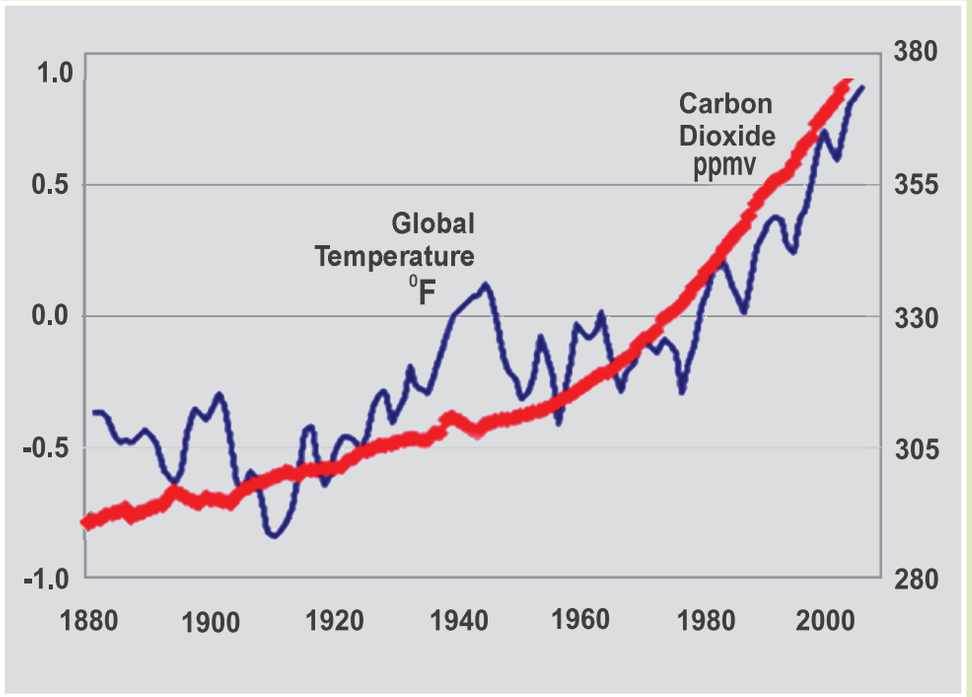
CRIDA

Annual Report 2007 - 08



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Central Research Institute for Dryland Agriculture

Santoshnagar, Hyderabad - 500 059

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वार्षिक प्रतिवेदन

Annual Report

2007 - 08

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ICAR

केंद्रीय बारानी कृषि अनुसंधान संस्थान
संतोषनगर, हैदराबाद - 500 059

Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad - 500 059

Preface

Improving the productivity and profitability of rainfed agriculture is imperative from the perspective of growth, equity and sustainability of Indian agriculture and hence it continues to receive high priority by the Government of India. With increasing cost of production, degradation of natural resources and increased climatic risks, the livelihood security of rainfed farmers is continuously under threat. Generation of new technologies is one of the key elements in the strategy for improving rainfed agriculture, though one should take due cognizance of the importance of technology transfer and policy environments. It is important to deal with the short term objectives as well as to pursue the long term goals and challenges. The on-going efforts at CRIDA reflect such a mix of short and long term perspective. CRIDA has been actively involved in undertaking basic and applied research in the area of rainfed agriculture and climate change through its network research stations across the country.

Significant progress has been achieved in core research activities of the Institute during the year, besides good progress under the net work projects. Climate risk assessment remained the top research agenda during the year. The long term trends in temperature for different locations in the country were examined; WRSI values for various growth stages of crops were worked out; effect of climate change on crop duration, crop growth and pest incidence were investigated; water harvesting potential in different rainfed districts quantified; progress made in developing drought-resistant genetically modified sorghum plants; two high yielding varieties of horsegram reached an advanced stage for release; key agronomic practices for maximizing productivity of jatropha, pongamia and few medicinal and aromatic plants standardized; improvements in machinery were made for biomass incorporation in soil and oil extraction from jatropha and pongamia. Further, efforts were continued to transfer a number of

technologies to farmers through KVK and other on-farm research activities. Several training programmes were organized for officers involved in technology transfer. Another important event during this year was the launch of the NAIP-SRL sub project for evolving upscaleable models of participatory technology transfer through enhanced farming systems productivity and efficient support systems in eight districts of A.P. with an overall goal of improved livelihoods. The efforts of the Institute were reflected in the number of publications and recognitions of the scientists. Finally, I am privileged to present this annual report after assuming the responsibility of Director of this Institute and I am thankful to my predecessors for building a strong foundation for the Institute. I am also thankful to the members of the Editorial Committee for an excellent job of putting this report together.

Hyderabad
Date : September 09, 2008

B. Venkateswarlu

(B. Venkateswarlu)

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संसाधन लक्षण

- थ्रांन्थवेट एवं मेथर वाटर बैलेंस बुक कीपिंग (Thronthwaite & Mather water balance book keeping) विधि का उपयोग कर आंध्र प्रदेश के कुल 23 जिलों का वर्ष 2007 के 52 सप्ताहों के लिए सत्पाहिक मृदा नमी सूचकांक निकाले गए। भौगोलिक सूचना प्रणाली का उपयोग कर मानचित्र भी तैयार किए गए। यह जानकारी आचार्य एन.जी. रंगा कृषि विश्वविद्यालय के कृषि मौसमविज्ञान केंद्र को उपलब्ध कराई गई ताकि वे इसका उपयोग, किसानों हेतु साप्ताहिक कृषि सलाह तैयार करने में कर सकें।

- मक्का, मूंगफली, अरहर, ज्वार, बाजरा एवं कपास जैसी फसलों की वृद्धि की विभिन्न अवस्थाओं के लिए वृद्धि के आंध्र प्रदेश की पांच कृषि मौसम-विज्ञान क्षेत्रीय इकाइयों हेतु (अनकापल्ली, अनंतपुर, तिरुपति, राजेंद्रनगर एवं जगत्याल) यथेष्ट जल आवश्यकता सूचकांक आंकड़ो की गणना की गई। मक्का एवं मूगंफली की सभी वृद्धि अवस्थाओं के लिए डब्ल्यू.आर.एस. आई. मूल्यांक 85 प्रतिशत से भी अधिक पाया गया। अनंतपुर में मूंगफली की पैगिंग (pegging) अवस्था से आगे की वृद्धि के दौरान यह मूल्यांक 90 प्रतिशत तक कभी भी प्राप्त नहीं हुआ। राजेंद्रनगर में, अरहर के पुष्पीकरण से लेकर फलीकरण के दौरान डब्ल्यू. आर. एस. आई. करीब 90 प्रतिशत था। जगत्याल में उगाई गईं कपास में यह 95 प्रतिशत से अधिक था।

- सोयग्रो (SOYGRO) मॉडल का उपयोग कर सोयाबीन किस्म पी. के. - 416 में बोवाई की विभिन्न तिथियों से पैदावार एवं पैदावार संबंधित लक्षणों को स्थापित किया गया। सात जून के बाद की गई बोवाई में फली प्रति पौधा, दानों की संख्या प्रति फली एवं 100 बीज भार में कमी आई। पांच जुलाई, 2006 के उपरांत बोवाई करने की तुलना में सात जून, 2006 को की गई बोवाई में अनाज उत्पादन, भूसा उत्पादन एवं जैविक उत्पादन अत्यधिक थे। सोयग्रो (SOYGRO) मॉडल द्वारा अनुमानित फसल घटनाक्रम सीमा (<10%) के अंदर ही रहा।

जलवायु परिवर्तन प्रभाव

- आंध्र प्रदेश में कुछ चयनित केंद्रों की फसल-जल आवश्यकता एवं फसल अवधि पर जलवायु परिवर्तन परिपेक्षों के प्रभाव पर किए अध्ययन में वर्षा आधारित परिस्थितियों के अंतर्गत उगाई गई प्रमुख फसलों, जैसे मक्का, मूंगफली, अरहर, कपास संपूर्ण जल, आवश्यकताओं में वर्धमान प्रवृत्ति देखी गई। इसका मुख्य कारण संभवत : आधार वर्ष सन् 1990 के बाद से औसत तापमान में करीब एक डिग्री सेंटीग्रेड की वृद्धि होना है। अनुमान लगाया जा रहा है कि राज्य में उगाई जाने वाली सभी प्रमुख फसलों में सन् 2020 तक फसल अवधि में एक से दो सप्ताहों की कमी आ सकती है।

- वर्ष 1901-2003 के दौरान, देश के अत्यधिक स्थानों के औसत वाषिकी तापमान मे वृद्धि देखी गई। अधिकतम तापमान क बढ़ने की प्रवृत्ति उतनी व्यापक नही थी जबकि अध्ययन किए गए 78 प्रतिशत स्थानों पर न्युनतम तापमान में वृद्धि देखी गई।

- CO_2 के स्तर में वृद्धि होने से अरंड के कुल बायोमॉस में सुधार देखा गया और यह बढ़ोत्तरी नियंत्रण परिवेश की अपेक्षा 700 पी.पी.एम. अधिकतम (22%) थी उसके बाद 550 पी.पी.एम. पर इसका स्तर (11%) अधिक था। बढ़ी हुई कार्बन डाइआक्साइड के परिणामस्वरूप अरंड की फसल में फूल आने की अवस्था 1-3 दिन तक अगेती हो गई। जबकि 50 प्रतिशत पुष्पीकरण की अवस्था 7-15 दिन तक अगेती हुई। इसके अतिरिक्त सामान्य नियंत्रण की अपेक्षा 700 पी.पी.एम. CO_2 स्तर पर 46 प्रतिशत अधिक था। जबकि यह वृद्धि 550 पी.पी.एम. पर सिर्फ 35 प्रतिशत ही रही। 12 एवं 15 प्रतिशत, स्पाईक भार 46 प्रतिशत, कैप्सूल संख्या 64 एवं 98 प्रतिशत, कैप्सूल भार 46 एवं 54 प्रतिशत एवं बीज भार 144 एवं 167 प्रतिशत बढ़े।

- नियंत्रण की अपेक्षा (365 पी.पी.एम.) 550 पी.पी.एम. कार्बनडाइआक्साइड की सांद्रता में उगाए गए बाजरे के पौधों में नाइट्रेट अवशोषण की क्षमता दृष्टिगोचर रूप में अधिक पाई गई। इन पौधों में इंजाइम इंडक्शन

की क्षमता भी काफी ज्यादा पाई गई। यह क्षमता नाइट्रेट की 15 मिलि कार्बनडाइआक्साइड की मात्राक्रमश : 550 एवं 700 पी.पी.एम. तक बढाने से स्पाइकों की प्रभावी लंबाई 12 एवं 15 मोलर (mM) सांद्रता तक ही दिखाई दी और उसके उपरांत यह क्षमता नियंत्रण और उच्च कार्बन डाइआक्साईड दोनो स्तर पर ही घट गई।

- जब बढ़ी हुई CO_2 मात्रा का पौधों पर, कीट पतंगों से होने वाली हानि का, अध्ययन किया गया तो यह पाया कि नियंत्रण की अपेक्षा बढ़ी हुई CO_2 की स्थिति में *एस. लिटुरा* नामक लार्वों ने पत्तों को ज्यादा हानि पहुंचाई। ईसके अतिरिक्त अरंड के पत्तों पर कीट पतंगों का कुल नुकसान नियंत्रण की अपेक्षा उच्च कार्बन डाइआक्साइड की स्थिति में बहुत अधिक लगा। लार्वों का भार भी नियंत्रण (350 पी.पी.एस.) की अपेक्षा उच्च कार्बन डाइआक्साइड की स्थिति में ज्यादा दर्ज किया गया। यह भी देखा गया कि जो लार्वे उच्च कार्बन डाइआक्साइड द्वारा उगाए गए पौधों के पत्तों पर थे, उनके विकास में नियंत्रण की अपेक्षा अधिक समय लगा।

- बीटी कपास (क्रई 1 ए (सी) एवं बीटीयेतर पर भरण किए गए *हेलिकोवेरण अर्मिजेरा* के विकास पर अत्थित कार्बन डाइआक्सईड के प्रभाकों का अध्ययन करने के लिए किए गए भरण जांचों से ज्ञात हुआ कि किया कि परिवेश नियंत्रण कार्बन डाईआक्सईड पर्णों की तुलना में *एच. अर्मिजेरा* के लार्बो का उत्थित कार्बन डाईआक्सईड पर्ण (बीटी एवं बीटीयेतर) का उपभोग अधिक था। दोनों ही परिस्थितियों में लार्वों ने बीटी कपास पर्णों की अपेक्षा बीटीयेतर (Non Bt) कपास के पर्णों का अधिक उपयोग किया।

वर्षाजल प्रबंधन

- देश के प्रमुख वर्षा आधारित जिलों के लिए जल संतुलन मॉडल का प्रयोग कर वर्षा की कभी एवं हार्वेस्ट करने योग्य जल मात्राओं का अनुमान गया। यह अनुमान लगाया गया कि वर्षा आधारित 28 मिलियन हैक्टेयर से करीब 114 बिलियन क्युबिक मीटर जल सतही अपवाह के रूप में प्राप्त किया जा सकाता है।

- आंध्र प्रदेश के कुरमापल्ली जलग्रहण क्षेत्र में कुल 817 मिलीमीटर वर्षा हुई जिसमें से 66 प्रतिशत वर्षा अगस्त एवं सितंबर महीने में हुई। जलग्रहण क्षेत्र में सिर्फ 6.7 प्रतिशत की वर्षा अपवाह (धरातल एवं उपधरातल) के रूप में प्राप्त हुई। अपवाह की तुलना में भूमि में अधिक मात्रा में गहरे अंत: स्त्रवण का कारण मृदा की अच्छी किस्म का होना था।

ट्रांसजेनिक दृष्टिकोण से सूखा सहिष्णुता की वृद्धि

- ट्रांसजेनिक ज्वार के आणविक एवं क्रियात्मक गुणों का अध्ययन किया गया तथा अग्रिम संतति की ओर ले जाया गया। T_3 और T_4 ट्रांसजेनिकों और अरूपांतरित पौधों का जिनोमिक डी.एन.ए., Mltd जींस स्पेस्फिक प्राईमरों का प्रयोग कर पी.सी.आर. विधि द्वारा बढ़ाया गया। जब दोनों ट्रांसजनिक और अरूपांतरित पौधों को सोडियम क्लोराईड के 200 मिलि मोलर (200 mm) घोल में चुनौती दी गई तो यह देखा गया कि ट्रॉसजनिकों में जड़ो और शाखाओं की लंबाई अधिक थी। आश्चर्यजानक रूप से, एमटी एलडी ट्रॉसजनिकों में भी जड़ एवं शाखाओं की संपाई (औसतन 2.8 एवं 1.7 गुना) में दबाब के प्रति अच्छी रिकवरी देखी गई।

- निरंतर प्रयासों के अंतर्गत मूंग में अजैविक दबाब सहिष्णुता वृद्धि के लिए जननिक रूपांतरण प्रयास जारी हैं। ऐग्रोबैकटीरियम मध्यस्तता वाले दृष्टिकोण के लिए रूपांतरण परिस्थितियों का अध्ययन किया गया और अरूपांतरित पौधों का पी.सी.आर.एम.टी.एल.डी. जीन विशेष प्राइमरों का उपयोग कर बढ़ाया गया।

किस्मों का विकास

- कुलथी म्यूटेंटों का मूल्यांकन अच्छी प्रगति पर है। आई.बी.टी. किस्म में प्रविष्टि एच.जी. 24 ने 781.24 किलोग्राम प्रति हेक्टेपर का अत्यधिक अनाज उत्पादन दर्ज किया। इसके बाद एच. जी. 28 का उत्पादन 733.62 किलोग्राम प्रति हेक्टेयर था। इन दोनों प्रविष्टियों की परिपक्वता 89 एवं 88 दिनों मे हुई।

सूखा प्रबंधन

- मूंग की फसलों में नमी उपलब्धता एवं जड़ विकास के अध्ययनों ने दर्शाया कि वनस्पतिक अवस्था में जल दबाव डालने से पौधों की जड़ों में अधिकाधिक वृद्धि हुई। यद्या पि दबाव रहित पौधों की जड़ों की गहराई में भी वृद्धि हुई लेकिन यह कम थी। नमी दबाव रहित मूंग के पौधों की अपेक्षा नमी दबाव वाले पौधों में जड़ एवं शाखाओं का अनुपात अधिक था।

- अरंड में सूखा प्रबंधन अध्ययनों ने दर्शाया कि ग्लैरीसीडिया से 25 प्रतिशत नाइट्रोजन (N) एवं अकार्बनिक उर्वरकों से 75 प्रतिशत नाइट्रोजन (N) के प्रयोग के उपचार के अंतर्गत गोबर की खाद डालने से अथवा न डालने से सबसे अधिक (1876 एवं 1577 किलोग्राम प्रति हेक्टेयर) उपज प्राप्त हुई। यह भी पाया गया कि अरंड़ी की फसल के बीच जल संरक्षण कुंड़ बनाने से फसल को काफी लाभ मिला। जल संरक्षण कुंड़ बनाकर उर्वरकों की साधारण मात्रा के साथ-साथ खाद डालते समय 10 किलोग्राम नाइट्रोजन प्रति हेक्टेयर की अतिरिक्त मात्रा के प्रयोग से (1689 और 1369 किलेग्राम प्रति हेक्टेयर) अच्छा उत्पादन प्राप्त हुआ।

जैविक उत्पादन

- तिल के जैविक उत्पादन पर किए गए अध्यायनों ने दर्शाया कि तीसरे वर्ष के प्रयोगों के दौरान पहले अकार्बनिक प्रक्रियाओं से अधिकतम बीज उत्पादन (416 किलोग्राम प्रति हेक्टेयर) प्राप्त हुआ, उसके बाद कार्बनिक प्रक्रियाओं एवं नियंत्रण का स्थान रहा। अकार्बनिक प्रणालियों के अंतर्गत प्रति वर्ग मीटर फलियों की संख्या एवं बायोमॉस (stick) का उत्पादन भी अधिक था। जबकि विभिन्न उपचारों से तेल की मात्रा में महत्वपूर्ण अंतर नहीं देखा गया।

- तीसरे वर्ष के दौरान उच्च निवेश के जैविक पैकेज़ से अरहर का अधिकतम उत्पादन (1524 किलोग्राम प्रति हेक्टेयर) प्राप्त हुआ। इसके बाद उच्च निवेश पैकेज में उत्पादन 146 किलोग्राम प्रति हेक्टेयर ही रहा।

समेकित नशीजीव प्रंबधन

- निम्न वाह्य निवेश समेकित नाशीजीव प्रबंधन-I एवं माडयुल-II, जो कि वनस्पतिक अर्कों एवं तेलों से युक्त थे, ने अच्छा कार्य किया एवं ये समोकित उपचार के सामान ही श्रेष्ठ पाए गए। यधपि अरहर में विशिष्ट रसायन उपचार से नाशीजीवों का प्रकोप काफी कम रहा।

- अध्यनों से पता चला कि सपैकट्राल बैंड समूह 810, 870, 950 और 1100 नैनोमीटर () जट्रोफा में हुए जड़ छेदक के द्वारा दबाव के प्रति काफी संवेदनशील पाएगए। सुदूर संवेदी का उपयोग कर नाशीजीव की समस्यायों की पहचान के लिए इस सूचना का उपयोग किया जा सकता है।

- *अच्छीया जनता* (Achaca Janata) किस्म के लार्वा स्तर (205.5) थी। उसके बाद प्यूपल (127.8), वयस्क (76.6) एवं अंडा स्तर का क्रम (58.8) पाया गया।

- बीटी के सोलह विगलकों ने मानक स्तर से अधिक क्रिस्टल प्रोटीन का उत्पादन दिया। उडा (Uda) विगलक भी उच्च प्रोटीन देने वाला आँका गया जो कि मुख्य नाशीजीवों (अर्धकुंडलक, *हेलिकोवेरण* एवं *स्पोडेप्टेरा*) के नियंत्रण हेतु व्यापक स्पेक्ट्रम (Broad spectrum) संपन्न सिद्ध हुआ।

मॉडल कृषि प्रणाली

- सूक्ष्म जलग्रहण आधार पर कृषि प्रणाली मापकों के अध्ययन से पता चला कि 1.12 हेक्टेयर में कृष्य फसलों के साथ कृषि-वानिकी, सब्जियां, झाडियाँ एवं घास आदि उगाने से लगभग 10.433 रूपए की शुद्ध आय प्राप्त हो सकती है। निवेशों का बी.सी. अनुपात 1.72 रहा।

कर्षण एवं पोषक प्रबंधन

- कम जुताई की अपेक्षा पारंपरिक जुताई से ज्वार एवं मूंग के उत्पादनों में क्रमांश : 15 एवं 35 प्रतिशत बढ़ोत्तरी पाई गई। ज्वार की फसल में, नियंत्रण की अपेक्षा यूरिया ($टी_4$) सहित 2 टन ग्लैरीसिडिया के कर्तन + 20 किलोग्राम नाइट्रोजन का उपयोग करने सें उत्पादन मे सर्षेच्च प्रतिशत वृद्धि (107 प्रतिशत) दर्ज की गई। जबकि मूंग की फसल में, नियंत्रण की अपेक्षा $टी_4$ (1 टन गिलैरिसिडिया के कर्तन + 10 किलोग्राम नाइट्रोजन थूरिया सहित) तथा $टी_5$ (2 टन कंपोस्ट + 1 टन ग्लैरीसीडिया के कर्तन) दोनों ने उपचारों ने समान रूप से मूंग के उत्पादन को 40 प्रतिशत तक बढ़ाया।

- शमतिल की फसल में जैविक एवं अजैविक माध्यमों द्वारा सिफारिश की गई पोषकों की मात्राओं का प्रयोग करने से बेहतर शुष्क पदार्थ संग्रहण, पर्ण क्षेत्र सूची, बीज प्रति पौधा, बीज एवं तेल उत्पादन (किलोग्राम प्रति हेक्टेयर) समग्र प्रतिफल, शुद्ध प्रतिफल एवं बी.सी. अनुपात प्राप्त हुए।

- इंदौर में, नियंत्रण की तुलना में समोकित पोषक प्रंबधन उपचार से जैविक कार्बन (0-20 सेंटीमीटर) में वृद्धि हुई। गोबर की खाद के प्रयोग से विवित्त जैविक कार्बन (प्रतिशत) में महत्वपूर्ण वृद्धि हुई। मृदा की गहराई के

साथ इसमें कमी देखी गई। सभी उपचारों में सूक्ष्म बायोमॉस कार्बन मात्रा में महत्वपूर्ण रूप से सूधार पाया गया। फसल अवशेषों के उपयोग से इसमें अधिक वृद्धि हुई।

मृदा गुणवत्ता मूल्यांकन

- सोथाबीन (जे.एस. 335) कुसुम (Safflower) सस्यन प्रणाली में सोयाबीन अवशेष को 5 टन प्रति हेक्टेयर की दर से डालने के साथ 20 किलोग्राम नाइट्रोजन +13 किलोग्राम प्रासफोरस डालने से सर्वोच्च सापेक्ष मृदा गुणक्ता सूची (आर.एस.क्यू.आई) 0.97 दर्ज किया गया। उसके बाद गोबर खाद 6 टन प्रति हेक्टोयर + 20 किलोग्राम नाईट्रोजन +13 किलोग्राम फासफोरस डालने से आर.एस.क्यू.आई., 0.87 रहा।

- पोटाशियम परमेगनेट ($KMno_4$) का निष्प्रभावी हल्का घोल एवं अन्य रसायन कई साक्रिय जैविक पदार्थों से अभिक्रिया करते हैं तथा $KMno_4$ के गहरे बैगनी रंग को हल्के गुलाबी या रंगहीन में बदल देते हैं। इसी सिद्धांत का उपयोग कर अस्थिर कार्बन (Labile C) का अनुमान लगाने के लिए एक फील्ड किट का विकास किया गया। खेत से मिट्टी के नमुनों का संग्रहण कर तुंरत (1-2 दिनों के अंदर) विश्लेषण करने के लिए यह प्रक्रिया काफी उपयुक्त पाई गई।

- गोबर की खाद 5 टन प्रति हेक्टेयर-1 के उपयोग से ज्वार + अरहर प्रणाली (0.92) एवं सोयाबीन + अरहर प्रणाली (0.98) में सर्वोच्च सापेक्ष मृदा गुणवत्ता सूची (आर.एस.क्यू.आई) प्राप्त हुई जबकि कपास - उड़द प्रणाली एवं मूंग-रवि ज्वार प्रणालियों में, 25 प्रतिशत आर.डी.एफ. +1.5 टन प्रति हेक्टेयर की दर से ग्लैरीसीडिया तथा 25 प्रतिशत आर.डी.एफ + 2.5 टन प्रति हेक्टेयर की दर से गोबर खाद का समोकित उपयोग करने से क्रमश : 0.98 और 0.95 की सर्वोच्च सापेक्ष मृदा गुणक्ता सूची (आर.एस.क्यु.आई) प्राप्त हुई, यह उपचार मृदा की गुणवत्ता में सुधार लाने के लिए बेहतर सिद्ध हुए।

