation of ARIS room
- Renovation of Conference Hall II

17.2 At HRF

- Strengthening of nursery
- Vehicle shed
- WBM Road in Phase III
- Security-cum-office room for Phase-III
- Renovation of sheep shed
- Borewell in Phase-III

17.3 At GRF

- Borewell in Phase-III
- Strengthening of nursery
- Shelter rooms
- Security room

Acronyms

AAS	Agro-Advisory Services
ACU	Adult Cattle Unit
AD	Approximate Digestibility
AICRPAM	All India Coordinated Research Project on Agrometeorology
AICRPDA	All India Coordinated Research Project for Dryland Agriculture
AjGV	*Achaea janata* Granulosis Virus
ANGRAU	Acharya N.G. Ranga Agricultural University
AP-NL	Andhra Pradesh – Netherlands
ASCI	Administrative Staff College of India
AU	Andhra University
BAP	Benzylaminoputine
BC	Benefit Cost
BD	Bulk Density
Bt	*Bacillus thuringiensis*
CAZRI	Central Arid Zone Research Institute
CICR	Central Institute for Cotton Research
CPR	Common Pool Resources
cv	Cultivar
DAS	Days After Sowing
DHA	Dehydrogenase Assay
DOR	Directorate of Oilseed Research
DRR	Directorate of Rice Research
DST	Department of Science and Technology
ECD	Efficiency of Conversion of Digested Food
ECI	Efficiency of Conversion of Ingested Food
EPS	Exo Polysaccharide
FP	Farmers Practice
FYM	Farm Yard Manure
GIS	Geographical Information System
GRF	Gunegal Research Farm
GSM	Groundnut Shell Manure
HC	Hydraulic Conductivity
HQ	Headquarters
HRD	Human Resource Development
HRF	Hayathnagar Research Farm

IAA	Indole Acetic Acid
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
ICT	Information and Communication Technology
IIHR	Indian Institute of Horticultural Research
IISC	Indian Institute of Science
IISS	Indian Institute of Soil Science
IMD	India Meteorological Department
IPE	Institute of Public Enterprise
IPM	Integrated Pest Management
IVLP	Institute Village Linkage Programme
JNTU	Jawaharlal Nehru Technological University
KVK	Krishi Vigyan Kendra (Agricultural Sciences Centre)
LAE	Land Area Equivalent
LAI	Leaf Area Index
LC	Labile Carbon
LER	Land Equivalent Ratio
LGP	Length of Growing Period
LIS	Lift Irrigation Scheme
MANAGE	National Institute of Agricultural Extension Management
MBC	Microbial Biomass Carbon
MBN	Microbial Biomass Nitrogen
MtlD	Mannitol-l-Phosphate Dehydrogenase
MSAVI	Modified Soil Adjusted Vegetation Index
MSSRF	M.S. Swaminathan Research Foundation
MWD	Mean Weight Diameter
NAA	Naphthalene Acetic Acid
NAARM	National Academy of Agricultural Research Management
NASC	National Agricultural Science Complex
NBAIM	National Bureau of Agriculturally Important Microorganisms
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
NCAP	National Center for Agricultural Economics and Policy Research
NCMRWF	National Center for Medium Range Weather Forecasting
NDVI	Normalized Difference Vegetation Index
NE	North East
NGO	Non-governmental Organization
NIR	Near Infra Red
NIRD	National Institute for Rural Development
NR	Nitrate Reductase
NRCS	National Research Center for Sorghum

NRCWA	National Research Center for Women in Agriculture
NRM	Natural Resource Management
NRSA	National Remote Sensing Agency
NW	North West
NWDPRA	National Watershed Development Program for Rainfed Areas
OU	Osmania University
PET	Potential Evapo Transpiration
ppm	Parts per million
PRA	Participatory Rural Appraisal
PSB	Phosphorus Solubilizing Bacteria
QRT	Quinquennial Review Term
RAC	Research Advisory Committee
RCR	Relative Consumption Rate
RDF	Recommended Dose of Fertilizer
RGR	Relative Growth Rate
RH	Relative Humidity
RSQI	Relative Soil Quality Index
RUE	Radiation Use Efficiency
SAU	State Agricultural University
SAVI	Soil Adjusted Vegetation Index
SMW	Standard Meteorological Week
SRC	Scientific Research Council
TAR	Technology Assessment and Refinement
TMW	Treated Micro Watershed
UTMW	Untreated Micro Watershed