कृषिवानिकी

- सेटारिया जब *ए. सैनिगल* के साथ या अकेले में उगाया गया तो दृष्टिगोचर रूप से अच्छी उपज मिली। इन दोनो स्थितियों में सेटारिया की उपज आमला एवं इमली के साथ अंत : सस्यकरण की अपेक्षा बहुत अच्छी पाई गई। एकल फसल की तुलना में पेडों से अंतर फसलों में महत्वपूर्ण रूप से उच्च कार्य सूची प्राप्त हुआ।

- ल्यूकेना के वृक्ष वृद्धि के दूसरे वर्ष के दौरान अन्य घासों की अपेक्षा गिनी घास किस्म मकुनी एवं रिवर्सडेल से महत्वपूर्ण रूप से बेहतर बायोमॉस प्राप्त हुआ। ल्यूकेना के साथ बहुवार्षिक घासों के कारण पेड़ की उंचाई एवं आवक्ष उच्चता व्यास (DBH) में महत्वपूर्ण रूप से कमी आई।

औषधी, सुगंधित एवं रंग उत्पादन करने वाले पौधे

- इंडिगो में गोबर की खाद एवं वर्मिकंपोस्ट के प्रयोग से अत्यधिक बायोमॉस का उत्पादन हुआ। जबकि अरंड केक एवं अजैविक उर्वरकों के प्रयोग से न्यूनतम उत्पादन प्राप्त हुआ। गोबर की खाद, अरंड केक, एवं अजैविक उर्वरकों की अपेक्षा वर्मीकंपोस्ट से क्रमश : 24, 104, 145 प्रतिशत बेहतर रंग वाला उत्पादन प्राप्त हुआ। वर्मिकंपोस्ट एवं फासफोरस के प्रयोग से इंडिगोटिन की मात्रा मे वृद्धि हुई।

- युगल पंक्ति + भूमि संरक्षी फसल एवं भूमि संरक्षी उपचारों में सेन्ना के पत्तों का उत्पादन बेहतर था। एंडोग्रफिस फसल के साथ भूमि सरंक्षी फसल के रूप में कुलथी उगाने से बायेमॉस तथा शुष्क पदार्थ के उत्पादन मे वृद्धि हुई। युगल पंक्ति फसल + भूमि संरक्षी उपचारों से अश्वगंधा की जडों में बेहतर वृद्धि पाई गई। बायो नेक्टर (देसी गायं के गोबर का मिश्रण, मूत्र, काला गुड, चना, उडद, मूंग इत्यादि दालों का आटा एवं घास प्रयोग के उपचारों से भी प्रभावी रूप से उत्पादन मे वृद्धि हुई।

- प्रण सुरक्षा सिंचाई (Life saving irrigation) एवं युगल पंक्ति फसल + भूमि संरक्षी फसल जैसे सुखा प्रंबधन प्रफियोओं से बेहतर एंडोग्रोफोलाईड मात्रा देखी गई।

- अजैविक उर्वरक, वर्मिकंपोस्ट एवं अरंड केक के प्रयोगों से *लेमनग्रास* एवं *पलमरोसा* में बायोमॉस का उत्पादन एवं तेल अत्यधिक था। नियंत्रित उपचारों में न्यूनतम बायोमॉस एवं तेल उत्पादन दर्ज किया गया। वर्मिकंपोस्ट एवं अरंड केक प्रयोग से लेमनग्रास में अत्यधिक सिट्रल ए की मात्रा एवं पलमरोसा में गारनियल दर्ज हुआ जबकि अजैविक उर्वरकों के प्रयोग से यह न्यूनतम था।

जैवईधन फसल

- जैट्रोफा में अधिकतम उत्पादन के लिए काट-छांट सारणी का मानकीकरण किया गया। इस सारणी में प्रथम वर्ष भूमि से 45 सेंटीमीटर तक, द्वितीय वर्ष में प्रत्येक शाखा का आधा भाग एवं तृतीय वर्ष से हल्की कांट-छांट शामिल है। नलगोंडा जिले के किसानों के खेतों में 4 x 2 मीटर अंतराल पर लगाए गए जट्रोफा के पौधों में 60 प्रतिशत कांट-छांट करने से बीज उत्पादन अधिक रहा।

- महबूबनगर जिले में किसानों के खेतों पर किए गए अध्ययनों ने स्पष्ट किया कि 6 x 4 मीटर की अंतराल की तुलना में 5 X 4 मीटर के अंतराल में लगाए गए पौधों की उंचाई महत्वपूर्ण रूप से कम थी जबकि नज़दीक अतंराल की तुलना में दूर के अंतराल (6 X 6 मीटर) से, भूमि से प्रथम शाखा की उंचाई बेहतर दर्ज हुई। पोंगमिया का क्लोन इलाइट (elete), जिसमें तेल की मात्रा 38 प्रतिशत से अधिक है, का स्वस्थाने (insitu grafting) कलम बांधने का प्रयास किया गया।

पशुधन प्रबंधन

- ताल्लपल्ली गांव में किए गए पशुधन सर्वोक्षण से पता चला कि अधिकांश डेरी पशुओं मे कम शक्टि (रख-रखाव की आवश्कताओं में, 21 से 38 प्रतिशत) एवं प्रोटीन (रख-रखाव की आवश्यकताओं में, 43 से 68 प्रतिशत) की कमी देखी गई। डेरी पशुओं में शक्ति एवं प्रोटीन से जुडे कुपोषण के कारण लो बल्ड प्लासमा-यूरिया, नाइट्रोजन, ग्लूकोस एवं उच्च किटोन बॉडिस देखे गए।

- भेड़ो के प्रबंधन पर किए गए अध्ययनों से पता चला कि दक्कनी भेड़ो के विकास एवं उनके वज़न को बढ़ाने के लिए प्रंबधन की गहन प्रणाली के अंतर्गत मोटे चारे, जोकि मूल आहार है। (कटी हुई ज्वार की कड़बी) के साथ-साथ स्टाइलो एवं ग्लैरीसीडिया के पत्तों को वैकल्पिक सांद्राता मिश्रण के रूप में दिया जा सकता है।

- तेल निकालने वाले यंत्रों में 'सक्रु' के हिजाइन में रूपांतरण द्वारा जट्रोफा एवं पोंगमिमा से अधिक मात्रा में तेल निकाला गया। इसी प्राकार बीजों के पूर्वोपचार से तेल की मात्रा एवं गुणक्ता में यथेष्ट वृद्धि हुई।

ऊर्जा प्रबंधन

- ट्रेक्टर द्वारा चालित उपकरणों बनाई गई मेंडों एवं खूडों के परिणामस्वरूप ज्वार (3210 किलोग्राम प्रति हेक्टेयर) एवं अरहर (761 किलोग्राम प्रति हेक्टेयर) की फसलों के अत्यधिक अनाज उत्पादन दर्ज किया गया तथा दुसरे स्तर पर 0.9 मीटर एवं 1.35 मीटर के अंतराल पर क्यारी एवं खूड उपचार का स्थान रहा।

- मृदा में बायोमॉस मिश्रण हेतु किए गए अनुसंधान से ज्ञात हुआ कि एम.बी.हल + रोटावेटर से 92 प्रतिशत, बेहतर रोटावेटर से 79 प्रतिशत, एम.बी. हल से 72 प्रतिशत एवं वर्तमान रोटावेटर से 51 प्रतिशत बायोमॉस स्थापना क्षमता हासिल हो सकती है। यद्यपि सुधरे हुए रोटावेटर की तुलना में एम.बी. हल + रोटावेटर द्वारा बायोमॉस डालने से स्थापना क्षमता 13 प्रतिशत अधिक थी। सुधरे हुए रोटावेटर में कार्य की लागत प्रभावी हल + रोटावेटर की तुलना में 39 प्रतिशत कम थी।

सामाजिक अर्थिक अध्ययन

- जलग्रहण विकास कार्यक्रमों की सामाजिक स्वीकार्यता के मूल्यांकन से पता चला कि गरीबी उन्मूलन के लिए सरकार द्वारा निधिबद्ध कार्यक्रमों में किसानों ने खुशी से भाग लिया जोकि शहरी केंद्रों की ओर मजबूरी में प्रवास करने वालों को रोकने में सहायक सिद्ध हुए। जलग्रहण विकास कार्यक्रमों के अन्य पहलुओं जैसे मृदा एवं जल संरक्षण ढांचों का विकास एवं रखरखाव, फसलों के अवशेषों को मृदा की गुजवत्ता बढ़ाने हेतु डालना और सूखे की स्थिति में फसलों के लिए आकस्मिक योजना बनाना आदि में अधिक सफलता हासिल नहीं हो पाई।

- अंनतपुर एवं करीमनगर को छोडकर आंध्र प्रदेश के सभी जिलों में वर्ष 1995 से 2005 के बीच फसलों एवं वैकल्पिक कृषि अवयवों में अधिक विविधता देखी गई।

- कपास के अग्रिम पंक्ति प्रदर्शनों (FLD) के अर्थिक विश्लेषणों ने स्पष्ट किया कि किसानों की प्रक्रियाओं (21.3 क्विटल प्रति हेफ्टेयर) की तुलना में अग्रिम पंक्ति प्रदर्शनों (FLD) में बेहतर उत्पादन (31.5 क्विंटल प्रति हेक्टेयर) प्राप्त हुआ। इन सिफारिश की गई प्रक्रियाओं को अपनाने के कारण कृषि की लागत में थोडी सी वृद्धि, करीब 808 रूपस प्रति हेक्टेयर, हुई। सीमांत

वसूली दर (MRR) के 15.9 होने के कारण लागत दर में यह वृद्धि उचित पाई गई।

- रंगा रेड्डी जिले आठ मंडलों से लिए गए नमूनों में बी.एम.आई मूल्यों से पता चला कि करीब 22 प्रतिशत ग्रामीण महिलाएं कुपोषण की शिकार हैं।

- अरहर की फसल के लिए 'वर्षा आधारित कृषि सूचना प्रणाली ' (RAINS) नामक निर्णय सहायक सुचना प्रणाली का विकास किया गया और इसमें और सुधार किया गया। इसी प्रकार बागवानी, कृषि एवं सबद्ध विज्ञानों में सूचना प्रौद्योगिकी (ITIHAS) नामक वेब योग्य सेवा का विकास किया गया। इस सेवा के लिए सूचना के डिजिटल आंकड़े एकत्रित करनोपरंत वितरित किए गए तथा अब इसे सेवा का मूल्यांकन किया जा रहा है।

राष्ट्रीय कृषि नवोन्मषी परियोजना

- अवयन-3 के अंतर्गत राष्ट्रीय कृषि नवोन्मेषी परियोजना की उप परियोजना ''वर्षा अधारित क्षेत्रों में बेहतर कृषि प्रणालियों की उत्पादकता एवं बेहतर सहायक प्रणालियों द्वारा टिकाऊ ग्रामीण रोज़गार'' का आरंभ किया गया। आंध्र प्रदेश के आठ जिलों में बेहतर कृषि प्रणालियों द्वारा रोज़गार सुधार के लिए प्रभावी एवं सूचारू माध्यमों की पहचान के मुख्य उद्देश्यों से आचार्य एन.जी.रंग कृषि विश्वविद्यालय एवं गैर सरकारी संगठनों की भागीदारी से इस परियोजना का कार्यान्वयन किया जा रहा है।

प्रौद्योगिकी हस्तांतरण

- कृषि विज्ञान केंद्र ने खरीफ के दौरान 322 हेकटेयर क्षेत्र में प्रमुख तिलहनों, दलहनों अन्य फसलों जैसे कि सोयाबीन (100) अरहर (105) कपास (100), एवं मक्का (500) की फसलों पर 805 फ्रंक्रंटलाइन प्रदर्शनों का आयोजन किया।

- कृषि विज्ञान केंद्र द्वारा बेहतर कृषि प्रौद्योगिकियों के विभिन्न पहलुओं पर 58 आवश्यकता आधरित एवं कौशलोन्मुख प्रशिक्षण कार्यक्रमों का आयोजन किया गया जिसमें किसानों, कृषि महिलाओं, ग्रामीण युवाओं एवं क्षेत्रीय स्तर के विस्तार कर्मचारियों सहित 1945 सदस्यों ने भाग लिया।

शिक्षा

- संस्थान के वैज्ञानिकों के मार्गदर्शन में बारह स्नातकोत्तर विद्यार्थी अपना अनुसंधान कार्य कर रहे हैं। वर्तमान में पांच वैज्ञानिक पीएच.डी.हेतु अध्ययनरत है।

पुरस्कार एवं मान्यताएं

- डॉ. कौशल्या रामचंद्रन, राष्ट्रीय अध्येता को भारतीय कृषि अनुसंधान परिषद द्वारा वर्ष 2006 के लिए पंजाब राव देशमुख महिला कृषि वैज्ञानिक पुरस्कार प्रदान किया गया।

- डॉ. क्षीनाथ दीक्षित, प्रधान वैज्ञानिक (कृषि विस्तार) को आई.एस.ई.ई. युवा वैज्ञानिक पुरस्कार प्रदान किया गया।

- डॉ.के.नागश्री, वैज्ञानिक (वरिष्ठ वेतनमान) (कृषि प्रसार) को आई.आई.आई.टी., हैदराबाद द्वारा ग्रीष्म डॉक्टोरल अनुसंधान पुरस्कार के लिए चुना गया।

- संस्थान को हैदराबाद के श्रेष्ठ पुष्प रख-रखाव वाला संस्थागत रोज़री का प्रथम पुरस्कार प्रदान किया गया। दिसंबर 8-9, 2007 के दौरान हैदराबाद गुलाब सोसायटी द्वारा वार्षिक गुलाब प्रतियोगिताओं के विभिन्न वर्गों में संस्थान ने दो प्रथम, एक द्वितीय एवं तीन हतीय पुरस्कार जीते।

- डॉ.एम. महेश्वरी को 29 अप्रैल, 2007 को कृषि वैज्ञानिक के रूप में उनकी उपलब्धियों के लिए मद्रास तेलुगु अकादमी का समैक्य भारत गौरव पुरस्कार प्रदान किया गया।

- डॉ. कोशल्या रामचंद्रन, जिओमेटिक्स अनुप्रयोग अनुसंधान केंद्र, हैदराबाद की सलाहकार चुनी गई।

प्रकाशन

- विभिन्न पत्रिकाओं में संस्थान के वैज्ञानिकों के 53 लेख प्रकाशित हुए।

संगोष्ठियां, कार्यशलाएं, सम्मेलन, सेमिनार, प्रशिक्षण कार्यक्रम आदि

- इस अवधि में संस्थान में उन्नीत कार्यशालाएं, सेमिनार एवं प्रशिक्षण कार्यक्रम आयोजित किए गए।

संपर्क

- संस्थान राष्ट्रीय एवं अंतर्राष्ट्रीय संगठनों जैसे इक्रीसेट, आई.पी.ई., भा.कृ.अनु.प. के संस्थानों, विभिन्न सरकारी विभागों, राज्य कृषि विश्वविद्यालयों एवं गैर सरकारी संगठनों से सक्रिय सहयोग बनाए हुए है।

Executive Summary

Resource Characterization

- The weekly soil moisture index was calculated for all the 23 districts of Andhra Pradesh for 52 weeks (year 2007) using Thronthwaite & Mather water balance book keeping procedure and mapped using GIS. The information was provided to the Agromet center of the Acharya N G Ranga Agricultural University for further use in the preparation of weekly agro advisories to the farmers.

- The water requirement satisfaction index (WRSI) values have been computed for five agrometeorological field units in Andhra Pradesh (Anakapalli, Anantapur, Tirupathi, Rajendranagar and Jagtial) for different stages of crops viz., maize, groundnut, pigeonpea, sorghum, pearlmillet and cotton. The WRSI values were found to be more than 85 per cent for for all stages of maize and groundnut. These values never reached 90 per cent from pegging onwards for groundnut in Anantapur. At Rajendranagar, the WRSI was around 90 per cent during flowering to pod initiation for pigeonpea. It was above 95 per cent for cotton at Jagityal.

- The yield and yield attributes of soybean cultivar (PK-416) with different dates of sowing was simulated using "SOYGRO" model. Pods per plant, number of grains per pod and 100 seed weight decreased with subsequent delay in sowing from 7th June onward. Grain yield, straw yield and biological yield were highest in 7th June 2006 sowing as compared to 5th July 2006 sown. Phenology of the crop predicted by "SOYGRO" model was within the limit (<10%).

Climate Change Impacts

- Study of the impact of climate change scenarios on crop water requirement and crop duration at selected stations in Andhra Pradesh indicated that the overall water requirements of the major crops grown (maize, groundnut, pigeonpea, cotton) under rainfed conditions have shown an increasing trend. This is mainly attributed to the increase in average temperature by approximately 1 °C over the base year, 1990. The crop duration is expected to decrease by 1 to 2 weeks by 2020 in all the major crops of the state.

- During 1901-2003, the average annual air temperature was found to be increasing in a majority of locations across the country. The increasing trend in maximum temperature was not so widespread. However, the minimum temperature was found to be increasing in about 78 per cent of the locations studied.

- Elevated CO_2 levels improved the total biomass of castor and it was highest at 700ppm (22%) followed by 550ppm (11%) compared to ambient control. It also reduced the days to initiation of flowering (1-3 days) and days to 50% flowering (7&15 days) and improved the reproductive biomass at the maturity of first order spikes by 46% at 700 ppm and 35% at 550 ppm than ambient level. Improvement in effective spike length (12&15%), spike weight (46%), capsule number (65&98%), capsule weight (46&54%) and seed weight (155&167%) of primaries was observed with CO_2 enrichment at 550 and 700 ppm respectively.

- Pearlmillet seedlings grown at elevated CO_2 (550 ppm) had significantly higher NO_3^- uptake rates compared to ambient (365 ppm) grown seedlings. Induction potential for NO_3^- reduction by direct feeding of the excised plants with NO_3^- and energy source (0.2% sucrose) showed that plants grown under elevated CO_2 had higher potential for enzyme induction. Inclusion of NO_3^- upto 15 mM increased

the inducible activity, beyond which it decreased at both ambient and elevated CO_2 conditions.

- Impact of elevated CO_2 on insect plant interactions indicated that larvae of *S. litura* consumed more foliage from the plants raised under elevated CO_2 than ambient CO_2 conditions. The total consumption of castor foliage during entire feeding period was significantly more when grown under elevated CO_2 conditions than ambient. The larval weights were higher with the former. The developmental period for larvae fed with castor foliage grown under elevated CO_2 conditions was longer (18 days) compared to larvae fed with foliage raised under ambient CO_2.

- Feeding trials to study the effects of elevated CO_2 on growth of *Helicoverpa armigera* fed on Bt (Cry 1 A(c)) and Non Bt cotton indicated that larvae of *H. armigera* consumed more of elevated CO_2 foliage of both Bt and non-Bt plants compared to ambient CO_2 foliage. In both the conditions, larvae consumed more Non-Bt cotton foliage than the Bt-cotton foliage.

Rainwater Management

- Using water balance model, rainfall deficits and harvestable water quantities were estimated for dominant rainfed districts in the country. It was estimated that about 114 billion cubic meters (BCM) of runoff could be generated from 28 M. ha of rainfed area.

- A total rainfall of 817 mm was received in the Kurmapalli watershed area of Andhra Pradesh of which 66% was received in August and September. About 6.7% of rainfall was received as runoff (surface and sub surface) in the watershed area. Higher quantity of deep percolation compared to runoff is attributed to the soil type.

Enhancing the Drought Tolerance through Transgenic Approach

- Molecular and physiological characterization of the transgenic sorghum and advancement of generation was carried out. Genomic DNA of T_3 and T_4 transgenics and untransformed plants was PCR amplified using *mtlD* gene specific primers. The root and shoot lengths were higher in transgenics when compared to the untransformed controls when challenged with 200mM NaCl stress. Interestingly, the *mtlD* transgenics also recorded significantly higher stress recovery in both root and shoot lengths (on average 2.8 and 1.7 folds).

- In the continuing efforts for genetic transformation of green gram for enhancing abiotic stress tolerance, transformation conditions have been optimized for *Agrobacterium* mediated approach.

Varietal Development

- Evaluation of horsegram mutants reached an advanced stage. In IVT, entry HG-24 recorded highest grain yield of 781.24 kg/ha followed by HG-28 with 733.62 kg/ha. These entries matured in 89 and 88 days respectively.

Drought Management

- Studies on root development in greengram as affected by moisture availability showed maximum rooting in plants water stressed at vegetative stage, though the rooting depth of non-stressed plants has also increased but to lesser extent. Further root shoot ratio was high with the stressed greengram plants at vegetative stage over the greengram plants not subjected to moisture stress.

- Drought management studies in castor showed that pod yields with and without FYM (1876 and 1577 kg/ha) were highest under the treatment of application of 25% N through gliricidia and 75% N through inorganic fertilizers. Next best treatment was making conservation furrows between castor rows (1786 and 1526 kg/ha) and application of additional dose of 10 kg N/ha through top dressing along with normal dose of fertilizers (1689 and 1369 kg/ha).

Organic Production

- Studies on organic production of sesame showed highest seed yields with inorganic practices (416 kg/ha) followed by organic practices and control during third year of experimentation. The number of pods, stick yield were also highest under inorganic system. However, the oil content did not differ significantly across the treatments.

- Grain yield of pigeonpea was highest with the high input organic package (1524 kg/ha) followed by high chemical input package (1471 kg/ha). This was the third year of experimentation.

Integrated Pest Management

- Low External input IPM I and II, consisting of botanical extracts and oils, performed well and were comparable with integrated treatment although the exclusive chemical treatment recorded marginally low level of pest incidence in pigeonpea.

- The spectral bands at 810, 870, 950 and 1100 nm were found to be sensitive to the stress caused by the root borer in Jatropha. This information could be utilized for identifying the pest problems using remote sensing.

- Maximum degrees days were required for larval stage (205.5) followed by pupal (127.8), adult (76.6) and egg stage (58.8) of *A. janata* at temperatures ranging from 18-36^0 C. This information could be useful for building weather based developmental models for forecasting.

- Sixteen isolates of Bt produced more crystal protein than the standard. The Uda isolates which possessed broad spectrum activity against key pests (semilooper, *Helicoverpa* and *Spodoptera*) turned out to be high crystal protein producers.

Model Farming System

- Studies of the farming system modules on micro watershed basis showed that the combination of arable crops, agro-forestry, vegetables, bushes and grasses in 1.12 ha recorded a net income of Rs. 10,433/- with BC ratio of 1.72.

Tillage and Nutrient Management

- Conventional tillage maintained 15 and 35 per cent higher yields of sorghum and green gram over reduced tillage respectively. In case of sorghum , 2 t gliricidia loppings + 20 kg N through urea (T4) recorded the highest per cent increase (107 %) in yield over control. While in case of green gram, both T4 (1 t gliricidia loppings + 10 kg N through urea) and T5 (2t compost + 1t gliricidia loppings) were at par in increasing the green gram yields by 40 per cent over farmers' practice.

- In niger, application of recommended doses of nutrients through organic and inorganic sources resulted in higher dry matter accumulation, LAI, seeds/plant, seed and oil yield (kg/ha), gross returns, net returns and BC ratio.

- At Indore, build up of organic carbon in INM treatment in surface layers (0-20cm) increased when compared to control. Particulate organic carbon (%) increased significantly with the application of FYM. It decreased with increasing depths. Microbial biomass carbon (mg/g) content was improved significantly in all the treatments. This increment was more with the use of crop residue.

Soil Quality Assessment

- In soybean (JS 335) – safflower cropping system, application of soybean residue @ 5 t ha^{-1} + N20 P13 recorded the highest Relative Soil Quality Index (RSQI) of 0.97 followed by FYM 6 t ha^{-1} + N20 P13 (RSQI 0.87).

- A field kit for estimating labile carbon was developed using the principle that neutral dilute solutions of potassium permanganate ($KMnO_4$) and other chemicals react with most of the active organic matter and change the colour of $KMnO_4$ from deep purple colour to light pink or colourless. The

procedure was found suitable for samples analyzed immediately (within 1-2 days) after collection from the field.

- Application of FYM @ 5 t ha^{-1} gave the highest RSQI in sorghum + pigeon pea system (0.92) and soybean + pigeonpea system (0.98). While under cotton + black gram system and green gram – rabi sorghum systems, the integrated use of 25% RDF + gliricidia @ 1.5 t ha^{-1} and 25% RDF + FYM@ 2.5 t ha^{-1} gave RSQI as high as 0.98 and 0.95 respectively and proved superior.

Agroforestry

- Setaria intercrop with *A senegal* being at par with sole setaria yielded significantly higher grain than when the crop was intercropped with amla and tamarind. The harvest index was significantly higher in the intercrops with trees than sole crop.

- Guinea grass (var. makuni and riversdale) produced significantly higher biomass yields over other grasses during the second year of tree growth of leucaena. Intercropping leucaena with perennial grasses significantly influenced tree growth. Tree height and diameter at breast height were significantly reduced due to perennial grasses.

Medicinal, Aromatic and Dye Plants

- In indigo, the biomass yield was highest with FYM and vermicompost application, while castor cake and inorganic fertilizers gave lowest yields. Vermicompost application registered 24, 104, 145 % higher dye yield over FYM, castor cake and inorganic fertilizer, respectively. Application of vermicompost and phosphorus increased the indigotin content.

- The leaf yields of senna were higher in paired row+ cover crop and cover crop treatments. In andrographis, horse gram as cover crop increased biomass yield and dry matter production. The root yields of ashwagandha were higher with paired row crop + cover crop treatments. Bio nectar (mixture of desi cow dung, urine, black jaggery, pulse flour (chick pea/black gram/green gram) and grass application treatments were also effective in increasing yields. Higher andrographolide content was observed with drought management practices viz., life saving irrigation and paired row crop + cover crop.

- The lemongrass and palmarosa biomass yields and oil were highest in inorganic fertilizer, vermicompost and castor cake applications. Control treatment recorded lowest biomass and oil yields. Highest citral A content in lemongrass and geranial in palmarosa were recorded in vermicompost and castor cake application while the lowest was recorded in inorganic fertilizer.

Biofuel Crops

- Pruning schedule for jatropha was standardized for maximizing yields. The schedule included cutting the plants leaving 45 cm height from the ground level in first year, half of each branch in second year and light thinning from third year onwards. The seed yield of jatropha was more in 4x2m spacing in combination with 60% pruning in farmers' fields of Nalgonda district.

- Studies on farmers' fields in Mahabunbnagar district revealed that closer spacing of 5 m x 4 m caused significantly lower height of of pongamia than 6 mx4 m spacing, while height to the first branch from the ground was markedly higher in the widest spacing (6 m x 6 m) over closer spacing. *In-situ* grafting was attempted with elite clone of pongamia having more than 38% oil content.

Livestock Management

- A livestock survey conducted in Tallapalii village showed low energy (deficit ranged from 21-38% of the maintenance requirement) and protein (deficit ranged from 43-68% of the maintenance requirement) intake in most of the dairy animals. Low blood plasma urea nitrogen and glucose and higher ketone bodies were observed, reflecting malnutrition

with respect to energy and protein in dairy animals.

- Studies on management of sheep indicated that the *Stylo* and *Gliricidia* leaf meal could be used as alternative to the concentrate mixture to feed the growing Deccani lambs along with the roughage based diet (chopped sorghum stover) under intensive system of management for higher live weight gain.

- Modifications in screw designs in oil expellers increased oil recovery from jatropha and pongamia. Similarly, pretreatment of seed increased oil yield and oil quality considerably.

Energy Management

- The highest grain yield in sorghum (3210 kg/ha) and pigeonpea (761 kg/ha) were recorded under ridge and furrow system made using tractor-drawn equipment followed by bed and furrow at 0.9 m and 1.35 m spacing.

- The biomass incorporation efficiency was found to be 92% with MB plough+ rotavator, 79% with improved rotavator, 72% with MB plough and 51% with existing rotavator. Though incorporation efficiency of MB plough + rotavator was 13% higher than improved rotavator the overall reduction in cost of operation with improved rotavator was 39% of operational cost for MB plough+ rotavator.

Socioeconomic Studies

- Evaluation of social acceptability of watershed development programmes indicated that while farmers readily participated in the government funded programs for poverty reduction which helped to check forced migration to urban centres, other aspects of WDP like developing and maintaining S&WC structures, recycling crop residue, or adopting crop contingency plan in the event of drought, etc., have not been very successful.

- Diversification was found to increase between 1995 and 2005 in all the districts of Andhra Pradesh except in Anantapur and Karimnagar.

- An economic analysis of frontline demonstrations (FLDs) in cotton showed that higher yield (31.5 q/ha) was realized in FLDs compared to farmers' practice (21.3q/ha). Though there was a small increase in the cost of cultivation by about Rs. 808/ha because of adoption of the practices recommended, the increase in cost was justified as evident from a marginal rate of return of 15.9.

- About 22 per cent of rural women in a sample drawn from eight mandals of Rangareddy district were found to be suffering from malnutrition as indicated by BMI values.

- Rainfed Agricultural Information System (RAINS), a decision support information system on pigeonpea was developed and being further improved. Similarly, a web-enabled service namely Information Technology in Horticutural, Agricultural & Allied Sciences (ITIHAAS), with digital content collected and delivered was developed and being evaluated.

NAIP

- The NAIP-subproject "Sustainable Rural Livelihoods Through Enhanced Farming Systems Productivity and Efficient Support Systems in Rainfed Areas" under Component-3 was launched. The project is being implemented in eight districts of Andhra Pradesh in partnership with ANGRAU, ICRISAT and NGOs with the main objective of identifying upscaleable means for livelihood improvement through better farming systems.

Transfer of Technology

- The Krishi Vigyan Kendra (KVK) conducted 805 FLDs during *kharif* in an area of 322 ha covering important oilseeds, pulses and other crops such as soybean (100), pigeonpea (105), cotton (100) and maize (500).

- The KVK organized 58 need based and skill oriented training programmes on various aspects of

improved farm technologies which were attended by 1945 clients including farmers, farmwomen, rural youth and field level extension functionaries.

Education

- Twelve post-graduate students are pursuing their research work under the guidance of CRIDA scientists. Five scientists are currently pursuing their doctoral degree.

Awards and Recognition

- Dr. Kausalya Ramachandran, National Fellow was awarded the Punjabrao Deshmukh Women Agricultural Scientist Award 2006 by ICAR.
- Dr. Sreenath Dixit Sr. Scientist (Ag.Extn.) was presented with the ISEE Young Scientist Award.
- Dr. K. Nagasree, Scientist (SS), (Agril.Extn.) was selected for Summer Post doctoral Research Award by IIIT, Hyderabad.
- CRIDA was awarded First prize for the Best Maintained Institutional Rosary of Hyderabad. CRIDA won two first prizes, one second prize and three third prizes in different categories of Annual Rose Competition organized by Hyderabad Rose Society during December 8-9, 2007.
- Dr M. Maheswari was awarded with Samaikya Bharat Gaurav Satkar of Madras Telugu Academy for achievements as agricultural scientist
- Dr Kausalya Ramachandran was elected Advisor to Centre for Applied Research in Geomatics (CARG), Hyderabad.

Publications

- Fifty one research papers were published in peer reviewed journals.

Symposia, Workshops, Conferences and Seminars, Training Programmes etc

- CRIDA conducted nineteen workshops, seminars, training programmes etc.

Linkages

- The Institute maintained close functional collaboration with national and international research organizations like ICRISAT, IPE, ICAR institutes and several government departments, SAUS and NGOs.

1 Introduction

Rainfed agriculture assumes high importance from the perspective of growth, equity and sustainability. Agricultural growth in India has so far been lopsided in favour of irrigated agriculture leading to wide disparities between the living standards of irrigated and rainfed farmers. Further growth has to necessarily originate in rainfed agriculture if we are to sustain the growth that is needed for our growing population as well as to reduce the disparities among different groups of farmers with differential resource endowments. Broadening the base of growth is also helpful to make the agricultural production more resilient to different climatic and biotic risks that are highly localized in nature. Further, growth in rainfed agricultural productivity is also important considering the large number of farmers for whom rainfed agriculture is a source of livelihood.

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 evolution

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

The mandate of CRIDA is:

- 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 base models for adoption
- 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.

1.4 Current thrust areas

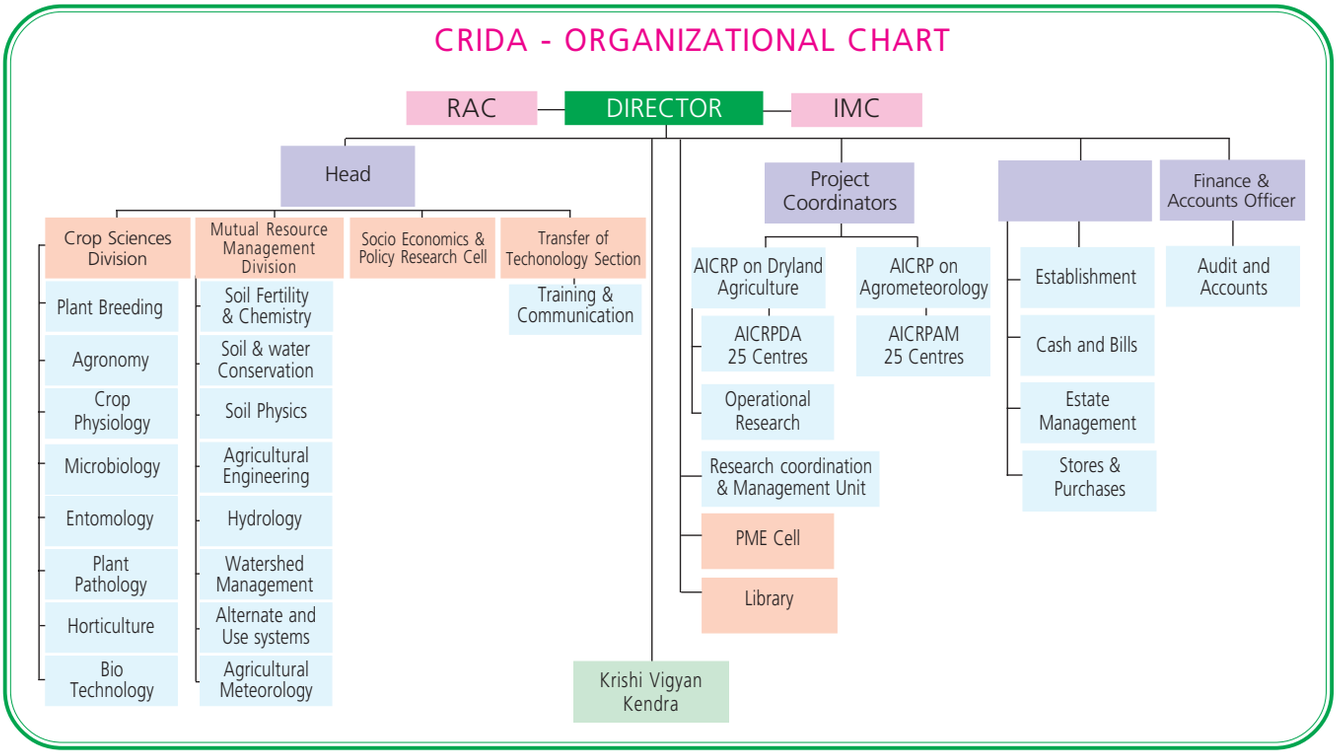
Along with the key programme areas mentioned above, the Institute also giving due importance to understand the nature of climate change and its potential impacts on the behaviour of rainfed crops, insect pests and microbes. Efforts are also on to identify the potential options such as carbon sequestration for mitigating the climate change. Another thrust area is how the livelihoods of the rainfed farmers can be improved through technological and institutional interventions. Drought mitigation continues to engage the resources of the Institute and efforts are apace to evolve transgenic crop varieties that are tolerant to drought.

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.

1.5 Organizational setup

The organizational setup of CRIDA is given below:



1.6. 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
- Probabilities of occurrence of drought in different regions in India.
- 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
- Developed a methodology for assessment of soil quality.
- 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

1.7 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 sapflow 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, neutron 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 instruction 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.

Bio-resource centre: A bio-resource centre to produce and make available biological pesticides and fertilizers was set up at HRF.

Farmers' service laboratory: A research and farmer's service laboratory was set up to cater to the analytical needs of experiments at HRF as well as of the farmers.

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 7952 books and 4156 back volumes of periodicals as on March 2008. It subscribes to about 131 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 Science Director for more periodical literature to the institute scientistsfull 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. Advanced facilities for processing of research material and data analysis are also available.

A total of 33 residential quarters (Type-A 12; Type-B 8; Type-C 4; Type-D 6; and Type-E3) are also located at the headquarters.

1.8 Financial outlay for 2007 - 08 (as on 31.03.2008)

(rupees in lakhs)

	CRIDA		AICRPDA		AICRPAM		Climate change	
	Sanctioned	Utilized	Sanctioned	Utilized	Sanctioned	Utilized	Sanctioned	Utilized
Non-Plan	890.00	879.02	13.00	12.84	26.00	24.87	-	-
Plan	180.00	178.73	960.00	605.40	260.00	154.64	210.00	170.38
Total	1070.00	1057.75	973.00	618.24	286.00	179.51	210.00	170.38

1.9 Staff position

As on 31 March, 2008

Staff	Positions	
	Sanctioned	Filled
Scientific	68	53
Technical	82	78
Administrative	49	46
Supporting	67	54
TOTAL	266	231

2 Research Achievements

2.1 Resource characterization

2.1.1 Weather conditions at Hayathnagar Research Farm

The southwest monsoon set in on June 13, 2007 over Hyderabad. The rainfall received at Hayathnagar Research Farm (HRF) was 719 mm as against long term (1971-2006) average of 737.5 mm.

Sowings of most of the crops commenced during 23 SMW week due to good pre-monsoon rainfall received and were completed during 24-26 week. July rainfall (24.2 mm) was highly deficient (-82.2%). Consequently the crops experienced early season moisture stress conditions. But the rainfall of 212.3 mm and 174.6 mm received during August and September were 43.7 and 31.2% excess over the long-term average and also well distributed. Therefore, crops like sorghum performed quite satisfactorily. Northeast / post monsoon (October-December) rainfall of 38.8 mm was highly deficient. This resulted in moderate / severe soil moisture stress for long duration crops like pigeonpea and castor more so in shallow/medium deep soils.

The southwest monsoon withdrew about one week in advance. The weekly weather data are given in Table 1. The actual and long term average rainfall and number of rainy days in 2007 are presented in Table 2, Fig.1 and Fig.2.

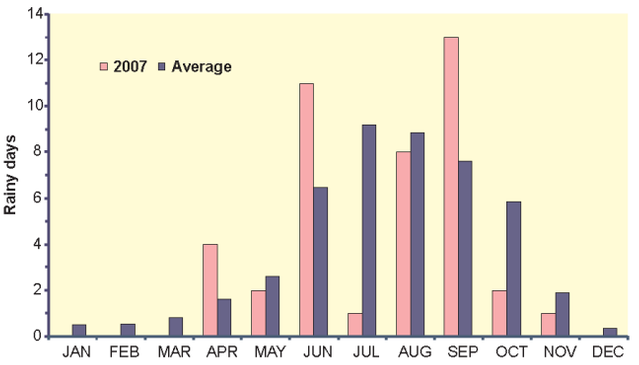


Fig. 1. Actual (2007) and average (1971-2006) number of rainy days at HRF, Hyderabad

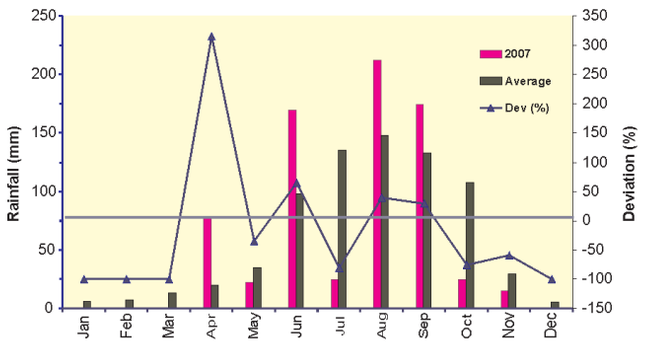


Fig. 2 Monthly actual (2007) and average (1971- 2006) rainfall along with deviation (%) at HRF

Table 1 Weekly meteorological parameters recorded at HRF during 2007

Standard meteorol-ogical week	Rainfall (mm)	Soil Temperature (°C) at 10 cm		Air Temperature (°C)		Relative Humidity (%)		Sun-Shine (h)	Wind Speed (km h^{-1})	Pan evaporation (mm)
		0716 h	1416 h	Max.	Min.	0716 h	1416 h			
1	0	20.5	29.1	28.2	11.6	87	34	8.3	3.0	4.0
2	0	20.6	29.2	27.4	12.3	91	38	8.9	3.8	4.0
3	0	21.6	30.6	30.0	13.1	87	32	8.8	3.3	4.3
4	0	22.8	31.2	30.3	14.6	93	34	8.4	3.5	4.6
5	0	23.0	32.0	31.0	14.4	80	26	8.5	5.1	5.5
6	0	23.6	32.6	32.1	15.5	90	25	8.0	5.0	5.5
7	0	23.8	32.8	30.4	15.6	78	30	7.6	4.3	5.1
8	0	23.3	33.3	30.4	14.2	74	26	9.4	6.2	6.7
9	0	24.9	35.0	33.6	15.9	67	22	9.4	5.2	7.4
10	0	27.3	36.7	34.1	19.0	84	29	7.3	6.7	7.3
11	0	26.9	37.1	34.0	17.6	71	29	9.3	6.3	7.9

Standard meteorol-ogical week	Rainfall (mm)	Soil Temperature (°C) at 10 Cm		Air Temperature (°C)		Relative Humidity (%)		Sun-Shine (h)	Wind Speed (km h^{-1})	Pan evaporation (mm)
		0716 h	1416 h	Max.	Min.	0716 h	1416 h			
12	0	28.6	37.8	37.0	21.2	78	27	5.9	4.2	7.0
13	0	28.6	38.8	37.0	19.6	65	22	8.7	4.9	8.0
14	0	29.4	40.1	38.2	19.9	81	26	8.8	6.0	8.3
15	4.5	29.4	40.1	37.2	21.3	88	33	3.3	6.6	7.5
16	72.8	26.2	35.9	33.8	20.7	78	45	7.9	4.8	6.7
17	0	30.1	42.0	38.8	22.1	59	36	9.5	4.5	7.6
18	0.8	32.5	41.3	37.5	24.5	82	30	7.7	5.2	7.9
19	0	33.4	42.0	40.3	26.9	63	35	9.0	7.5	11.4
20	0	33.8	42.6	40.2	27.4	58	37	9.5	7.3	12.4
21	5.9	32.1	41.3	38.8	25.9	70	48	8.4	8.0	9.7
22	18.9	30.6	39.1	37.3	24.3	71	38	5.9	6.2	7.9
23	56.0	27.9	35.2	35.2	21.0	74	52	4.0	7.1	7.8
24	22.8	29.0	34.4	33.6	23.0	77	52	4.5	5.4	5.3
25	50.4	28.3	31.3	31.2	22.3	83	51	0.7	9.3	5.4
26	37.0	25.0	27.7	28.7	21.6	70	54	1.1	10.8	3.7
27	1.0	27.0	35.1	32.1	22.9	84	55	6.6	14.7	6.8
28	22.5	27.8	33.6	32.3	22.4	83	63	3.8	11.0	6.0
29	0.7	27.8	35.5	31.8	23.0	84	66	4.3	6.6	5.0
30	0	29.4	36.5	32.5	22.0	85	60	5.4	5.5	4.3
31	93.4	27.3	32.4	31.0	21.6	76	57	3.0	7.0	5.7
32	26.1	25.5	31.0	30.4	21.7	80	59	4.7	11.3	4.8
33	1.8	26.4	33.0	30.8	21.7	76	55	5.1	6.7	4.6
34	78.0	27.3	33.7	31.2	21.5	81	48	5.6	4.9	5.6
35	22.2	25.7	30.7	29.8	21.3	85	70	2.6	5.3	3.5
36	15.2	25.8	31.1	29.5	21.4	86	74	3.4	7.5	4.1
37	17.6	26.3	33.3	31.6	20.8	87	66	4.9	3.8	4.1
38	102.2	24.8	29.1	28.9	20.8	85	53	0	4.5	4.8
39	30.4	25.2	31.8	30.3	20.7	76	55	3.7	7.1	4.6
40	15.0	24.9	31.2	29.6	19.6	85	51	2.9	3.5	4.3
41	0	24.6	34.8	31.4	17.5	70	43	9.8	3.2	5.0
42	0	25.8	33.6	30.7	17.5	79	49	7.5	2.6	4.1
43	0.8	26.8	33.3	29.8	17.0	84	54	6.8	3.3	3.7
44	23.0	24.4	31.1	29.0	18.2	90	63	4.4	3.2	3.7
45	0	23.8	31.4	30.6	15.8	83	45	9.2	2.6	4.1
46	0	21.4	30.9	29.6	11.9	75	35	9.8	3.7	4.8
47	0	20.7	29.4	28.3	10.9	69	33	9.5	3.4	4.6
48	0	21.0	30.0	29.0	11.7	80	41	8.0	2.7	3.9
49	0	21.3	28.7	27.6	12.4	84	48	6.8	2.8	3.3
50	0	21.7	29.3	28.5	13.1	88	49	7.1	3.1	3.3
51	0	22.4	30.0	29.7	14.2	77	49	7.6	4.1	4.4
52	0	22.0	28.9	31.9	13.3	79	50	9.3	2.4	4.7

Table 2. Rainfall (mm) pattern during 2007 in comparison with normal

Parameter/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
RF in 2007	0	0	0	77.3	22.5	169.3	24.2	212.3	174.6	24.0	14.8	0	719.0
Average (1971-06)	5.8	6.9	13.7	20.0	34.6	97.7	135.6	147.7	133.1	107.5	29.6	5.3	737.5
% Deviation	-100	-100	-100	76	27	48	-6	9	13	1	-2	-3	-3.1
RD in 2007	0	0	0	4	2	11	1	8	13	2	1	0	42
Average RD	0.5	0.5	0.8	1.6	2.6	6.5	9.2	8.8	7.6	5.9	1.9	0.3	46.3

RF – Rainfall RD – Rainy days

2.1.2 Impact, adaptation and vulnerability of Indian agriculture to climate change

2.1.2.1 Temperature trends over India

Temperature is one of the most important weather parameters that influence plant growth, development and yield. Wheat yields were reduced in Indo-Gangetic plains due to increase in temperatures in March 2004. Increased temperatures in Himachal Pradesh resulted in decrease in apple production and shifting of apple belts to further higher elevations. The increase in average temperatures affects the GDD of the crops, which influence the length of crop growing period / reduce the duration of the crops. To find out the significant changes/trends, long-term temperature data of 47 stations across India (Northern region – 9 stations; Eastern India – 5 stations; Western India – 8 stations; South India – 12 stations and Central India – 13 stations) was collected, checked for quality and analyzed using non-parametric Mann Kendall test (Tables 3-5). The trends in mean temperatures at Hyderabad, Indore and Kolkata are presented in figures 3-5.

It was observed that the average annual temperature is increasing in 28 stations and decreasing in 2 stations with high significance. Significant increasing trend was noticed in 4 stations and decreasing trend in 4 stations. There was no trend observed in remaining 9 stations. The average annual maximum temperature has shown increase in 22 stations and decrease in 3 stations with high significance. No trend was observed in 15 stations. In the remaining 7 stations 4 showed increasing trend and 3 showed decreasing trend. In the case of average annual minimum temperature, 27 stations showed increasing trend and 3 stations showed decreasing trend with high significance where as 7 stations showed increasing trend and 4 stations showed decreasing trend. No trend was seen in 6 stations. Overall 55 to 80% of out of 47 stations located in North, East, South, West and

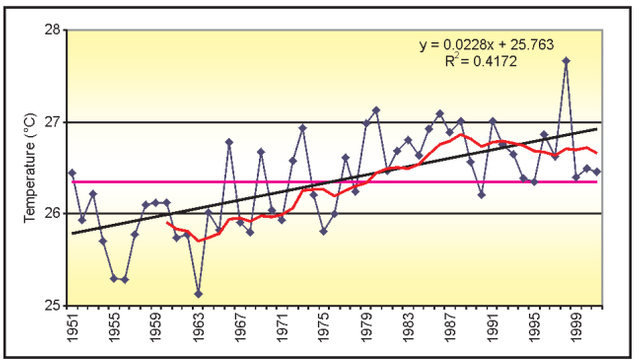


Fig 3. Mean annual temperature trend at Hyderabad, 1951-2001

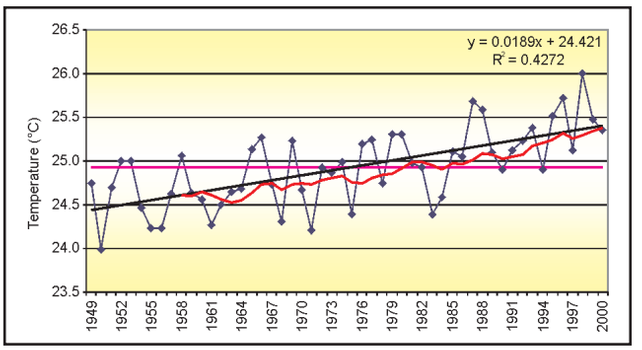


Fig 4. Mean annual temperature trend at Indore, 1949-2000

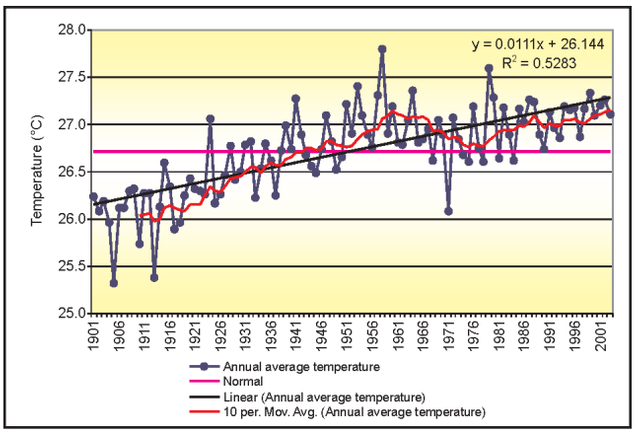


Fig 5. Mean annual temperature trend at Kolkata, 1901-2003

Table 3. Trends in maximum temperature (°C) in different regions of India

Region	No. of stations	Maximum temperature		
		Increasing trend (% of the stations)	Decreasing trend (% of the stations)	No trend (% of the stations)
North India	9	33	22	44
East India	5	60	20	20
West India	8	50	13	37
South India	12	75	17	8
Central India	13	54	8	38

Table 4. Trends in minimum temperature (°C) in different regions of India

Region	No. of stations	Minimum temperature		
		Increasing trend (% of the stations)	Decreasing trend (% of the stations)	No trend (% of the stations)
North India	9	78	11	11
East India	5	80	20	-
West India	8	63	25	13
South India	12	75	8	16
Central India	13	69	8	23

Table 5. Trends in average temperature (°C) in different regions of India

Region	No. of stations	Average temperature		
		Increasing trend (% of the stations)	Decreasing trend (% of the stations)	No trend (% of the stations)
North India	9	56	22	22
East India	5	80	-	20
West India	8	63	13	26
South India	12	75	8	16
Central India	13	69	15	15

Central parts of India considered for this study showed an increasing trend in average annual temperature. In the case of maximum temperature, only 33 percent of stations in north India showed an increasing trend and 78 per cent of stations showed decreasing trend in minimum temperature.

2.1.2.2 Climate change impacts

Study of the impact of climate change scenarios on crop water requirement, crop duration at selected stations in Andhra Pradesh was carried out. Results presented in tables 6 and 7 indicate that the overall water requirement of the major crops grown under rainfed conditions in Andhra Pradesh showed an increasing trend.

This is mainly attributed to the increase in average temperature by approximately 1°C over the base year. There is no significant decrease in crop duration due to fulfilling the required growing degree-days at an early date. The crop duration is expected to decrease by 1 to 2 weeks by 2020 in all the major crops of the state.

2.1.2.3 Impact of elevated CO_2 on rainfed crops

The response of castor bean (*Ricinus communis* L.) to increased levels of carbon dioxide, in terms of

Table.6. Projected crop water requirements of major rainfed crops in Andhra Pradesh by 2020

Station	Agro-climatic zone	Crop	Increase in water requirements (mm) by 2020
Anakapalli	North Coastal Zone	Maize Groundnut	51.7 61.3
Anantapur	Scarce Rainfall Zone	Ground nut Red gram	70.1 174.3
Jagtiyal	North Telangana Zone	Cotton Maize	60.5 49.0
Rajendranagar	South Telangana Zone	Red gram Ground nut	114.5 73.0
Tirupathi	Southern Zone	Ground nut	73.0

Table.7. Projected changes in crop duration by 2020

Station	Agro-climatic zone	Crop	Reduction in crop duration (weeks) by 2020
Anakapalli	North Coastal Zone	Maize Groundnut	1 1
Anantapur	Scarce Rainfall Zone	Ground nut Red gram	1 1
Jagtiyal	North Telangana Zone	Cotton Maize	2 1
Rajendranagar	South Telangana Zone	Red gram Ground nut	2 1
Tirupathi	Southern Zone	Ground nut	1

growth, yield and oil quality was investigated. Castor bean cv DCS-9 was raised in open top chambers (OTCs). The seeds were sown directly in the soil to study the effect of different levels of CO_2 (700, 550 and 365 ppm) on growth and yield of castor. There were two open top chambers (replications) for each level of CO_2. The chambers without any external CO_2 supply served as chamber control (Ch-control). The crop, raised purely as rainfed, received 573 mm rainfall in 25 rainy days with good distribution and the crop never experienced any visible moisture stress during the crop growth period. The crop was maintained up to maturation of primary spikes (105 DAS).

The crop showed significant response to elevated CO_2 levels (700 & 550 ppm) in terms of increased growth, biomass (Fig. 6) and seed yield when compared with ambient level chamber control (Ch-control). All the growth characteristics showed highest response under elevated CO_2 of 700 ppm followed by 550 ppm and Ch-control. Leaf area, leaf weight, leaf area duration and specific leaf area increased during the crop growth period at elevated CO_2 levels than at ambient level. However, decreased specific leaf weight resulted from thinner leaves with increased levels of CO_2. Root length, volume and dry weight were significantly increased under 700 ppm followed by 550 ppm over Ch-control. Root shoot ratio (Fig 7) was high under elevated CO_2 for both CO_2 levels showing that response of root biomass was more than the shoot with enhanced CO_2.

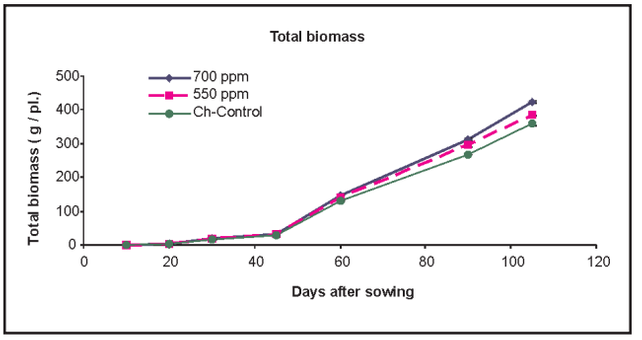


Fig 6. Impact of elevated CO_2 on the total biomass of castor at different growth stages

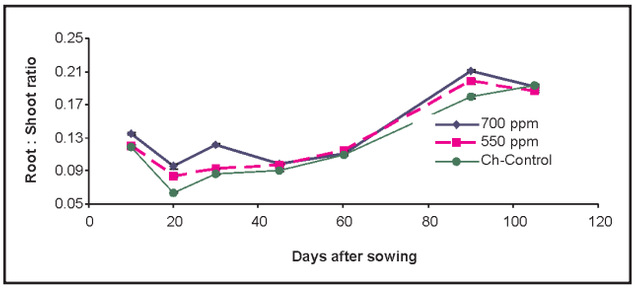


Fig 7. Impact of elevated CO_2 on the root:shoot ratio of castor at different growth stages

The yield parameters *viz.,* spike length, spike dry weight, number of capsules, capsule dry weight, seed weight and 100 seed weight were recorded for the first order spike for each treatment (Table 8). Elevated CO_2 levels improved the total biomass and it was highest at 700 ppm (22%) followed by 550 ppm (11%) and ambient control. It also reduced the days to initiation of flowering (1-3 days) and days to 50% flowering (7&15 days) and improved the reproductive biomass at the maturity of first order spikes by 46% at 700 ppm and 35% at 550 ppm than ambient level. The improvement in effective spike length (12&15%), spike weight (46%), capsule number (65&98%), capsule weight (46&54%) and seed weight (155&167%) of primaries was observed with CO_2 enrichment at 550 and 700 ppm respectively. A critical observation of yield components *viz.,* total spike length vs effective spike length revealed a higher female to male flower ratio at higher level of CO_2. Higher seed yield was recorded at 700 ppm due to better 100 seed weight even though the number of capsules recorded was less than 550 ppm level.

No significant change in oil content and quality was observed with increased CO_2 levels (Fig 8). The ambient level recorded slightly higher values for percentage of oil (44.2%) followed by 550 ppm (44.1%) and 700 ppm (43.8%). The variation in individual fatty acid composition (Fig 9) was marginal and at 700 ppm, CO_2 decreased the ricinoleic acid content by 1.5% as compared to chamber control. The fraction of palmitic and stearic acid contents were found to be slightly higher under 700 ppm and 550 ppm, whereas oleic and linolenic acid contents were high at 700 ppm compared to chamber control.

Table 8. Yield parameters (per plant) of castor bean at maturity of first order spikes under ambient and elevated CO_2 levels

Parameters	Treatments		
	700 ppm	550 ppm	Chamber Control
Spike length (cm)	26.0	27.21	23.8
Effective spike length (cm)	24.4	23.7	21.2
No. of capsules	31.2	37.4	18.9
Spike dry weight (g)	35.7	35.6	24.4
Capsule dry weight (g)	26.8	25.4	17.4
Seed weight (g)	17.9	17.1	6.7
100 Seed weight (g)	23.5	23.3	22.0

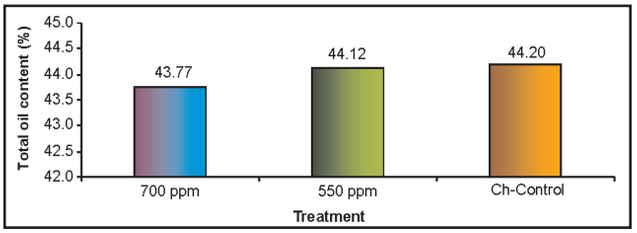


Fig 8.. Impact of elevated CO_2 on the total oil content of castor

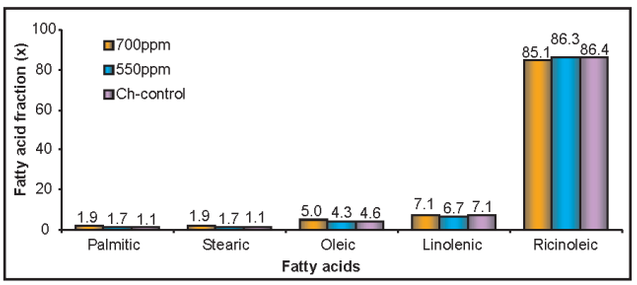


Fig 9. Impact of elevated CO_2 on the fatty acid composition in castor

The results obtained from the present study showed an increase in dry matter production as well as economic yield at both increased levels of CO_2 i.e., 550 and 700 ppm. The increment in CO_2 from 550 to 700 ppm also improved the seed yield by 17.3% whereas the harvest index decreased. This clearly shows that the increased CO_2 levels above 550 ppm improves biomass in castor more than economic yield. The studies in the present investigation were restricted only up to the maturity of the first order spikes as the canopy was too large to accommodate in OTCs. The contribution of first order spike yield to total bean yield in castor ranges from 40 to 60%. The yield increment can be expected to be much higher in this indeterminate crop with CO_2 enrichment than what was observed in the present investigation.

2.1.2.4 Effect of elevated CO_2 on nitrate uptake and assimilation in rainfed crops

Nitrogen assimilation by plants requires carbon skeletons derived from photosynthesized carbohydrates. Photosynthesis and leaf N assimilation are mutually dependent processes. Since elevated CO_2 increases photosynthesis and biomass production, it also affects

the nitrogen metabolism. To explore this, nitrate uptake and assimilation studies were taken up in pearl millet at ambient (365 ppm) and elevated CO_2 (550 ppm) levels. Pearl millet (*Pennisetum americanum*) variety ICTP 8203 was sown in plastic pots containing acid washed sand. These pots were placed in open top chambers (OTC) maintained at 550 ppm and ambient CO_2 conditions. The seedlings were irrigated with full strength Hoagland solution without nitrate for nitrate uptake studies and with different concentrations of nitrate (KNO_3) for 15 days for growth and dry matter studies. Seedlings grown with 5 mM NO_3^- were used for induction potential for Nitrate Reductase (NR) activity. Shoots of 10 day old plants were cut 1 cm above the root-shoot junction under water and placed in 10 ml incubation medium of 0.25 Hoagland solution with 0,5,15,30 and 100 mM NO_3^-. The effect of inclusion of carbohydrate (0.2% sucrose) on induction potential was also determined. Incubation was carried out in light for 24 hours after which *in vivo* NR activity was assayed.

Nitrate uptake was determined in 10 day old pearl millet seedlings 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 seedlings grown in elevated CO_2 (550 ppm) had significantly higher NO_3^- uptake rates compared to ambient (365 ppm) grown seedlings (Fig 10).

Induction potential for NO_3^- reduction by direct feeding of the excised plants with NO_3^- and energy source (0.2% sucrose) showed that plants grown under elevated CO_2 had higher potential for enzyme induction. Inclusion of NO_3^- upto 15 mM, increased the inducible activity, beyond which it decreased in both ambient and elevated CO_2 conditions (Fig 11).

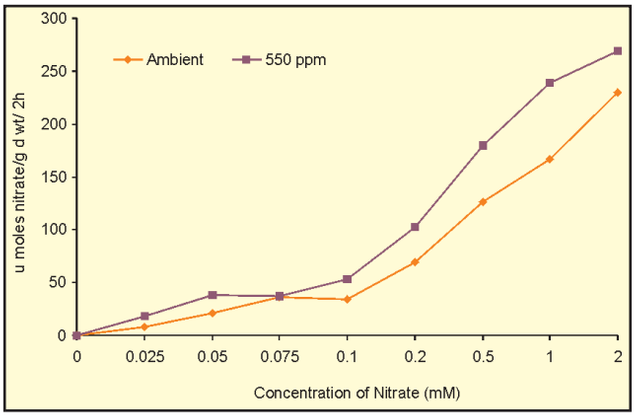


Fig 10. Nitrate uptake in pearl millet seedlings grown under ambient and elevated CO_2 conditions as a function of NO_3 concentration in the medium

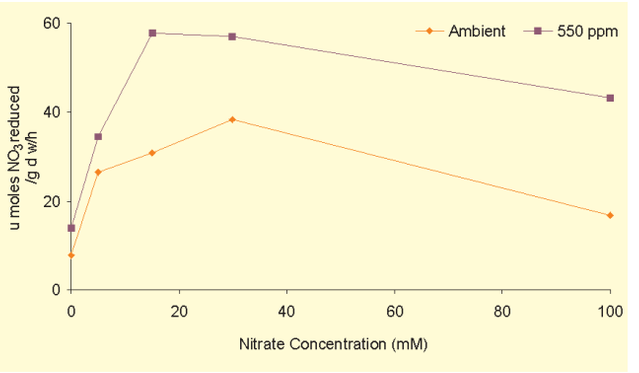


Fig 11. Inducible NR activity in pearl millet grown at ambient and elevated CO_2 conditions as a function of concentration of nitrate in the medium

Leaf area and total dry matter of 15 day old seedlings grown with 0,5,15 and 30 mM NO_3^- was significantly higher under elevated CO_2 compared to ambient conditions at all levels of nitrogen applied (Table 9). Increase in the dose of applied NO_3^- significantly increased the total dry weight of plants up to 15 mM and decreased there after.

Table 9. Effect of elevated CO_2 and nitrogen on pearl millet growth (15 DAS)

NO_3^- levels (mM)	Leaf area (cm^2/plant)		Dry wt (mg/plant)	
	Chamber control (365 ppm)	Elevated CO_2 (550 ppm)	Chamber control (365 ppm)	Elevated CO_2 (550 ppm)
0	2.78	3.87	122	152
5	5.85	5.82	185	223
15	6.43	7.60	192	310
30	7.76	8.03	190	277
Mean	5.71	6.33	172	240
LSD at 0.05				
CO_2(C)	0.540		3.25	
NO_3^-(N)	0.763		4.59	
C x N	NS		6.49	

These results indicate that greater induction potential for NR along with better uptake in plants grown under elevated CO_2 results in higher nitrate assimilation leading to more leaf area and higher dry matter production.

2.1.2.5 Impact of elevated CO_2 on insect - plant interactions

Experiments were conducted to study the impact of elevated CO_2 on insect pests of castor. Feeding trials using neonate larvae of *Spodoptera litura* on castor were performed. Castor was grown in four conditions; two elevated CO_2 concentrations 700±25, 550±25 ppm in OTCs, one ambient CO_2 (350±25ppm) in OTC and one ambient CO_2 in the open outside the OTC.

Significant differences in the growth and consumption of larvae were observed when fed with leaves grown under different CO_2 conditions. Larvae of *S. litura* consumed more of elevated CO_2 foliage than ambient CO_2 foliage. The total consumption of castor foliage during entire feeding period was significantly more under elevated CO_2 than ambient CO_2 (Table.10). Final larval dry weights differed among treatments and the impact of elevated CO_2 on larval weight of *S. litura* on castor was significant. The larval weights were higher with elevated CO_2 foliage compared to ambient CO_2 foliage. The developmental period for larvae fed with castor foliage grown under elevated CO_2 conditions was longer compared to larvae fed with ambient CO2 foliage. Indices of insect performance differed significantly among treatments (Table10). Approximate digestibility (AD) of larvae was higher in elevated CO_2 conditions than ambient CO_2 conditions indicating that elevated CO_2 foliage was more digestible. The relative growth rate (RGR) of larvae was not influenced by CO_2 conditions.

2.1.2.6 Impact of elevated CO_2 on Bt cotton and bollworms

The project was initiated in 2007 to find out the effect of elevated CO_2 on plant allocation to defensive compounds in transgenic cotton (Bt) and Non- Bt cotton plants and consequent changes in insect growth and development. Bt and Non- Bt cotton plants were grown during *kharif* 2007 under four conditions; two elevated CO_2 concentrations 700±25, 550±25 ppm in Open Top chambers (OTC), one ambient CO_2 in OTC and ambient CO_2 (350±25ppm) in the open, outside the OTC. Feeding trials were conducted to study the effects of elevated CO_2 on growth of *Helicoverpa armigera* fed on Bt cotton (Cry 1 A(c)) and Non Bt cotton.

Marked differences in the growth and consumption of larvae were observed when fed with leaves grown under different CO_2 conditions. Larvae of *H. armigera* consumed more of elevated CO_2 foliage of both Bt and non-Bt plants compared to ambient CO_2 foliage. No mortality of larvae was observed in larvae fed with Bt cotton foliage grown under elevated CO_2. In contrast, larvae fed with ambient CO_2 grown Bt foliage recorded mortality in 8-9 days after initiation of experimentation. Larval life span was significantly longer for *H. armigera* fed transgenic Bt cotton foliage grown under elevated CO_2 conditions. No mortality of larvae was observed in larvae fed with non-Bt foliage irrespective of CO_2 conditions, and larvae attained pupation 14 days after feeding. The total consumption by *H. armigera* during entire feeding period was more under elevated CO_2 (0.582±0.048 and 0.604±0.039 g dry leaf weight) than other ambient CO_2 treatments (0.495±0.023 and 0.432±0.0001 g) indicating about 30% more consumption under elevated CO_2 conditions on Bt foliage (Fig 12). Maximum amount of foliage was consumed in case of non-Bt cotton grown under 700 ppm CO_2.

Table 10. Impact of elevated CO_2 on *Spodoptera litura* on castor during 2007

Treatments	Weight of leaf ingested (g)	Larval weight (g)	AD (%)	RGR (mg/mg/d)
Elevated CO_2 550 ppm	0.820±0.131	0.137±0.002	70.61±3.99	76.31±0.159
Elevated CO_2 700 ppm	0.869±0.054	0.137±0.001	74.66±2.96	76.45±0.611
Ambient CO_2 inside OTC	0.594±0.044	0.117±0.006	58.80±4.01	73.33±0.344
Ambient CO_2 outside OTC	0.588±0.192	0.118±0.002	57.02±7.23	74.25±0.152
LSD (p=0.05%)	0.166	0.011	0.106	NS

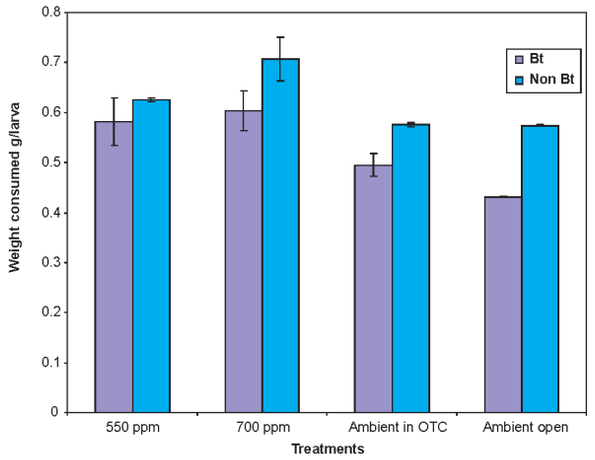


Fig 12. Effect of CO_2 growing conditions on leaf consumption during larval growth period by *H. armigera* in Bt and Non Bt cotton

2.1.3 Utilization of agroclimatic information for advisories

2.1.3.1 Water requirement satisfaction index (WRSI)

The water requirement satisfaction index (WRSI) is an indicator of crop performance based on the availability of water to the crop during a growing season. WRSI for a season is based on the water supply and demand a crop experiences during a growing season. WRSI, defined as the percentage of ratio of AET and water requirement (AET/WR X 100), is an indicator of soil moisture stress. An index of 100 indicates an excellent crop and an index of 50 indicates crop failure. Crop growth stage wise WRSI values have been computed for the five AMF Units in Andhra Pradesh (Anakapalli, Anantapur, Tirupathi, Rajendranagar and Jagtial) for the following crops viz., Maize, Groundnut, Pigeonpea, Sorghum, Pearlmillet and Cotton.

At Anakapalli the WRSI values are more than 85 percent for maize and groundnut for all growth stages indicating that there is no soil moisture stress under normal sowing condition (Table 11). Even under delayed sowing condition by 4 to 5 weeks soil moisture can meet the water requirements to the desired level because of contribution from post-monsoon season rainfall at Anakapalli. The WRSI for groundnut crop at Anantapur indicated that WRSI value never reached above 90 percent from pegging to end of crop season. Here also, delayed sowing did not reduce the WRSI values due to assured rains in post-monsoon season. The values of WRSI at Anantapur for redgram indicated that there is a soil moisture stress condition right from the flowering stage showing that soil moisture stress may cause impediment for better crop growth. On the other hand the index was around 90 per cent during flowering to pod initiation stages at Rajendranagar for redgram, which indicates that there is no obstacle for crop growth and

Table 11: Water Requirement Satisfaction Index (%) of important crops at AMF Units in Andhra Pradesh

Maize at Anakapalli						
Sowing Time	Emergence	Vegetative	Silking	Milking	Dough	PM*
Normal (25 week)	100.0	98.8	97.8	95.1	94.0	94.0
Delayed by 1 week	100.0	98.9	96.8	93.9	93.6	93.6

Groundnut at Anakapalli							
Sowing Time	Emergence	Vegetative	50% Flowering	Pegging	Pod initiation	Pod development	PM
Normals (23 Week)	100.0	98.4	96.1	93.7	91.5	89.7	88.4
Delayed by 1 week	100.0	98.1	95.4	93.1	92.1	90.0	89.3

Groundnut at Anantapur							
Sowing Time	Emergence	Vegetative	50% Flowering	Pegging	Pod initiation	Pod Development	PM
Normal (25 Week)	100.0	93.9	86.6	78.1	69.0	55.1	47.3
Delayed by 1 week	100.0	95.3	87.8	80.6	70.6	57.2	51.0

Redgram at Anantapur					
Sowing Time	Emergence	Vegetative	Flowering	Pod Initiation	PM
Normal (24 Week)	93.2	84.4	67.9	58.6	54.2
Delayed by 1 week	94.0	85.8	70.8	60.3	55.1

Groundnut at Tirupathi							
Sowing Time	Emergence	Vegetative	50% Flowering	Pegging	Pod initiation	Pod Development	PM
Normal (27 Week)	100.0	97.2	93.3	88.5	80.7	73.0	70.2
Delayed by 1 week	100.0	97.3	93.4	88.5	79.6	73.7	71.0

Pearlmillet at Tirupathi					
Sowing Time	Emergence	Vegetative	Ear emergence	Grain filling	PM
Normal (23 Week)	100.0	96.9	89.8	82.5	73.0
Delayed by 1 week	100.0	96.7	90.6	83.1	74.1

Redgram crop at Rajendranagar					
Sowing Time	Emergence	Vegetative	Flowering	Pod Initiation	PM
Normal (25 Week)	100.0	97.8	94.1	90.1	84.2
Delayed by 1 week	100.0	97.9	94.5	90.2	83.4

Sorghum at Rajendranagar					
Sowing Time	Emergence	Vegetative	Ear emergence	Grain formation	PM
Normal (23 Week)	100.0	98.6	95.6	91.3	87.4
Delayed by 1 week	100.0	99.0	96.4	93.4	89.3

Cotton at Jagtial						
Sowing Time	Emergence	Vegetative	Squaring	Flowering	Boll deve.	Boll mat.
Normal (30 Week)	100.0	99.9	99.9	99.9	99.7	92.2
Delayed by 1 week	100.0	99.8	99.8	99.8	98.8	87.3

* Physiological maturity

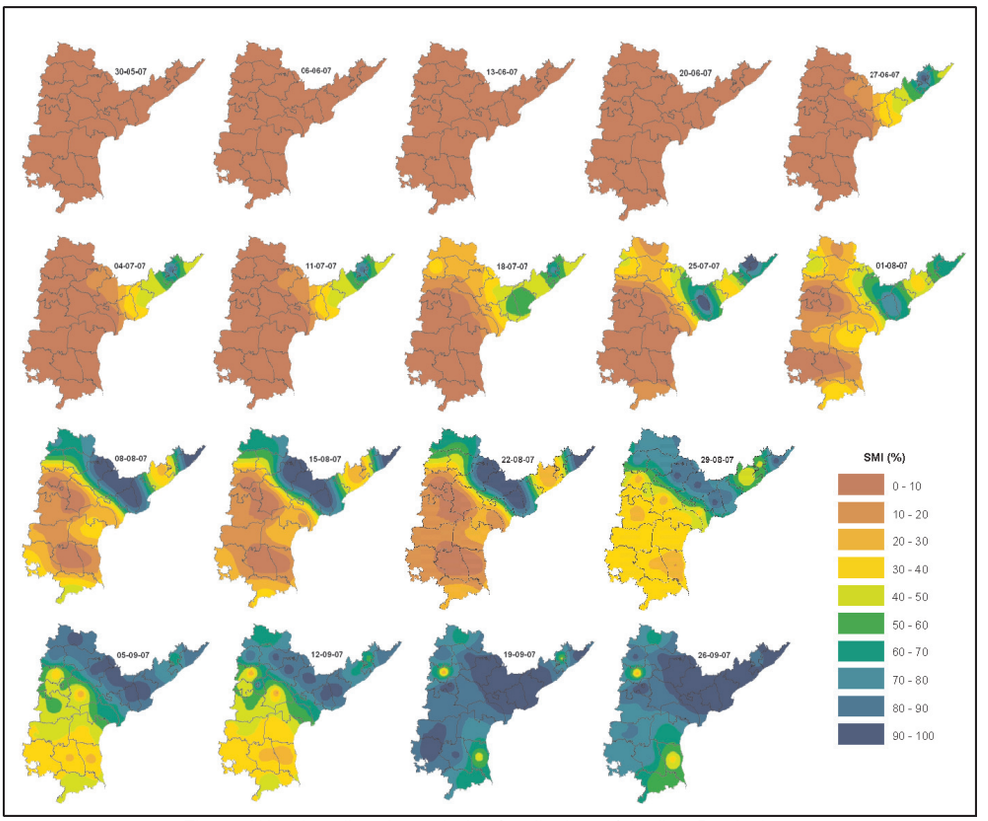


Fig 13. Weekly soil moisture index for districts of Andhra Pradesh

development. The WRSI value for cotton at Jagityal was well above 95 percent throughout the crop growth except at boll maturity stage. At Tirupathi, WRSI values at later stages of crop growth were around 70 per cent, pointing to a moderate stress condition during the later stage, which may result in yield reduction.

2.1.3.2 Monitoring of Soil Moisture in Andhra Pradesh Using SMI (%)

The weekly soil moisture index was calculated for all the 23 districts of Andhra Pradesh for 52 weeks (year 2007) using Thronthwaite & Mather water balance book keeping procedure and mapped using GIS (Fig 13). The information is supplied to the Agromet center of the Agricultural University for further use in the preparation of agro advisories for providing weekly advisories to farmers.

2.2 Rainwater management

2.2.1 Runoff potential

2.2.1.1 Rainfall-runoff & groundwater dynamics in semi arid region

Quantification of hydrological parameters in semi arid watersheds is crucial for planning the sustainable management of available water resources. With the objective of integrating field trial and hydro meteorological data and quantifying the hydrological parameters in a GIS environment by combining a suitable water balance model, this study was started in 2004. The experimental gauging stations for runoff were located in Kurmapally watershed located at 100 km away from Hyderabad. Runoff and soil loss were monitored along with rainfall data within the watershed. Water table data was also collected from selected wells within watershed. Data on land use and soils was used to generate homogenous polygons within sub-watersheds for runoff estimation. A two layered water balance model was run for homogenous polygons for the years 2004-2007.

During 2007, a total rainfall of 817 mm was received in the watershed area of which 66% was received in August and September. About 6.7% of rainfall was received as runoff (surface and sub surface) in the watershed area. Spatial distribution of estimated runoff and deep percolation for homogenous polygons within watershed is shown in Fig 14a and 14b. A higher quantity of deep percolation compared to runoff is attributed to the soil type.

2.2.2 Rain water use

2.2.2.1 Strategies for enhancing water productivity in dryland agriculture

As the rainfed area is spread in different rainfall zones, opportunities may be available through better management of available rainfall. A study was undertaken in 2006 to analyze the district wise deficits of effective rainfall in meeting the water requirements of important crops at different time periods of crop growth and to assess the potential of water harvesting to supply water at local level. Crop-wise and annual water balance

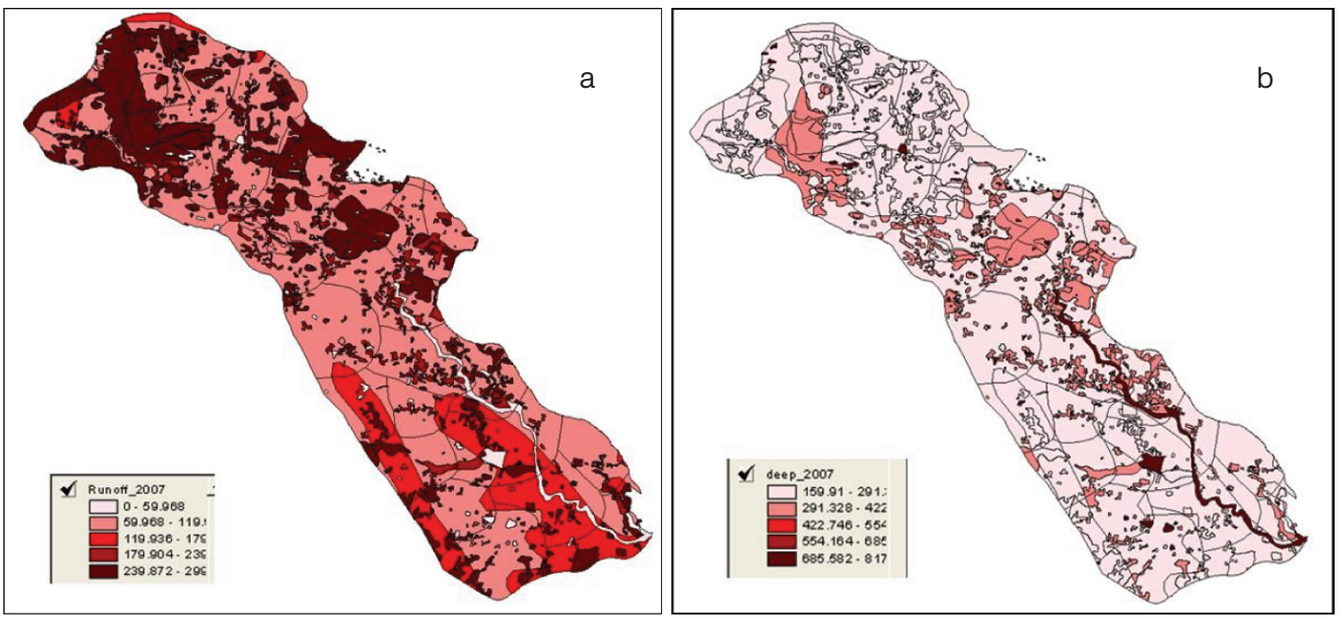


Fig. 14. Spatial distribution of runoff and deep percolation in watershed area estimated through water balance model (a. Runoff distribution, b. Deep percolation distribution)

analyses were done for dominant rainfed districts identified for each crop which could make significant area contribution at the national level. The water balance analysis was carried out for assessing the surplus and/or deficit during the year to estimate the changes in available water through rainfall and atmospheric requirements of evaporation and changes in temporal availability of rainfall and plant water requirement. Districts and regions for different rainfed crops where suitable interventions can be made for water harvesting and supplemental irrigation to increase the production potentials were identified. The investment needs of the suggested interventions were also estimated. The salient findings of the study are:

- About 28 Mha of rainfed area was identified as prioritized area under various crops. About 114 billion cubic meters (BCM) of runoff is generated from this 28 M. ha of rainfed area. Of this total surplus, rainfed rice area (6.4 Mha) contributes 41 BCM, coarse cereals other than rice (7.5 M ha) contributes 21 BCM, cotton (3.2 Mha) contributes 7.5 BCM, oilseeds (6.3 Mha) contribute 24 BCM and pulses (5.3 Mha) contribute 20.4 BCM.
- Among individual crops, soybean contributes significant amount of 13.3 BCM from an area of 2.8 Mha.

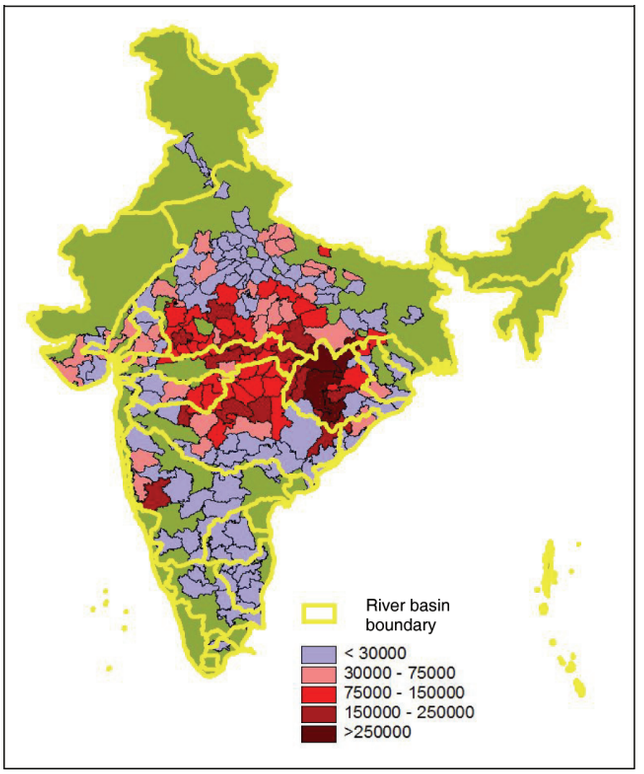


Fig 15 Spatial distribution of estimated surplus runoff (ha-m) across districts and river basins

- About 25 Mha of rainfed area can be provided with supplemental irrigation (one irrigation of 100mm) with an estimated harvest surplus of 28 BCM out of 114 BCM during normal monsoon period and about 20 Mha out of 51 BCM during drought period.
- By introduction of supplemental irrigation (with 'Business as usual' scenario), the crop production can be enhanced by a total of 28-36 M tonnes from an area of 20-25 Mha during drought and normal monsoon periods which accounts for about 12% increase over the present production. The percentage increase is about 20% in case of rainfed rice.
- With adoption improved technologies (if initiatives like SRI cultivation in rice, crop and land use diversification, castor cultivation for eri silk worm, use of improved irrigation technologies like drip and micro-sprinkler (which further increase water use efficiency), the production can be increased further. The investment cost can be promoted through community based water harvesting structures.

Spatial distribution of surplus generation for all major rainfed districts and river basins is shown in Fig 15.

2.2.2.2 A critical evaluation of conservation furrows in Alfisols

Conservation furrows are being recommended in cropped areas of Alfisols to intercept occasional runoff and thus enhance rainwater retention in drylands. Although numerous studies show benefits of such practices elsewhere, earlier studies conducted at CRIDA indicated that the effect of such conservation practices may not be significant due to the limitations imposed by the low water holding capacity of the soil. Moreover, runoff generally occurs when antecedent moisture content is high and therefore any further retention of rainwater may result in deep percolation only. A study was therefore

Table 12. Yield of crops as influenced by conservation furrows with different spacings at GRF

Treatments	Grain Yield (kg/ha)	
	Sorghum	Pigeonpea
T1 (Conservation furrow at 0.9 m spacing)	578	1164
T2 (Conservation furrow at 1.8 m spacing)	467	1239
T3 (Conservation furrow at 2.7 m spacing)	752	1261
T4 (Conservation furrow at 3.6 m spacing)	707	1348
T5 (Control)	668	1378

initiated in 2003-04 to critically evaluate the performance of conservation furrows in terms of their effect on crop yield and soil moisture.

During 2007-08, different treatments viz., conservation furrows with spacings of 0.9 m, 1.8 m, 2.7 m and 3.6 m and control (i.e.. without conservation furrows) were tested in a 2:1 intercropping system of sorghum (SPV 1616) + pigeonpea (PRG-100). The results are given in Table 12.

The treatment differences in the yield of crops were not statistically significant. There was no trend in the spacing of conservation furrows vis-à-vis crop yield in the case of sorghum. T3, i .e. conservation furrows at 2.7 m spacing recorded the highest sorghum yield of 752 kg/ha which in itself was low because of early season drought.

During this season, the yield of pigeon pea was negatively correlated with the spacing of furrows; the highest yield of 1378 kg/ha was recorded in control plot and the lowest yield of 1164 kg/ha in T1, i.e., conservation furrows at 0.9 m spacing. The treatment differences were not statistically significant.

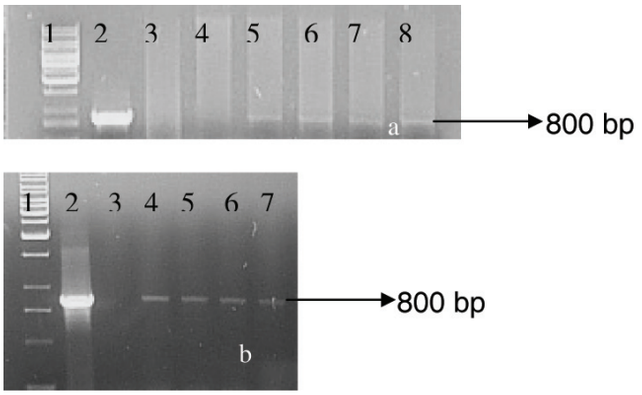
2.3 Crops and cropping systems

2.3.1 Enhancing the drought tolerance through transgenic approach

2.3.1.1 Enhancing tolerance of sorghum to abiotic stresses through genetic manipulation

Sorghum is an important staple food crop grown in drylands, erratic rainfall and frequent and intermittent and terminal dry spells seriously affect its yield and the losses could be up to 50% in the monsoon season. Therefore, development of stress tolerant genotypes of sorghum is an urgent priority in order to stabilize productivity of drylands. Osmotic adjustment due to compatible solutes is an important adaptive mechanism to overcome water deficit in crop plants. In this research project, transformation of sorghum cv SPV 462 with mtlD gene (mannitol-1-phosphate dehydrogenase which catalyses the conversion of mannitol – 1- phosphate to mannitol) was attempted.

During this year, molecular and physiological characterization of the transgenics and advancement of generation was carried out. Genomic DNA of T_3 and T_4 transgenics and untransformed plants was PCR amplified using *mtlD* gene specific primers. Presence of 800 bp product confirmed the carrying forward of the integrated *mtlD* transgene. Further total RNA isolated from T_3 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.



PCR (a) and RT- PCR (b) verification of T_3 transgenics with *mtlD* gene specific primers. (a) Lane 1: 1Kb ladder; 2: plasmid pCAM1300 *mtlD*; 3: Untransformed control of sorghum *cv* SPV462; 4 to 8: T_3 transgenic lines. (b) Lane 1: 1Kb ladder, 2: plasmid pCAM1300 *mtlD*; 3: Untransformed control of sorghum *cv* SPV462; 4 to 7: T_3 transgenic lines

Leaf segments from *mtlD* transgenic plants when incubated on PEG 8000(-2.0 MPa) in general maintained remarkably higher leaf water content compared to untransformed control, which lost upto 30% of moisture and exhibited severe leaf rolling (Table 13). Root and shoot growth was recorded at 15 days after NaCl treatment and subsequently a fortnight after stress recovery. The root and shoot lengths were higher in transgenics when compared to the untransformed controls when challenged with 200mM NaCl stress. Interestingly, the *mtlD* transgenics also recorded significantly higher stress

Table 13: Leaf water content in *mtlD* transgenic leaf segments incubated in PEG 8000 solution for 24 h

mtlD transgenic plant	Water potential of PEG solution (MPa)	Leaf water content
Untransformed control	0	78.33 ± 0.08
	-2	56.00 ± 0.87(29)[a]
5	0	78.25 ± 0.14
	-2	74.67 ± 0.51(5)
72	0	79.83 ± 0.17
	-2	66.58 ± 0.68(17)
75	0	80.40 ± 0.0
	-2	68.00 ± 0.0(15)

[a] Numbers in parenthesis indicate percent reduction from control values

Table 14: Root and shoot growth of sorghum mtlD T_1 seedlings under NaCl (200 mM) stress and recovery

mtlD transgenic plant	15 days after NaCl treatment		15 days after stress recovery	
	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
Control	0.97 ± 0.03	0.90 ± 0.15	13.50 ± 0.87	12.33 ± 1.45
5	1.30 ± 0.06	2.07 ± 0.18	37.67 ± 2.19	22.50 ± 0.76
72	1.17 ± 0.12	1.40 ± 0.06	33.67 ± 4.18	20.50 ± 0.29
75	1.67 ± 0.07	1.80 ± 0.12	44.67 ± 0.33	22.33 ± 1.20

Sorghum *mtlD* transgenics (T3) at reproductive stage

recovery in both root and shoot lengths (on average 2.8 and 1.7 folds) (Table 14).

The T2 and T3 seed of selected transgenic lines were raised in pots in transgenic glass house. They were subsequently selfed and seed of individual cobs was harvested on maturity for further advancement of generation.

2.3.1.2 Genetic transformation of green gram for enhancing abiotic stress tolerance

Various biotic and abiotic stresses cause significant yield losses in legume crops. Development of stress tolerant genotypes to stabilize pulse productivity under fragile and uncertain environments is an urgent priority. Work began in 2006 to transform green gram with *annexin bj* gene. The gene product is known to impart tolerance to various abiotic stresses by relieving oxidative stress. A highly efficient and easily reproducible direct multiple shoot regeneration protocol from half cotyledonary node with intact cotyledon, cotyledonary node and double cotyledonary node has been developed. Transformation conditions have been optimized for *Agrobacterium* mediated approach.

Salient achievements during this year are:

- Cloning of 954 bp *annexin* gene with CaMV 35S promoter in pCAMBIA 2301 binary vector. The vector had kanamycin as plant selectable marker for transgene selection and GUS as a reporter gene.

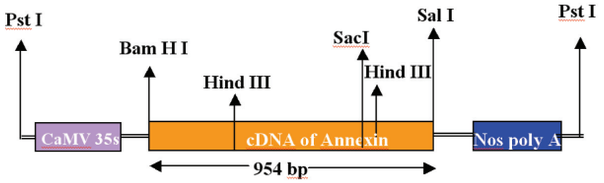


Fig 16. Annexin gene cassette

The *annexin* gene had Bam H1 restriction site at 5' and Sal I at 3' end. The coding region of the gene had two restriction sites for Bam H1 and one for Sac I (Fig 16.).

- Gene specific and npt II primers were designed and got synthesized. PCR amplification conditions were standardized for characterization of putative transgenics. *Annexin* and *nptII* primers yielded 950bp and 645 bp product, respectively.
- Half cotyledonary node with intact cotyledon and double cotyledonary node explants have been transformed with pCAMBIA 2301 binary vector containing *annexin bj* gene. The success of transformation event was confirmed by assaying transient GUS expression. Transformants were selected on medium containing kanamycin.
- Plantlets surviving on medium containing kanamycin were successfully rooted on half MS B_5 in case of double cotyledonary node and half MS B_5 containing indole butyric acid for half cotyledonary node with intact cotyledon explants.

Currently primary hardening and acclimatization of selected independent putative transgenic lines is being carried out in green house.

2.3.2 Varietal development

2.3.2.1 Evaluation of horsegram mutants of CRIDA

Two AICRP trials on horse gram entries were conducted at Hayathnagar Research Farm, during 2007 late Kharif. Six entries were evaluated in advanced varietal trial I (AVT-I) and AVT-II of the All-India Arid Legumes Network Project. In initial varietal trial (IVT) 18 entries are being evaluated at all locations. Trials were sown during August last week (AVT-I, AVT-II & IVT). Each entry was sown in 4 replications with 30 X 10 cm spacing. The trials were evaluated with no input condition under purely rainfed

Table 15: Yield and its components in Horsegram in AVT-I and AVT-II of All India Arid Legumes Project (Southern Zone)

S. No	Entries	Seed Yield kg/ha	Fodder Yield kg/ha	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant (no.)	Pods per plant (no.)	Seed per pod (no.)	100 Seed wt (g)
1	HG-10	907.73	473.21	44	79	34.32	6.75	31.35	5.80	3.15
2	HG-11	892.85	416.66	42	77	33.60	6.85	30.75	5.90	3.16
3	HG-12	599.69	499.99	55	91	36.85	6.65	23.85	5.60	3.16
4	HG-13	199.40	180.05	40	75	23.80	5.35	16.55	5.35	3.09
5	HG-14	590.77	468.74	56	93	35.95	6.10	24.45	5.65	3.02
6	HG-15	165.17	195.23	41	75	22.70	5.45	17.55	5.65	3.05

Table 16. Yield and its components in Horsegram in IVT of All India Arid Legumes Project (Common to Northern and Southern Zone)

S. No	Entries	Seed Yield kg/ha	Fodder Yield kg/ha	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant (no.)	Pods per plant (no.)	Seed per pod (no.)	100 Seed wt (g)
1	HG-16	205.35	374.99	45	85	23.65	5.3	16.3	5.0	3.12
2	HG-17	244.04	415.17	46	86	25.10	6.3	14.9	5.4	3.05
3	HG-18	183.03	342.26	45	85	15.75	4.9	16.8	5.0	3.06
4	HG-19	190.47	377.97	46	87	16.30	4.3	14.4	5.1	3.18
5	HG-20	190.47	366.06	48	88	26.40	6.3	18.4	5.3	3.00
6	HG-21	255.95	416.66	49	89	26.20	6.3	19.5	5.3	3.10
7	HG-22	229.16	354.16	48	88	22.40	6.6	29.6	5.4	3.02
8	HG-23	642.85	720.23	46	86	33.85	6.9	27.8	5.1	3.20
9	HG-24	781.24	639.87	48	89	47.35	8.1	38.7	5.8	3.18
10	HG-25	644.34	645.82	49	90	44.50	7.3	34.2	5.9	3.19
11	HG-26	654.75	620.53	47	89	52.35	7.3	38.9	5.8	3.21
12	HG-27	681.54	718.74	47	84	35.05	7.1	34.1	5.4	3.22
13	HG-28	733.62	779.75	47	88	45.00	7.4	41.1	5.5	3.15
14	HG-29	-	-	-	-	-	-	-	-	-
15	HG-30	-	-	-	-	-	-	-	-	-
16	HG-31	276.78	421.12	47	86	25.60	6.1	21.0	5.2	3.02
17	HG-32	563.98	583.33	50	93	39.15	7.1	28.7	5.3	3.05
18	HG-33	229.16	383.92	50	90	20.55	5.9	19.2	5.3	3.00

situation. The data on yield and its components are presented in Table 15 (AVT-I & AVT-II) and Table 16 (IVT).

In AVT-I & AVT-II, HG-10 was the highest grain yielder followed by HG-11 and HG-12, with 907.73, 892.85 and 599.69 kg/ha respectively and matured in 79,77 and 91 days respectively. In IVT, entry HG-24 recorded highest grain yield of 781.24 kg/ha followed by HG-28 with 733.62 kg/ha. These entries matured in 89 and 88 days respectively.

2.3.3 Drought management

2.3.3.1 Root studies in relation to profile moisture availability

Most drought management practices currently being adopted are based on the results of performance of above ground plant parts. However, studies on below ground plant parts viz., roots, need to be carried out to understand and fine-tune drought management measures. The studies require root chambers. A study was initiated in 2007 to standardize such root chamber and study the response of greengram and horsegram.

Root chambers were fabricated with the acrylic sheet based on single plant spacing. Three boxes of 30X15X15 cm size were joined with the removable tape by fixing one above the other with the last box having the base. Soil was filled up to 45 cm, simulating the soil profile of top three soil depths at Hayathnagar Research Farm. A small drainage hole was provided at the bottom.

Root Chamber with fine roots in the inset

Green gram (WGG-37) crop was raised in these chambers in a net house with the treatments of maintaining soil moisture at half the field capacity and at field capacity. Rooting depth increased when soil moisture deficits were created at vegetative stage (25 DAS) while the number of laterals and fine roots were more with the control treatment (Fig 17). This might be due to the fact that the non availability of soil moisture forced the tap root to go further in search of soil moisture while the availability of soil moisture at top layers enabled the tap root to exploit existing soil moisture by producing more of laterals and fine roots. Maximum rooting depth was observed when plants were stressed at vegetative stage though the rooting depth of non-stressed plants also increased but to lesser extent. Further root shoot ratio was high with stressed greengram plants at vegetative stage compared to plants not subjected to moisture stress.

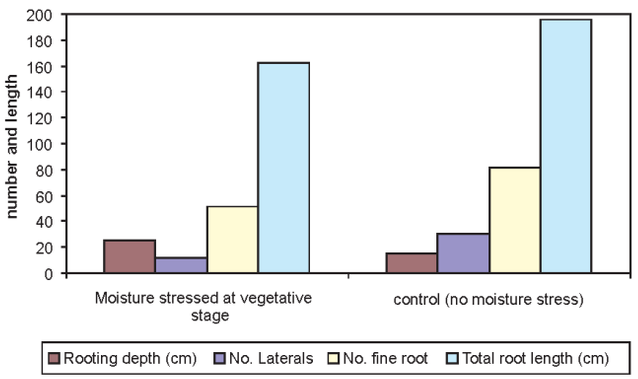


Fig 17. Greengram root parametric differences due to soil moisture stress in root chambers at vegetative (25 DAS) stage

2.3.3.2 Drought Management in Castor

Castor is mostly a rainfed crop grown during kharif and suffers from moisture stress caused by intermittent dry spells and sub optimum nutrient supply. Resource poor farmers do not use required level of inputs and hence the productivity is low. To evolve simple low cost integrated moisture conservation and INM practices to improve productivity and minimize drought effects in castor, a field experiment was carried out during 2007-08 season at Hayathnagar Research Farm at Hyderabad.

Castor (*Kranthi*) was sown during July. Recommended agronomic practices were followed (row spacing of 90 cm and plant density of 55,000 per ha). The trial consisted of 8 treatments and 4 replications: Farm yard manure (FYM) @ 10 t/ha and no FYM as the 2 main plots, and 25% N through gliricidia + 75% N through inorganic fertilizers (T1), making conservation furrows along with application of recommended dose of fertilizers (RDF, 50-30-0) (T2), additional dose of 10 kg N/ha through top dressing along with normal dose (T3) and application of 100% N through inorganic fertilizers (50-30-0) and control (T4) as sub plots. A basal dose of 10 kg N and 30 kg P_2O_5 was applied through DAP to all the plots. Gliricidia green leaves of about 200 kg/ha equivalent to 12.5 kg N/ha were side placed one month after

Table 17. Effect of different drought management practices on yield and yield attributes in castor cv. Kranthi

Treatments	Total filled pod yield		Total filled pod number /sq.m.	
	With FYM	Without FYM	With FYM	Without FYM
25% N through gliricidia + 75% N through inorganic fertilizers	1876 (25.2)	1577 (32.2)	248	207
Conservation furrow after every two rows with RDF	1786 (19.2)	1526 (27.3)	236	202
Additional dose of 10 kg N/ha through top dressing during recovery from dry spell	1689 (12.2)	1369 (14.8)	223	180
100% inorganic fertilizers (RDF)	1498 (0)	1193 (0)	198	157
Mean	1712	1416	227	187

Note: Figures in parentheses are percentage increase in capsule yield over control (RDF) RDF: 50-30-0

germination of castor. Remaining N was top dressed through urea as per treatments. Rainfall was heavy (212 mm) during the months of August and September (175 mm) and scanty during November (24 mm) and December (15 mm).

The total pod yield and number of filled pods obtained under various treatments showed that filled pod yields with and without FYM (1876 and 1577 kg/ha) were highest under the treatment of application of 25% N through gliricidia and 75% N through inorganic fertilisers (Table 17). Next best treatment was conservation furrows between castor rows (1786 and 1526 kg/ha) and application of additional dose of 10 kg N/ha through top dressing along with normal dose of fertilizers (1689 and 1369 kg/ha). The lowest pod yield (1193 kg/ha) was obtained with 100% of N through inorganic fertilizers (50-30-0). Application of FYM improved pod yield and pod number in castor compared to no FYM application. The yield enhancement was about 19% under treatment T1 with FYM application over no application of FYM. Whereas in other treatments (T2 to T4) the pod yield enhancement was about 23 to 24% with FYM application over no application. 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 Southern Telancana of A.P.

2.3.4 Organic production

2.3.4.1 Organic Production of Sesame

A long-term field trial is under progress at GRF for studying the feasibility of raising sesame under organic farming practices and also to compare the organic and conventional production practices on yield, and oil quality besides other parameters like soil health and nutrient loss. Sesame – pigeonpea rotation was followed in the trial. This experiment was initiated during *kharif* 2005. This season (*kharif* 2007) represented the third year of the long-term experiment. An amount of 573 mm of rainfall was received in 33 rainy days during the crop season. The treatments imposed for sesame were (a) control (no inputs), (b) organic (meeting the requirements through permitted inputs on nutrient equivalent basis) and (c) inorganic (package of practices for the area). Apart from studying the effect of these treatments on crop growth, incidence of pests and diseases and nutrient uptake, efforts have also been made to quantify the loss of nutrient in the run-off water from different treatment plots.

Yield and yield parameters

The seed yield recorded at harvest, followed the order of inorganic (416 kg/ha) > organic (333 kg/ha) > control (194 kg/ha). The number of pods/sq.m., stick yield were also highest under inorganic production system (Table 18), whereas, the oil content did not differ significantly amongst the treatments. During third year also, inorganic production system proved superior to organic and control.

Soil fertility status

Results of the analysis of soil samples (0.15 cm) collected after the harvest of sesame revealed that organic carbon status in plots under organic management was highest as compared to inorganic and control (Table 19) after 3 years. The available potassium status under organic production system was highest as compared to other systems, which might be due to addition of potassium-rich ash. The soil test values with respect to available phosphorus, copper and iron did not vary much among different production systems. However, the available zinc status under organic production system was higher than inorganic and control indicating its build-up (Table 19). This shows that though yield levels after 3 years still remained lower in organic systems, the soil health improved significantly which might reflect in yield gains in subsequent years.

Nutrient loss through runoff

Two runoff events on 27.8.07 and 21.9.07 (with rainfall amounts of 75 and 84 mm, respectively occurring two days prior to the event) were monitored in the sesame plots for nutrient loss. Data of the analysis of the runoff water from both the events showed considerable loss of P and K and small quantities (less than 1 ppm) of Fe, Cu and Mn. In general, the loss was high in chemical plots

Table 18: Yield and yield parameters of sesame under different production systems (GRF, Kharif 2007)

Production system	Seed yield (kg/ha)	Stick yield (kg/ha)	No.of pods / m^2	Days to 50% flowering	Oil content (%)
Control	194	11.36	408	90	52.53
Organic	333	15.84	598	57	51.95
Inorganic	416	18.48	694	56	52.49

Table 19. Soil properties under different production systems after three years of experimentation (2005-07)

Soil property	Production system		
	Control	Inorganic	Organic
Organic carbon (%)	0.587	0.633	0.713
Available potassium (kg/ha)	227	237	245
Available phosphorus (kg/ha)	14.4	15	15
Available zinc (ppm)	0.547	0.623	0.779
Available copper (ppm)	2.2	2.1	2.1
Available iron (ppm)	23.9	23.2	23.8

as compared to organic and control plots. No clear effects were seen with respect to micronutrients.

2.3.4.2 Organic production of pigeonpea

A project was initiated in 2005 to examine the feasibility of producing pigeonpea and sorghum in drylands using approved organic production inputs and practices and to compare organic, integrated and chemical production packages in terms of crop productivity, production costs and returns. In *kharif*, 2007, the third year of the experiment, Sorghum (SPV 1616) and pigeonpea (PRG 100) were grown 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. Sorghum was removed at 30 days after sowing due to poor plant stand resulting from seedlings being washed away by heavy rain, and the field was left fallow. The pigeonpea crop survived the heavy rains and exhibited good growth throughout the growing period.

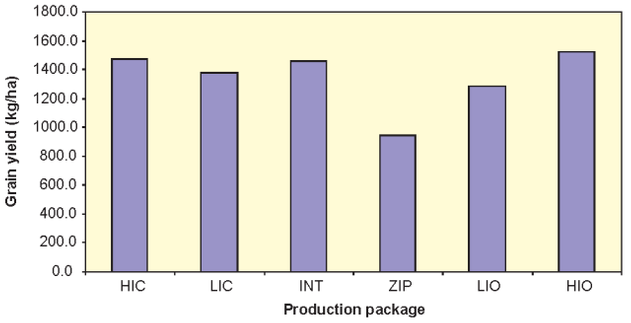


Fig 18. Pigeonpea grain yields with different production packages (GRF, Kharif 2007)

At all stages of growth of pigeonpea, the high input organic package registered the highest dry matter levels. Grain yield of pigeonpea was highest with the high input organic package (1524 kg/ha) followed by the high chemical input package (1471 kg/ha) (Fig 18). There were no significant differences in the population of jassids at any of the growth stages of pigeonpea. The population of *Helicoverpa armigera* larvae on pigeonpea did not differ with production package before specific control measures were taken up. Treatment specific control measures were initiated in all the production packages except the zero input package when the population of *H. armigera* rose above economic threshold level (around 120 days after sowing). All treatment specific control measures proved effective in bringing down the population of *H. armigera* larvae and by about 150 days after sowing, significant reduction in larval numbers was observed with all the production packages as compared to the zero input package. There were significant differences in per cent grain damage of pigeonpea with different production packages. The lowest grain damage was observed with high input chemical package (11%) followed by the high input organic package (13%), while the highest damage was observed with the zero input package (22.3%) in which no pest control measures were taken up (Table 20). The high input organic, and integrated production packages required 11 persondays of labour per ha for implementing the package specific operations over and above routine crop maintenance. In contrast, the chemical packages required only 3 persondays and were clearly less labour consuming. Package specific input costs over and above routine crop maintenance were highest (Rs. 3300 per ha) with the high input organic package followed by the high input chemical package (Rs. 1994 per ha) (Table 20). Neem cake and HaNPV were the expensive inputs that contributed to the high cost of the high input organic package.

Table 20. Grain damage, labour requirement and input costs with different production packages in pigeonpea

Production package	% Damaged grain	Labour (persondays/ha)	Input costs (Rs./ha)
HIC	11.0	3	1994
LIC	14.7	3	1550
INT	14.3	11	1406
ZIP	22.3	0	0
LIO	13.7	10	550
HIO	13.0	11	3300
CD 0.05	2.8	-	-

2.3.4.3 Organic niger production in high altitude tribal zone (HATZ) of Visakhapatnam district of AP

The HATZ in Visakhapattanam district comprises of 11 revenue mandals covering an area of 6293 Sq km, which is 56% of the geographical area of the district, with a population of 5.70 lakhs. The density of population is 90 compared to 343 per sq km of the Visakhapatnam district. The soils are mostly loamy to clayey type and severely eroded exposing rocky surfaces due to shifting cultivation. Normal annual rainfall is about 1600 mm distributed over 8 months.

On Farm Trials (55) were conducted by CRIDA to demonstrate productivity potential of organically grown niger, with the help of Integrated Tribal Development Authority (ITDA), Paderu. About 7000 kg niger seed of variety JCN-1 was procured from JNKKV, Jabalpur by ITDA, Paderu. The seed used for OFTs during 2007 was farmers' own seed produced in OFTs 2006. General productivity of niger in the zone is 160 kg/ha but OFTs registered higher yields up to 580 kg/ha by adopting improved variety, use of cuscuta free seed, application of manures, line sowing and optimum plant population (3.33 lakhs/ha) and timely weed control (Table 21).

Due to high slopes soil and water conservation measures shall go in a long way in improving over all productivity of crops in the zone. Plans are underway to make arrangements to use the seed of JCN-1 harvested from OFTs for large-scale adoption of seed of improved variety during Kharif 2008. Agricultural Staff of ITDA were sensitized regarding organic agriculture and improved package of practices of niger cultivation.

Table 21. Mandal wise performance niger cv JCN-1 in OFTs in HATZ of Visakhapatnam district

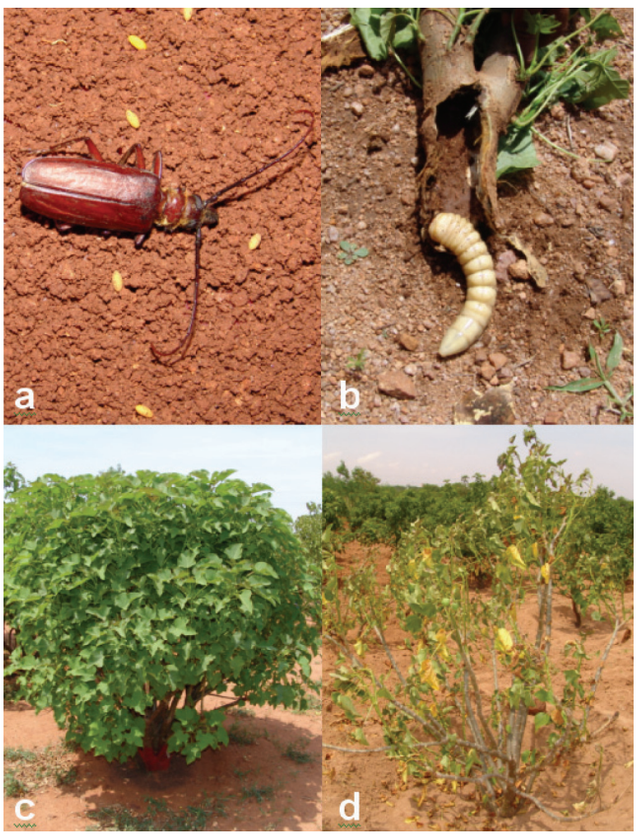
S. No	Mandal	Local (kg/ha)	JCN-1 (kg/ha)	JCN-1 With improved practices(kg/ha)
1	Paderu	185	325	550
2	Hukkumpeta	150	270	475
3	Dumriguda	170	250	480
4	Peddabayalu	135	295	430
5	Munchingpattu	120	310	530
6	Anatagiri	185	310	520
7	Araku	195	265	560
8	Koyyuru	135	210	450
9	G.Madugula	150	255	485
10	G.K.Veedhi	145	190	330
11	Chintapalli	210	265	580

2.3.5 Pest Management

2.3.5.1 Detection of pest and diseases using remote sensing techniques

Detection of crop stress by remote sensing is based on the assumption that stress factors interfere with photosynthesis or the physical structure of the plant and affect the absorption of light energy and alter the reflectance spectrum of the plant. The health status of the plant can be determined by reliably measuring the reflectance spectrum.

Among several pests that were recorded on Jatropha at Hayathnagar research farm, a cerambycid root borer (*Plocaederus ferrugineus* L.: Cerambycidae: Coleoptera) is the most dreaded. About 20 per cent of three years old plants in a 3 ha Jatropha plantation died due to root borer attack. On digging up the affected plants, large whitish creamy grubs of size up to 23 cm were found feeding on the main roots below ground. They rendered the main root and stem hollow by tunneling inside. The first symptom of withering of leaves appeared only 6 to 8 weeks after initial infestation. Two weeks later,



Cerambycid root borer infesting Jatropha plantations (a. adult with eggs, b. grub with damaged plant c. healthy plant, d. affected plant)

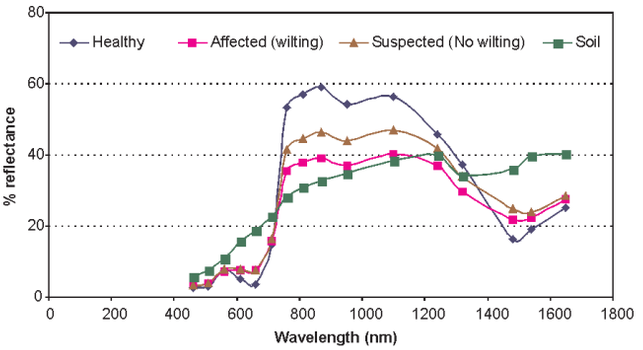


Fig 19. Reflectance spectra of healthy and root borer affected jatropha plants

the entire plant wilted and subsequently dried up. Further, the pest spread to neighboring plants in the subsequent seasons. It is difficult to distinguish the affected plants from healthy during the initial stages of infestation. By the time visible symptoms appeared on the plant, it is beyond the scope of taking any control measures and saving the plant. Damage due to borers goes unnoticed in large plantations and in those, which are less intensely managed. Efforts have been initiated for early detection of root borer incidence in Jatropha plantations using remote sensing techniques so as to initiate timely control measures to save the affected plants.

About 30 Jatropha plants, which were visibly healthy, and showed no symptoms of wilting, were selected from the 3 ha Jatropha plantation at Hayathnagar Research Farm. Observations on spectral reflectance and canopy temperature were recorded on the selected plants at fortnightly intervals starting from first week of July. A hand held radiometer (MSR -16, Crop Scan, USA) was used to measure the canopy spectral reflectance at different stages of crop growth. A hand held infrared thermometer (Teletemp Corp., USA) was used to measure the leaf surface temperatures. The reflectance spectra of 6 out of 30 plants recorded on 31 July showed variation in four bands having central wavelengths at 810, 870, 950 and 1100 nm (Fig 19). Though all the plants appeared healthy, the percent reflectance in near infrared region was less by 8 to 12% from these six plants compared to others. Similar trend was found in the next observation recorded on 11 August. The first symptoms of borer attack (wilting) appeared in the second fortnight of August, only on these six plants, which showed less reflectance in four bands at NIR region. Hence it could be inferred that the spectral bands at 810, 870, 950 and 1100 nm are sensitive to the stress caused by the root borer in Jatropha. The observations recorded on 10 August also showed 2-5 °C higher canopy temperatures in the affected plants compared to healthy plants. This study clearly demonstrates the utility of remote sensing techniques in the early detection of borer incidence in Jatropha, at least 10 to 15 days before the visible symptoms of wilting appear on the plants. This will be useful to manage pests on time when large plantations of jatropha are taken up under biodiesel programme. It is possible that these techniques could be deployed in detection of root damaging pests and diseases in other crops as well.

2.3.5.2 Developmental thresholds, thermal constants and developmental models for major pests of dryland crops

Growth and development of living organisms are dependent on environmental factors. Because insects are cold blooded, temperature has the greatest effect on their development. Insects require certain amount of heat units to develop from one point in their life cycle to another. This measure of physiological heat units provides a reference for estimating and forecasting the pest incidence in the field. A study was initiated in 2005 to determine the lower and upper threshold temperatures, and thermal constants for each life stage of castor semilooper, *Achaea janata.*

The experiments were conducted in the environmental test chamber keeping the constant light-

Table 22: Developmental thresholds and thermal requirements for *Achaea janata*

Stage	Lower developmental threshold (95% confidence limit)	Regression equation	Degree days (± SD)	% Total developmental period
Eggs	8.5 (5.4-12.5)	0.159x + 7.8718 R^2 = 0.98	58.75 (± 9.82)	12.54
Larva	10.0 (7.2-14.0)	-0.9897x + 41.718 R^2 = 0.84	205.5 (± 29.14)	43.85
Pupa	8.2 (6.5-14.1)	-0.7436x + 28.949 R^2 = 0.93	127.8 (± 35.41)	27.27
Adult (For pre ovipositon)	13.4 (10.4-16.8)	-0.1641x + 10.513 R^2 = 0.87	76.6 (± 33.4)	16.34

dark phase (16:8 hrs), relative humidity (65 ± 5%) and four-temperature regimes viz., 18, 24, 32 and 36 °C (Table 22). Insect development was monitored and measured in terms of time taken for completion of each stage. Regression equations were developed for each life stage. The growing degree days were calculated for each stage by subtracting the lower threshold temperature value and multiplying it with the developmental period. The results showed that maximum degree days were required for larval stage followed by pupal, adult and egg stage. This information could be useful for building developmental models for forecasting semilooper outbreaks using weather data. Work is under progress to determine the 'bio-fix'. i.e., the cut off date from where to calculate degree day summation to predict the adult emergence and subsequent larval damage.

2.3.5.3 Development and evaluation of low external input IPM modules in pigeonpea and castor

The project was initiated in 2007 to develop low external input IPM (LEIIPM) modules for control of insect pests of dryland crops viz., pigeonpea and castor. Low external input IPM seeks to optimize the use of locally available resources by combining different components of a farming system. Two LEIIPM modules were evaluated in pigeonpea + sorghum and castor + clusterbean intercropping systems, which were found effective in earlier studies. Five different pest control packages were evaluated in these systems; 1. Exclusive chemical pest control, 2. Integrated, 3. Low external input IPM I, 4. Low external input IPM II and 5. Zero input. Sequential application of various components was adopted in these packages in different ways.

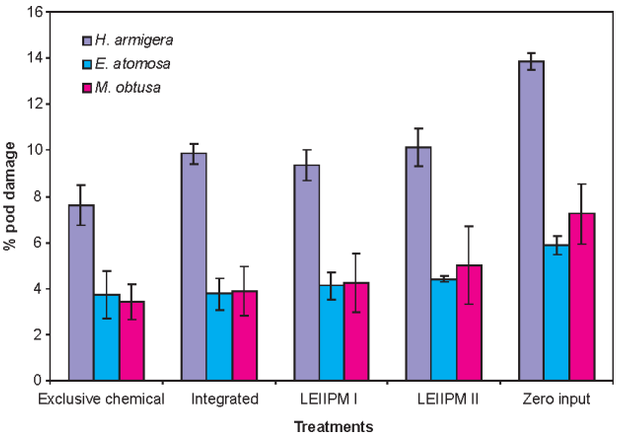


Fig 20. Impact of Low external input IPM modules on Pod borers of pigeonpea.

Low External input IPM I and II, consisting of

Table 23. Impact of low external input IPM modules on incidence of insect pests of pigeonpea

Treatments	Helicoverpa		Jassids	
	CPL	Mean pop/plant	CPL	Mean pop/plant
Exclusive chemical	4.56±0.509	0.569±0.064	34.11±3.86	4.263±0.483
Integrated	3.33±0.333	0.417±0.042	40.11±1.262	5.013±0.158
LEI IPM I	5.56±0.769	0.694±0.036	41.11±0.192	5.13±0.024
LEI IPM II	8.01±1.856	1.01±0.232	42.00±1.764	5.25±0.220
Zero input	13.56±2.21	1.694±0.272	54.11±3.596	6.764±0.449

Table 24. Impact of low external input IPM modules on pigeonpea during 2007

Treatments	Grain damage (%)		Grain yield q/ha
	Lepidopteran borers	Pod fly	
Exclusive chemical	8.97 (17.45)	5.14 (13.12)	8.83
Integrated	7.65 (16.07)	6.09 (14.18)	10.40
LEIIPM I	11.27 (19.56)	5.77 (13.85)	8.67
LEIIPMII	11.53 (20.72)	6.49 (14.55)	8.77
Zero input	22.32 (28.16)	9.71 (18.06)	5.64
SEm±	0.53	0.33	0.33
CD(0.05)	1.74	1.75	1.07

Figures in parentheses are angular transformed values

botanical extracts and oils, performed well and were comparable with integrated treatment although the exclusive chemical treatment recorded marginally low level of pest incidence. The mean and cumulative pest load (CPL) of insect pests like jassids and *Helicoverpa armigera* were highest in zero input treatment and lower in the integrated, LEIIPM I and exclusive chemical treatments (Table 23).

Marked differences were noticed in pod damage by lepidopteran borers, *H. armigera* and *Exelastis atomosa*, and pod fly *Melanogromyza obtusa* across the treatments/modules. Exclusive chemical (7.62%) and LEIPM II (9.37%) recorded lowest pod damage by *H. armigera* (Fig 20). Similarly the pod damage by other borers also varied significantly. Grain damage by lepidopteran borers was significantly less in integrated and exclusive chemical treatments (Table 24). Similar trends were reflected in grain yields also by recording 10.4 and 8.83 q/ha respectively.

2.3.5.4 Integrated disease management in groundnut based production systems; relationship between metlab and groundnut canopy weather & validation of late leafspot decision support system

An understanding of the relationship between weather from observatory and at canopy level is essential to arrive at developing functional decision support systems (DSS) for foliar diseases. Field trials of two consecutive years revealed that maximum- and minimum-temperature followed a logistic relationship. However, morning- and evening-relative humidity did not show consistent relationship over years. These functional relationships for temperatures could be used for developing weather based forewarning systems. A field trial was laid out to verify late leaf spot decision system at field level. Despite inoculation, the disease pressure remained very low and hence, no conclusions could be drawn. The variability of 'r' across locations helped in understanding the disease development and based on these observations, the DSS will be amended.

2.3.6 Biofertilizers and biopesticides

2.3.6.1 Production and distribution of bio-fertilizers and biopesticides

Integrated Bioresources Centre with a production capacity of 3 tonnes of biofertilizers, 5 tonnes of biopesticides and 23000 tissue-cultured planting material per annum was inaugurated formally by Padmashri Dr. MV Rao, Chairman, Agribiotech Foundation. As part of the activities of the Integrated Bioresources Centre, more than 500 kg formulated product of *Trichoderma* was produced and supplied to farmers. Field demonstrations were conducted for use of bio-pesticides by farmers. Nine one-day training programs were conducted for staff of line departments and farmers on use of biopesticides as part of awareness building. The research activities included improving shelf-life of the formulated product and novel formulation strategies. Paraffin oil+glycerol based formulation of *Trichoderma* retained viability up to $3x10^{-5}$ cfu/ml even after 4 months. PSB, *Azotobacter*, *Azospirillum* retained viability in liquid formulations for 12 months.

2.3.6.2 Isolation and characterization of agriculturally important microorganisms from ecosystem

During the year, 33 *Pseudomonas,* 25 *Bacillus,* 10 *Bradyrhizobium* and 10 *Azospirillum* isolates were isolated from rhizosphere soils of rainfed crops from arid and semi arid zones. Nine isolates of *Pseudomonas* and four isolates of *Bacillus* promoted more than 50% growth of sorghum while nineteen isolates of *Pseudomonas* and four isolates of *Bacillus* promoted more than 50% growth of pigeonpea (Table 25).

Nine and 18 isolates of *Pseudomonas* promoted more than 50% growth over control of sorghum and pigeonpea seedlings, respectively. Similarly, four and five isolates of *Bacillus* promoted more than 50% growth over control of sorghum and pigeonpea seedlings, respectively. One isolate of *Pseudomonas viz.,* P22 (isolated from rhizosphere of sorghum production system of A.P) and GASRB4 and HASRB25 *Bacillus* isolated from rhizosphere of sorghum production system of A.P were found to be promising plant growth promoters of sorghum in pot culture by 60% over control. Out of 74 isolates of *Pseudomonas,* P17, P74, P75 possessed more than 2 PGPR traits, of which P17 could promote growth of both sorghum and pigeonpea.

Solubilization of tri calcium phosphate by 74 *Pseudomonas* isolates was studied *in vitro* after 7 and

P22 P23 Control

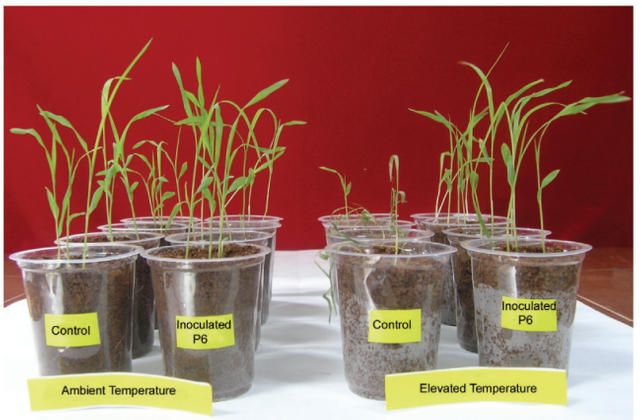
Strains of *Pseudomonas* showing plant growth promotion in sorghum

Table 25: Details of *Pseudomonas* and *Bacillus* isolates causing significant growth increment of sorghum and pigeonpea seedlings in paper cups containing sterile soil (15 days after sowing)

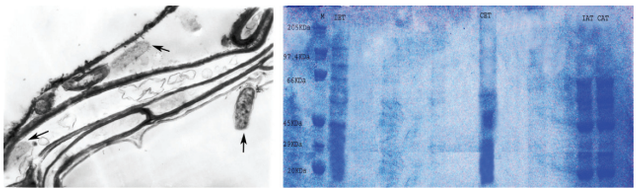
Isolates	Isolates showing growth promotion (increase over control)		
	<25%	25-50%	>50%
Sorghum			
Pseudomonas spp.	6 Isolates	16 isolates	P1, P2, P4, P13, P14, P17, P28, P29, P35 (9)
Bacillus spp.	20 isolates	9 isolates	GASRB7, HARRB33, HARRB37, GASRB16 (4)
Pigeonpea			
Pseudomonas spp.	19 Isolates	3 isolates	P17, P31, P35, P57-60, P62-P71, P73, P75 (19)
Bacillus spp.	18 isolates	7 isolates	GASRB7, HARRB33, HARRB37, GASRB16, SVSuRB74 (5)

HASRB25 GASRB4 GASRB5 GASRB11 Control

Strains of *Bacillus* showing plant growth promotion in sorghum



Fifteen day old sorghum seedlings grown at ambient and elevated temperatures inoculated with *P. putida* (P_6)



Root section of sorghum seedlings (left) under TEM inoculated with *P. putida* (P_6), showing the presence of bacterial cells inside the roots. High molecular weight proteins (right) induced in leaves of sorghum seedlings grown at elevated temperatures and inoculated with *P. putida* (P_6). (CET= Control at elevated temperature; CAT= Control at ambient temperature; IET= Inoculated at elevated temperature; IAT= Inoculated at ambient temperature; M= Marker)

14 days. The list of some promising isolates is shown in Table 28. Out of 64 isolates for phosphate solubilization by liquid medium assay, 56 were efficient, 6 isolates showed an efficiency of more than 50%. Out of 28 isolates of *Bacillus,* GASRB13 showed maximum solubilization efficiency of 23%. Out of 74 isolates of *Pseudomonas*, 2 were cellulase-producers, 23 were protease-producers, 18 were chitinase-producers, 12 were HCN-producers, 38 isolates were positive for both IAA and gibberellic acid production, 4 were strong producers of ammonia and all isolates except 11 could grow in nitrogen-free medium.

2.3.6.3 Microorganisms for enhancing abiotic stress tolerance in plants

From millet growing regions of 11 states covering arid/semi arid regions, 129 strains of AIMS were isolated and characterized. Promising isolates of drought and high temperature stress (beyond 25% PEG and 50°C) were identified. Preliminary studies indicate that the EPS production enhanced significantly under stress conditions in all the strains. Seed bacterization with stress tolerant strains of *Pseudomonas* (strain P6) helped sorghum and pearl millet seedlings to survive at 50°C up to 21 days. The strain P6 was characterized and identified as *Pseudomonas putida* by 16S rDNA profiling. Seed inoculation also induced synthesis of a novel high molecular weight protein. Role of this protein in offering protection to seedlings against abiotic stresses is being investigated. Less electrolyte leakage in inoculated plants suggested protection of membrane integrity of cell by bacterium. Inoculation also reduced the oxidative stress in seedlings exposed to high temperature (50°C) as evidenced by significantly lower anti oxidative enzyme activity in treated seedlings. Electron micrograph of

sorghum roots inoculated with P6 strain indicated the entry of the organism inside the roots.

2.3.6.4 Utilization of candidate microbial isolates for management of dryland insect pests

Microbial based pest control is an eco-friendly approach for pest management in dryland crops. Potential microbial isolates belonging to insect pathogenic bacteria and fungi have been isolated from dryland soils for use in pest management. A project was taken up in 2007 aiming at characterization of isolates, developing cost effective and standardized mass production techniques for wide spread availability and testing their potential under field conditions in castor, groundnut and pigeonpea.

Table 26. Biochemical characterization of *Bacillus thuringiensis* (Bt isolates)* from different dryland locations

S. No	Bt isolate	Protease production	HCN production	Protein production (mg/ml)
1	Uda1	+	-	16.0
2	Uda2	+	-	9.5
3	Uda4	+	-	28.0
4	Uda5	+	-	11.5
5	Uda7	+	+	13.5
6	Uda35	+	-	16.7
7	His4	+	-	13.7
8	Fzb2	-	-	25.0
9	Fzb3	+++	-	7.8
10	Fzb14	+	-	33.5
11	Fzb19	+	-	21.5
12	Rkt2	+	-	12.5
13	Arj10	+	+	40.0
14	Arj11	-	-	23.7
15	Arj16	+	-	35.0
16	Bng1	-	-	22.5
17	4D1(*BtK*)	+	-	7.8

Bacillus thuringiensis

Thirty isolates of *Bacillus thuringiensis* (Bt) isolated from dryland soils and tested through insect bioassays were further characterized for protein, protease and HCN production and compared with a standard strain (BGSC 4D1 Btk). Sixteen isolates produced more protein than the standard (Table 26). The Uda isolates previously reported to possess broad spectrum activity against key pests (semilooper, *Helicoverpa* and *Spodoptera*) turned out to be high protein producers. Three isolates were protease negative while one isolate (Fzb3) was prolific in terms of protease production. Two isolates (Uda7 and Arj10) were positive for HCN production. Based on these results, Uda7 was short listed for further detailed studies.

Beauveria bassiana

Effect of different incubation and drying times were studied for production of aerial conidia of *Beauveria bassiana* (Bb-913) fungal biopesticide on wheat bran solid substrate in autoclavable bags with aeration. The highest spore production (12.7 g spore / bag) was achieved with 7 days of incubation time and 7 days of drying (Table 27). The method yielded 23% more spore per kg of substrate over 5-day incubation time.

Table 27: Effect of incubation and drying time for spore production of *Beauveria bassiana* (Bb-913) strain through solid state fermentation protocol on wheat bran

Incubation time (days)	Drying time (days)	Mean spore production/ bag (g)	Spore produced per kg of substrate (g)
5	8 days	9.2	61.6
6	8 days	11.7	78.2
7	7 days	12.7	84.6
8	6 days	11.1	74.0

Field testing of *Bacillus thuringiensis*

Castor (DCS-9) and pigeonpea (PRG 100) were grown during *kharif* 2007, the first year of the project, with five treatments comprising candidate dryland isolates of *Bacillus thuringiensis* (Bt): 1. Bt-29b 2. Bt-48b 3. Bt-50c 4. Bt-50c-1 5. Bt-102-R3j and compared with untreated control and insecticide spray. Three sprays were applied during the season depending on the semilooper incidence and their efficacy was compared. Candidate

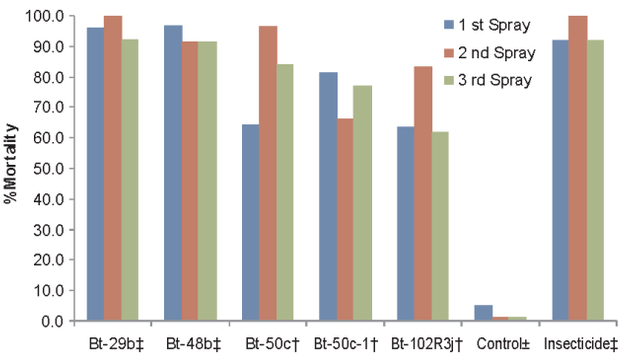


Fig 21. Field efficay of candidate *Bacillus thuringiensis* (Bt) isolates from dryland soils against semilooper, *Achaea janata* L. on castor (Isolate names on horizontal axis followed by same symbols are not significantly different from each other after DMRT on pooled data)

Bt isolates fell into two efficacy groups based on field performance against semilooper on castor. Efficacy of two Bt isolates (Bt 29b and Bt 48b) in terms of semilooper population reduction was consistently high (>90%) in all the 3 sprays and was comparable to insecticide sprays (Endosulfan 0.07%). The other three isolates resulted in a mean mortality between 70-80% (Fig 21).

2.3.7 Model farming systems

2.3.7.1 Farming system modules for marginal and small farmers of nutritive cereal based production system for Southern Telengana Zone of Andhra Pradesh

Southern Telangana Zone of AP is characterized by recurring droughts, degraded lands and sub optimum use of restorer inputs leading to low and uncertain productivity. The rainfed farming system in this area is dominated by the presence of small and marginal farmers (70%). Low productivity and lack of year round employment is leading to migration of the work force and even small farmers to urban areas. The small farmers are unable to meet both ends with income from crop activity alone. Hence, there is a need to integrate crops, livestock pasture and trees on farming system mode for stability of production, income and livelihood improvement. In this context, efforts were made to study the dairy and horticulture based farming system modules in Shabad Mandal of Ranga Reddy district during this year. Simultaneously, on-station model in 1.12 ha area was

Table 29. Yield and economics of on-station farming system module at HRF 2007-08 (1.15 ha area)

Enterprise	Area (Sq. m.)	Yield (kg/plot)		Net Income (Rs./plot)
		Grain	Fodder	
Arable Crops				
Sorghum + Pigeonpea	900	117+62	1545	1739
Castor	988	60		196
Sorghum + Pigeonpea	920	139+69	1620	2039
Castor	882	55		197
Soybean - Horsegram	1035	116	60+100	1272
Total:	4725		1780	5443
Agroforestry				
Pongamia + Veg cowpea	1166	0+63		440
Amla + Horse gram	1530	0+61	130	558
Custard apple	800	646+0		354
Fig in between vegetables	400	20		200
Total:	3496		130	1552
Vegetables	1150			1926
Grasses				
Cenchrus	800	-	716	905
Stylo	256	-	448	93
Lemon grass	200	-	725	13
Total:	1256		1889	1011
Bushes				
Curry leaf	545		30	170
Jatropha	345	10		-40
Total:	890	10	30	130
Henna (Border)	290 mts.		984 (196)	388
Grand Total	11,157			10,433

Table 30. Yield and economics of on-station farming system module covering 1.15 ha at HRF (Data represent mean of 2005-08)

Enterprise	Area (Sq. m.)	Yield (kg/ plot)		Net Income (Rs./plot)
		Grain	Fodder	
Arable Crops				
Sorghum+pigeonepa	900	99+46	483	1322
Castor+ Clusterbean	988	52+149	—	226
Sorghum/Pearlmillet + pigeonpea	920	227+84	307	1506
Castor	882	46	—	184
Sunflower/Soybean-Horsegram	1035	86-30	188	499
Total:	4725			3737
Agroforestry				
Pongamia + legume (veg. cowpea)	1166	0+30	89	36
Amla + Horsegram	1530	0+72	116	-444
Custard apple	800	693	—	1214
Fig between vegetables	400	20	—	200
Total:	3496			1006
Vegetables	1150	—	—	2665
Grasses	1256	—	1063	696
Bushes	890	—	—	1301
Henna (Border)	290 mts		984 (194)	388
Grand Total:	11517			9793

implemented on watershed basis in CRIDA Research Farm.

Studies of the farming system modules on micro watershed basis during 2007-08 showed that the combination of arable crops, agro-forestry, vegetables, bushes and grasses in 1.12 ha recorded a net income of Rs. 10,433/- with BC ratio of 1.72. Among various components, crops in 0.47 ha registered 52.09 % of the net income in watershed area. Agro-forestry (0.35 ha), vegetables (0.1150 ha), grasses (0.1256 ha) and bushes (0.089 ha) contributed 15, 18.43, 9.67, 4.95% of net income of watershed based farming system module respectively. The farming system module in the watershed generated 3 tons of dry fodder, which is sufficient to feed one diary animal per year (Table 29).

The results over the years (2005-08) indicated that a farming system module (1.15 ha area) with arable crops (0.4725 ha), agro-forestry options (0.3496 ha), vegetables (0.1150 ha), grasses (0.1256 ha) and bushes (0.0890 ha) gives a gross income of Rs. 16080/-, a net income of Rs. 9793/- and a BC ratio of 2.38. The enterprises of arable cropping, agro-forestry, vegetables, grasses and bushes contributed to the net income by 38.16, 10.27, 27.21, 7.11 and 17.25 % (Table 30).

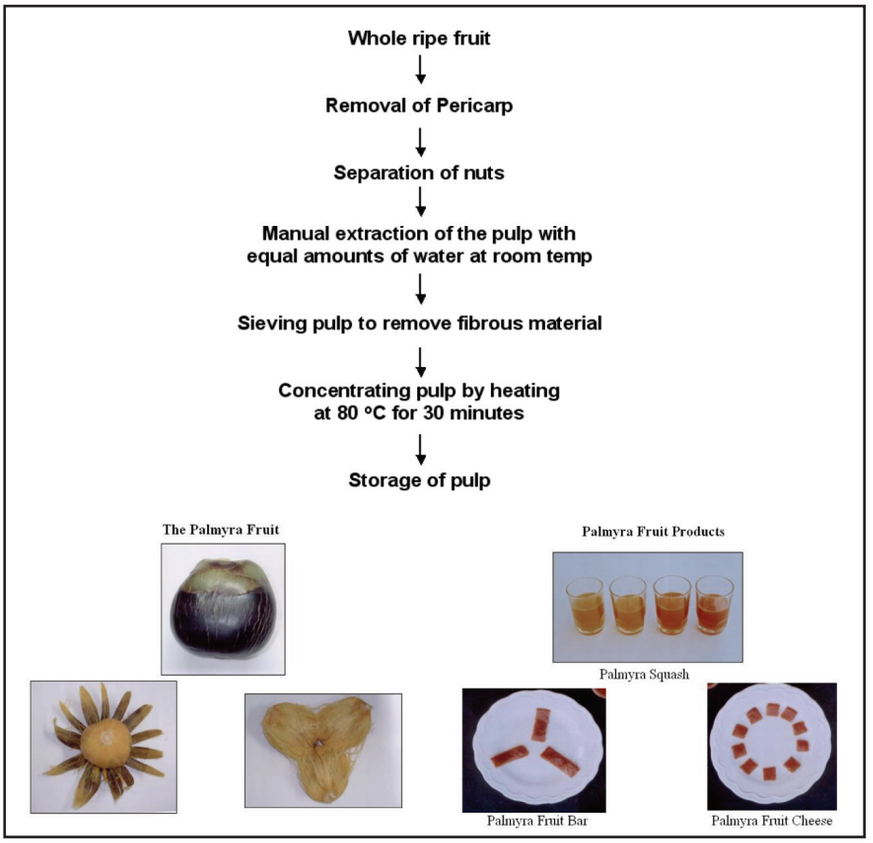
2.3.8 Value addition

2.3.8.1 Studies on enrichment of quality and utilization of Palmyra fruit in Ranga Reddy district

Palmyra palm fruits were collected from surroundings of Hyderabad and Rangareddy districts during the months of June and July 2007. Papaya, pineapple and guava were procured from local market. Mature, firm, ripe palmyra fruits were harvested manually directly from the palms. The fruits were thoroughly washed before extraction of pulp. The following flow chart shows extraction of palmyra pulp.

Jam, squash, fruit bar and fruit cheese were prepared with palmyra fruit pulp in combination with papaya, pineapple and guava pulp with different proportions / blends to enhance the sensory quality of the finished product. The different combinations of the fruit blends were:

1. Palmyra fruit pulp 100%
2. Palmyra fruit pulp 90% + Papaya pulp 10%
3. Palmyra fruit pulp 80% + Papaya pulp 20%



Palmyra fruit and fruit based products

4. Palmyra fruit pulp 60% + Papaya pulp 40%
5. Palmyra fruit pulp 70% + Papaya pulp 20% + Pineapple pulp 10%
6. Palmyra fruit pulp 70% + Papaya pulp 20% + Guava pulp 10%

The products prepared with blends of 20 and 40% papaya, pine apple and guava pulp 10% each and mixed fruit pulp in the ratio of 10% (pineapple), 10% (guava) and 20% (papaya) were suitable for acceptable product development. Palmyra squash was fortified with Roselle extract to impart good colour to the product. These studies show that the palmyra fruit can be processed effectively into different value added products in combination with papaya.

2.4 Soil and nutrient management

2.4.1 Integrated Nutrient Management

2.4.1.1 Low tillage and INM strategies for semi-arid tropics

A long-term experiment was initiated in 1998 at HRF, CRIDA with the objective of identifying effective Integrated Nutrient Management (INM) treatments and improving organic matter and soil quality. In 2007, the 10th year of the study, sorghum (SPV 1616) and green gram (ML-267) were grown as test crops. The experiment was conducted in a strip plot design with two tillage (conventional (CT) and reduced (RT)) 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. The results obtained in 2007 are as follows:

The grain yields of sorghum ranged between 869 to 1890 kg ha^{-1} across the treatments while the greengram yield varied from 763 to 1213 kg ha^{-1} (Table 31).The influence of tillage was not conspicuous on sorghum as well as greengram yields. Considering the effects of INM treatments averaged over tillage, all the treatments significantly improved the yields of both the crops over control. As all the treatments were designed equivalent to 40 kg N ha^{-1} in case of sorghum and 20 kg N ha^{-1} in case of green gram, their performance among themselves during this year remained at par. However, the highest average grain yields of both sorghum (1840 kg ha^{-1}) and

Table 31: Effect of INM treatments on sorghum and green gram grain yields and agronomic efficiency

Tillage	INM Treatments	Sorghum		Green gram	
		Grain yields (kg ha^{-1})	Agronomic efficiency kg grain kg^{-1} N	Grain yields (kg ha^{-1})	Agronomic efficiency kg grain kg^{-1} N
Conventional	T1	869	-	763	-
tillage	T2	1613	19	877	6
	T3	1774	23	1110	17
	T4	1890	26	1069	15
	T5	1734	22	1180	21
Minimum	T1	917	-	867	-
tillage	T2	1701	20	1039	9
	T3	1737	21	1093	11
	T4	1789	22	1213	17
	T5	1673	19	1087	11
LSD	Tillage means	291.1		254.3	
(0.05)	Treatment means	124.6		143.4	
	Treatment means at same tillage	176.2		202.8	
	Treatment means at same or different tillage	213.1		220.4	

greengram (1141 kg ha^{-1}) were recorded in case of 2 t gliricidia loppings + 20 kg N though urea (T4). Further, interactions between tillage and INM treatments were also found to be significant. On an average, the increase in sorghum grain yields as influenced by INM treatments over control varied from 86 to 107 per cent, whereas, in case of green gram, the extent of increase in yield was 18 to 40 per cent.

The agronomic efficiency of the treatments in case of sorghum crop varied between 19 to 26 kg grain kg^{-1} N while in case of green gram, it ranged between 6 and 21 kg grain kg^{-1} N. On an average, among the INM treatments, highest agronomic efficiency of 24 kg grain kg^{-1} N was recorded under 2 t gliricidia loppings + 20 kg N through urea (T4) in case of sorghum, while in case of green gram, both T4 (1 t gliricidia loppings + 10 kg N through urea) and T5 (2t compost + 1t gliricidia loppings) performed on par in recording higher agronomic efficiency of 16 kg grain kg^{-1} N.

Conclusively, conventional tillage maintained 15 and 35 per cent higher yields of sorghum and green gram over reduced tillage respectively. In case of sorghum , 2 t gliricidia loppings + 20 kg N through urea (T4) recorded the highest per cent increase (107 %) in yield over control. While in case of green gram , both T4 (1 t gliricidia loppings + 10 kg N through urea) and T5 (2t compost + 1t gliricidia loppings) were at par in increasing the green gram yields to an extent of 40 per cent over control.

2.4.1.2 Management of soil fertility related constraints for higher productivity and profitability

Soil fertility is one of the important components of soil health that influences the productivity of crops and cropping systems under rainfed condition. Imbalanced nutrition and soil erosion result in deterioration in soil fertility resulting in decreased yield and profitability. Hence, this study was planned to diagnose the soil fertility related constraints affecting the productivity and profitability of crops and to quantify the response of test crops to the addition of limiting nutrient(s) in Machanapalli

Table 32: Mean yield of maize and cotton under different nutrient management practices in farmers field

Treatment	Mean yield q/ha (average of 5 locations)	
	Maize	Cotton
Farmers practice	32	7.8
Recommended NPK + zinc sulphate	45	9.5
Per cent increase over farmers practice	30	18

village of Rangreddy district, Andhra Pradesh which is a KVK adopted village of CRIDA.

For identifying the soil fertility related constraints, composite surface soil samples (0-15 cm) were collected from farmers' fields of Machanapalli village during March 2007 and were analyzed for various parameters. Results revealed that about 80% of the samples were either low or medium in available nitrogen and about 58% of the samples were deficient in available zinc. There was also a build-up of available phosphorus as about 60% of the samples tested were high. Based on the soil test results, it was inferred that the soils of Machanapalli were deficient in available nitrogen and zinc and crops might be suffering from P induced Zn deficiency.

In order to overcome these constraints and to quantify the response of test crops to application of limiting nutrients, ten on-farm trials were conducted in Machanappalli village during the *kharif* 2008 with maize and cotton as test crops (five each in maize and cotton). The treatments used for the study were a) farmer practice (maize and cotton 1bag DAP plus one bag urea after 35-40 DAS); b) recommended NPK (maize = 120:60:50 kg/ha NPK; cotton = 90:60 NP kg/ha) plus zinc sulphate (50 and 25 kg/ha of zinc sulphate for maize and cotton, respectively). These treatments were imposed in the farmers' field in an area of 0.4 ha. All other agronomic practices recommended for maize and cotton were carried out uniformly for both the treatments. The mean yield of maize in treatment receiving recommended dose was 45q/ha whereas it was only 32 q/h under farmer's practice (Table 32). Similarly, cotton yield increased by 18% over the farmers practice due to application of recommended dose of NPK + $ZnSO_4$ @ 25kg/ha. It can be inferred that by the application of recommended dose of NPK and the limiting nutrient (Zinc), it is possible to enhance the yield of cotton and maize by 18 and 30%, respectively.

2.4.1.3 Impact of INM on soil health and quality of niger (*Guizotia abyssinica*)

An experiment was initiated at HRF during kharif 2005 to study the effect of INM on the grain yield and oil content of niger, soil quality and economics. There were 6 treatments viz., T1 - Control; T2 – RDF (Inorganic); T3 - RDF (Organic); T4 - RDF (50% inorganic + 50% organic); T5 - T2 + 15 kg S/ha; T6 - T3 +15 kg S/ha. The recommended dose of fertilizer (RDF) was basal application of 30-30-10 kg NPK/ha and top dressing with 20 kg N/ha at 40 DAS.

In 2007, significant difference in crop performance

Table 33. Dry matter at 75 DAS, seed yield, stalk yield, oil content in seeds and oil yield (kg/ha) of niger with different nutrient management practices

Treatment	Yield (kg/ha)	Stalks (q/ha)	Dry matter at 75 DAS (g/plant)	Oil content in seed (%)	Oil yield (kg/ha)
T1	185	13.5	9.4	36	67
T2	380	19.3	13.6	36	137
T3	425	21.4	18.2	37	158
T4	540	26.8	25.8	37	200
T5	435	19.4	21.1	37	161
T6	465	21.2	21.5	37	172
CD (5%)	53.4	3.24	2.3	NS	18.2

Table 34. Economics of niger cultivation, HRF, kharif 2007

Treatments	Cost of Cultivation (Rs/ha)	Gross Income (Rs)	Net Income (Rs)	BC Ratio
T1	2700	3340	640	1.23
T2	3200	6840	3640	2.14
T3	4400	7650	3250	1.74
T4	4000	9720	1720	2.43
T5	4700	7830	3130	1.67
T6	39000	8370	4470	2.14

Table 35. Seed yield and oil yield of niger with different nutrient management practices at HRF (Data represent mean of 3 years, 2005-07)

Treatment	Seed yield				Oil yield			
	2005	2006	2007	Mean	2005	2006	2007	Mean
T1	246	156	185	196	91	58	67	72
T2	497	322	380	400	182	117	137	145
T3	549	353	425	442	205	126	158	163
T4	787	455	540	594	288	167	200	218
T5	707	385	435	509	256	141	161	186
T6	780	420	465	555	283	154	172	203

Nutrient supply through organics has clear advantage over chemical fertilizer in niger

was observed with treatments. T4 resulted in higher dry matter accumulation, LAI, seeds/plant, seed and oil yield (kg/ha), gross returns, net returns and BC ratio (Tables 33 and 34). Supply of nutrients through vermicompost (T3) depressed net income and BC ratio due to its high cost. Application of 15 kg/ha sulphur along with RDF recorded 55 and 40 kg/ha additional seed yield over exclusive application of nutrients either through inorganic (T2) or organic (T3) sources.

Pooled analysis of results of 3 years (Table 35) showed that application of 50% of recommended dose of NPK through chemical fertilizers + 50% recommended N through vermicompost (T4) gave the highest seed yield as well as oil yield of niger, followed by 100% recommended N through vermicompost + 15 kg S/ha (T6).

2.4.2 Soil quality improvement

2.4.2.1 Organic carbon assessment and maintenance in rainfed production systems

Soil organic carbon content is one of the indices of sustainability in rainfed agriculture. To assess organic carbon and its maintenance through various agronomic/ INM options in dominant rainfed production systems, a project was initiated in 2005. During the year 2007, treatment wise soil profile samples (at five depths 0-20, 20-40, 40-60, 60-80 and 80-100 cm) under Permanent Manurial Trials at two network centers under AICRPDA viz., Indore (1992-2008).and Varanasi (1986-2008), were collected and analyzed for various physical, chemical and biological parameters. At Indore (Soybean based production system), the treatments were:T_1-Control; T_2-20 kg N + 13 kg P; T_3-30 kg N + 20 kg; T_4-40 kg N + 26 kg; T_5-60 kg N + 35 kg P; T_6-FYM 6t/ha + N20P13; T_7-Soybean residue 5t/ha + N20P13; T_8-FYM@6t/ha; T_9-Crop residues of Soybean @ 5t/ha and at Varanasi, the treatments consists of T_1-Control; T_2-100% RDF (inorganic); T_3-50% RDF (inorganic); T_4-100% organic (FYM); T_5-50% organic (FYM); T6-50% RDF+ 50%(foliar); T_7-50% organic (FYM)+ 50%RDF; T_8-Farmers practice. At Indore, application of organic manures in conjunction with inorganic fertilizers showed positive effect on available moisture content of the soil. In all the treatments, soils were in alkaline reaction, pH remained unchanged, profile EC increased compared to control. Salinity increased with depth in all the treatments. There was slight increase in CEC (54.62 meq/100g soil) with the application of 30 kg N + 20 kg P. Slight improvement in organic carbon status was noticed in all the treatments. Build up of organic carbon in INM treatment in surface layers (0-20 cm) increased when compared to control. Particulate organic carbon (%) increased significantly with the application of FYM. It decreased with increasing depths. Microbial biomass carbon (mg/g) was improved significantly in all the treatments. This increment was more with the use of crop residue. In most of the cases higher MBC content was found in surface (0-20 cm) and subsurface (20-40 cm) soils. This may be due to declining presence of microorganisms in lower depths of the profile. Dehydrogenase, aryl sulfatase and urease activity were increased in all the FYM treatments compared to control (Fig 22).

At Varanasi, slight improvement in water retention was observed in all the treatments and increased

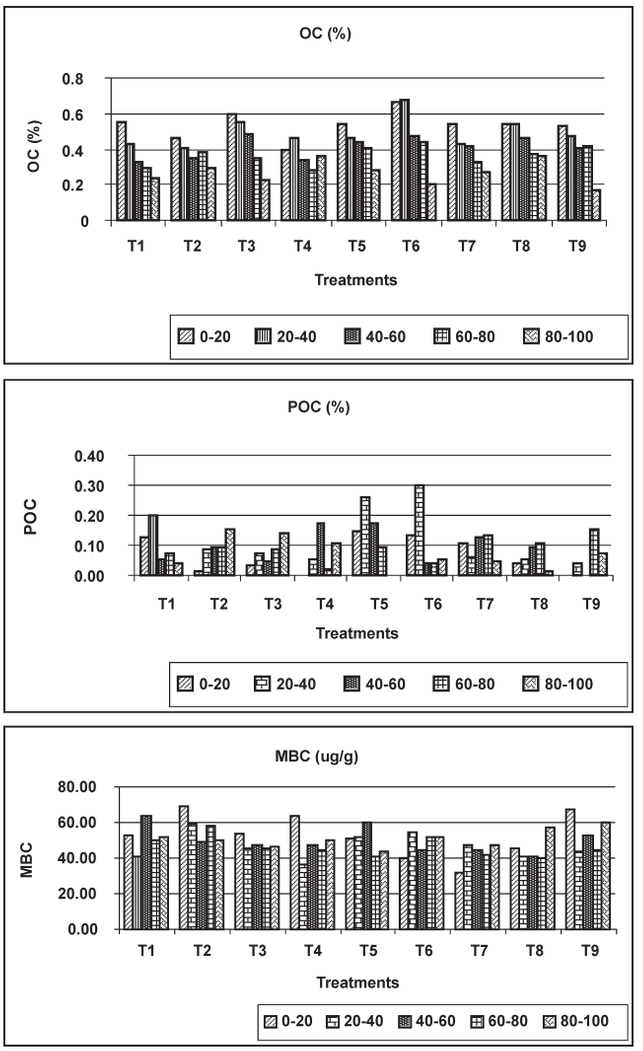


Fig 22. Effect of 15 years long term cropping, fertilization, FYM and crop residue addition on organic carbon (%), particulate organic carbon (%) and microbial biomass carbon (ug/g) in Vertisols at Indore.

(17.72%) with the application of 100% organic manures. Increase in EC was observed in all the treatments but more (0.11dS/m) in treatments including 100% FYM application (Fig 23). It decreased with increasing depth. The observed increase in $CaCO_3$ content with depth of the profile indicates presence of calcareous layer in lower depths (80-100cm). There was slight increase in CEC with the application of FYM treatments over control. Build up of organic carbon in surface layers (0-20 cm) is conspicuous with the application of FYM. Particulate organic carbon (%) increased significantly in all the treatments. It decreased with increasing depth. Microbial biomass carbon content also improved significantly in all the treatments compared to control. In most of the cases higher MBC content was found in surface soil (0-20 cm). This may be due to declining presence of microorganisms in lower depths of the profile.

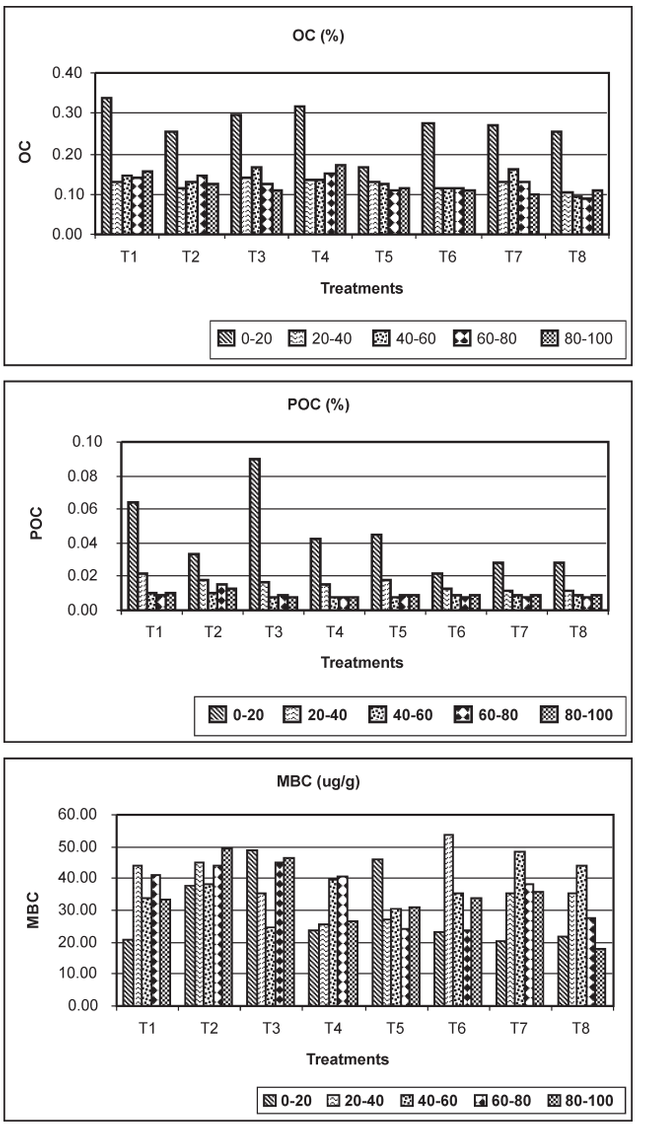


Fig 23. Effect of long term rice-lentil cropping sequence, fertilization, FYM addition on organic carbon (%), particulate organic carbon (%) and microbial biomass carbon (ug/g) in Inceptisol at Varanasi

Dehydrogenase, aryl sulfatase and urease activity were increased in all the treatments compared to control. Urease activity was more in the combined application of FYM and fertilizers.

2.4.2.2 Assessing soil quality key indicators for development of soil quality index under predominant management practices in rainfed agroecology

To assess the effects of soil and nutrient management practices such as tillage, fertilizer levels, conjunctive use of organics and inorganic sources of nutrients, application of herbicides, varying crop rotations, etc., on soil quality, a project initiated in 2005 to study the effect of key management practices like tillage,

fertilizer, residue application, green manuring, biofertilisers, herbicides, crops, cropping system, etc., on physical, chemical and biological parameters of soil, and to develop integrated soil quality index for delineating degradative and aggradative practices / systems. The results of the soil quality studies carried out for Indore AICRPDA centre are presented this year. Three main long-term ongoing experiments were adopted for the study.

Experiment 1: Integrated plant nutrient supply system: Soil samples were collected from ongoing long-term cropping systems viz., sole maize, maize + soybean and sole soybean systems. The treatments followed were: T1: Control, T2: 100% RDF (80:60:20), T3: 50% RDF (40:30:10), T4: 40 kg N through compost / FYM, T5: 20 kg (compost) + 20 kg N(urea) as top dressing, T6: 20 kg N (compost) + 20 kg N (urea)+ Azotobacter @ 2 kg /ha, T7: 20 kg (gliricidia) + 20 kg N(urea) as top dressing, T8: 20 kg N (gliricidia) + 20 kg N (urea)+ Azotobacter @ 2 kg /ha, T9: 20 kg (compost) + 20 kg N (gliricidia), T10: 20 kg (compost) + 20 kg N (gliricidia) + 10 kg N (urea), T11: 10 kg (compost) + 20 kg N (gliricidia) + 10 kg N (urea), T12: 10 kg (compost) + 10 kg N (gliricidia) + 20 kg N (urea) + Azotobacter @ 2 kg /ha.

Experiment 2: Long term manurial trial: Soybean (JS 335) followed by safflower were used as test crops. The INM treatments followed under this study for each crop were : T1: Control, T2: 20 kg N + 13 kg P, T3: 30 kg N + 20 kg P, T4: 40 kg N + 26 kg P, T5: 60 kg N + 35 kg P, T6: FYM 6 t ha^{-1} + N20 P13, T7: Soybean residue 5 t ha^{-1} + N20 P13, T8: FYM 6 t ha^{-1} – FYM @ 6 t ha^{-1}, and T9: Soybean residue 5 t ha^{-1}.

Experiment 3: Low till farming system: Soybean (JS-335) was test crop. The treatments followed were: T1: Conventional tillage (CT) + recommended dose of fertilizer (RDF) + hand weeding (HW), T2: CT+ RDF + off season tillage (OT) + HW, T3: LT+ 4 t ha^{-1} straw + HW, T4: LT+ 4 t ha^{-1} straw + herbicide, T5: LT+ 4 t ha^{-1} compost + HW, T6: LT+ 4 t ha^{-1} compost + herbicide, T7: LT+2 t ha^{-1} gliricidia + herbicide and T8: LT+2 t ha^{-1} gliricidia + HW.

In all these experiments, soils were analyzed for 19 different physical, chemical and biological indicators and the treatments were evaluated for their relative influence on soil quality using deviation method with appropriate scoring technique.

In experiment 1, out of the 12 treatments evaluated under sole maize system, 20 kg (compost) + 20 kg N (gliricidia) + 10 kg N (urea) recorded the highest RSQI of 1.00 followed by 40 kg N through compost / FYM (RSQI 0.90) and found superior. In case of maize, (when maize plots were sampled in maize + soybean system), application of 20 kg (compost) + 20 kg N (gliricidia) + 10 kg N (urea) recorded the highest RSQI of 1.00. This was followed by 40 kg N through compost / FYM; 20 kg (compost) + 20 kg N (gliricidia) and 10 Kg (compost) + 20 kg N (gliricidia) + 10 kg N (urea) with similar RSQI of 0.86. In case of soybean, (when soybean plots were sampled in maize + soybean system), 20 kg N (compost) + 20 kg N (urea) + Azotobacter @ 2 kg ha^{-1} recorded the highest RSQI of 0.99 followed by 40 kg N through compost / FYM (RSQI of 0.94). Under sole soybean system, application of 10 Kg (compost) + 10 kg N (gliricidia) + 20 kg N (urea) + Azotobacter @ 2 kg /ha, and 10 Kg (compost) + 20 kg N (gliricidia) + 10 kg N (urea) recorded highest RSQI of 0.96 and 0.95 respectively and maintained their superiority.

In experiment 2, out of the 9 INM treatments evaluated under soybean (JS 335) –safflower system, application of soybean residue @ 5 t ha^{-1} + N20 P13 recorded the highest RSQI of 0.97 followed by FYM 6 t ha^{-1} + N20 P13 (RSQI 0.87). In experiment 3, out of the 8 combination treatments comprising of tillage and soil nutrient management practices tested under soybean (JS-335) crop, practice of LT+ 4 t ha^{-1} compost + HW recorded the highest RSQI of 0.91 followed by LT+ 4 t ha^{-1} compost + herbicide with RSQI of 0.85 and established their superiority in improving the soil quality.

2.4.2.3 Assessment and improvement of soil quality and resilience in a watershed-scale under rainfed agroecosystem using GIS and remote sensing

Considering the importance of maintaining soil quality in rainfed agroecosystem, an investigation was initiated in 2006 on watershed scale by integrating the information collected from fields and landscapes using terrain analysis methods and the soil management framework. Sakali Seripalli micro-watershed (63 km from Hyderabad) in Chintapalli mandal of Nalgonda district in Andhra Pradesh was selected for this study. The watershed lies in between 16^0 91' and 16^0 92' North latitudes and 78^0 74' and 78^0 75' East longitudes. The elevation ranges between 427 and 517 meters above

Table 36a. Mean, minimum, maximum and coefficient of variance (CV) of all the soil parameters collected from watershed

Parameter	Mean	Min. Value	Max. Value	CV%
Organic carbon%	0.510	0.204	0.984	38.802
pH	7.44	6.492	8.581	7.165
Electrical Conductivity (dS/m)	0.129	0.044	0.734	82.759
Available N kg/ha	181.610	112.896	301.056	26.092
Available P (kg/ha)	14.414	1.564	67.492	84.126
Available K (kg/ha)	272.242	83.888	611.408	34.095
Cation Exchange Capacity (meq/100g soil)	12.66	3.58	36.95	51.95
Ca (meq/100g)	1.303	0.205	3.380	62.961
Mg (meq/100g)	0.491	0.080	0.976	54.529
S (mg/kg)	21.717	4.163	81.417	76.072
DTPA extractable Zn (ppm)	0.532	0.138	1.540	48.771
DTPA extractable Cu (ppm)	0.586	0.156	2.848	64.533
DTPA extractable Fe (ppm)	10.859	0.078	53.922	86.483
DTPA extractable Mn (ppm)	13.847	0.031	43.337	50.865
Available B (ppm)	0.266	0.094	0.540	32.796
Exchangeable sodium percentage (%)	7.917	2.033	25.155	55.060
% silt	5.730	2.000	40.288	108.435
% clay	20.285	8.836	39.888	33.247
% sand	9.850	38.240	87.660	13.313
0.1 bar % of moisture (w/w%)	14.204	5.771	39.363	34.559
0.3 bar % moisture(w/w%)	10.456	6.127	18.013	22.689
15 bar % moisture(w/w%)	4.091	1.307	9.973	40.187
Available water capacity (w/w%)	6.364	2.438	9.965	21.406
Mean weight diameter (mm)	0.047	0.007	0.243	79.110
Final Infiltration rate (cm/h)	0.668	0.08	1.975	70.364
Active carbon (mg/kg)	245.563	57.461	367.151	32.705
Dehydrogenase activity (ug/g/hr)	7.141	0.041	22.751	58.622
Microbial biomass carbon (ug/g)	164.208	51.730	299.865	33.033

mean sea level (MSL). Differential GPS was used to delineate the ridgeline of the watershed.

A total of 113 soil samples were collected at 50 x 50 m grid interval and the grids were marked using differential GPS. Farmers' name and survey numbers were also noted for each sampling point. Twenty four soil physical, chemical and biological properties were analyzed for each sample. The range, mean and variability of soil properties are give in table 36.

Soil spatial variability was analyzed using semivariogram model. Based on the elevation for each sampling point as well as hillocks, slope and contour maps were generated (Fig 24 and 25). A soil health card was prepared for each farmer's field and distributed to farmers with recommendation considering soil related constraints. Four on farm experiments were initiated considering soil related constraints in the watershed.

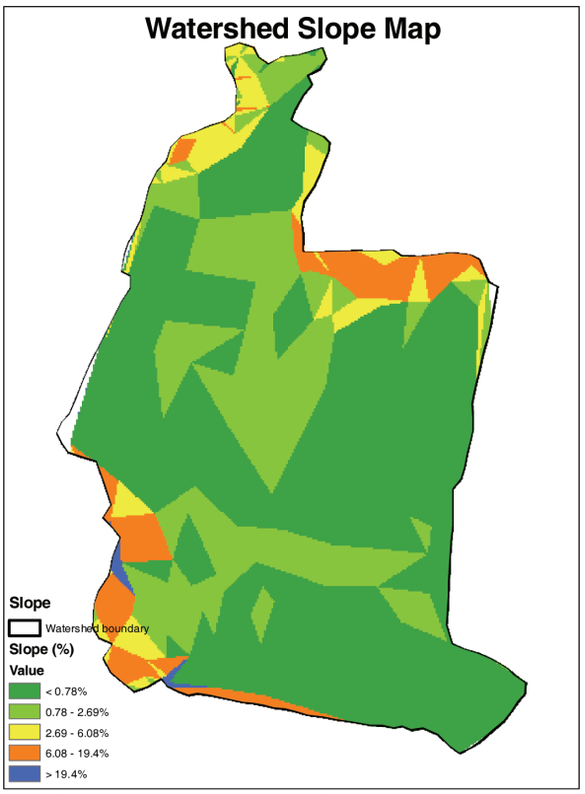


Fig 24. Slope map of the watershed Sakaliseripalli,Nalgonda district in Andhra Pradesh

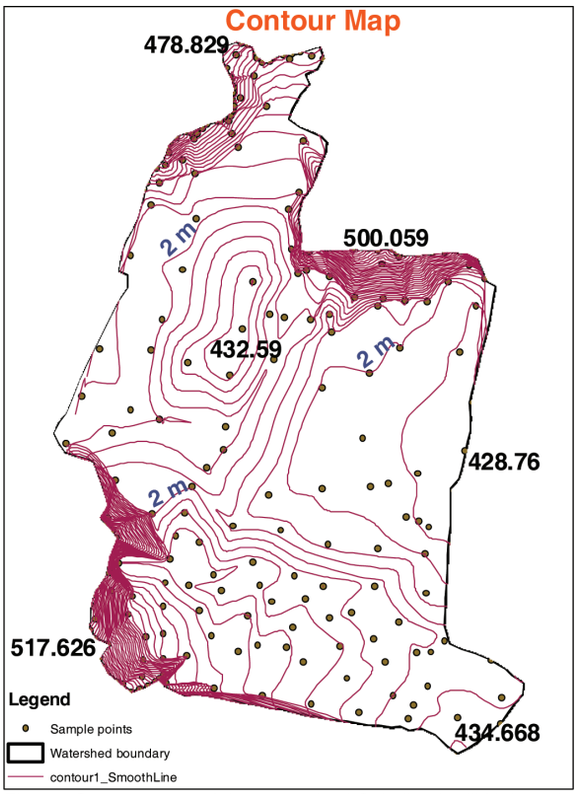


Fig 25. Contour map of the watershed Sakaliseripalli,Nalgonda district in Andhra Pradesh

2.4.2.4 Development of field kit for estimating labile carbon to assess the soil quality under different land use systems

A field kit for estimating labile carbon was developed using the principle that neutral dilute solutions of potassium permanganate ($KMnO_4$) and other chemicals react with most of the active organic matter and change the colour of $KMnO_4$ from deep purple colour to light pink or colourless. The lighter the colour of the $KMnO_4$ solution after reacting with soil, the greater is the amount of active or labile carbon and the better the soil quality. The procedure was tested on soils under different cropping systems as well as soil from the farmers' fields (Fig 26).

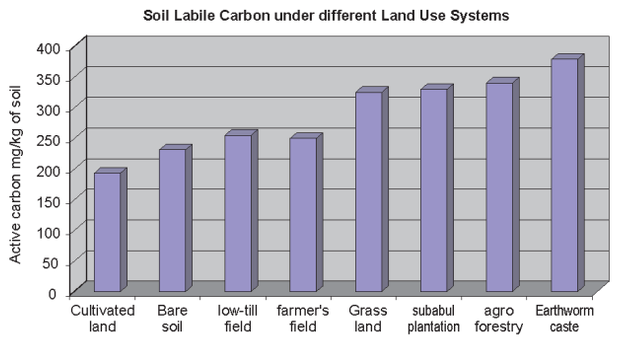


Fig 26. Soil labile carbon under different land use systems estimated using the field kit

The procedure was found suitable for samples analyzed immediately (within 1-2 days) after collection from the field. Results from stored samples didn't show good relationship with soil organic carbon, microbial biomass carbon and dehydrogenase activity.

2.4.2.5 Conservation agriculture and soil quality; Monitoring through ISQI

A study was initiated in 2005 i) to improve organic C content in soil and crop yields and ii) to evaluate the influence of existing long term soil and nutrient

Table 37. Effect of crop residue application on grain yield of sorghum crop (SPV 462)

Treatments	Grain yield kg ha^{-1}	% increase in grain yield over control
T1- Control	1878	—
T2-2 t ha^{-1} of sorghum stover	1882	0.51
T3- 4t ha^{-1} of sorghum stover	2020	7.98
T4-6 t ha^{-1} of sorghum stover	2242	19.79
CD @ 0.05 level	239.4	—

- Uniform fertilizer dose of N @ 60 kg ha^{-1} and 30 kg P_2O_5 were applied in all the treatments including control.

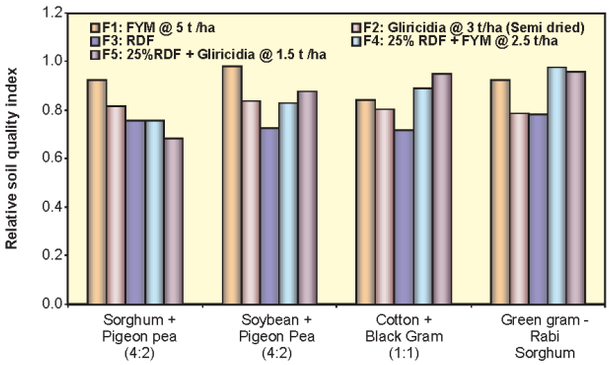


Fig 27: Effect of INM treatments on relatives soil quality indices under different cropping systems in Vertisols at Parbhani

management practices being followed at different rainfed regions on soil quality. To achieve the first objective, an experiment comprising of surface application of sorghum residues (0, 2, 4, 6 t ha^{-1}) in combination with uniform dose of 60 kg N/ha and 30 kg P_2O_5/ha with minimum tillage, was initiated during 2005 at Hayathnagar research farm. In 2007, sorghum (SPV 462) was grown as the test crop. To achieve the second objective, existing long-term experiments comprising of predominant soil and nutrient management practices followed at research centres of AICRPDA were used. This year, the results of Parbhani centre (Maharashtra) are presented. At this centre, seven integrated nutrient management (INM) treatments including two controls were tested under four different cropping systems viz., sorghum + pigeon pea (4:2) system, soybean + pigeon pea (4:2) system, cotton + black gram system (1:1) and green gram + rabi sorghum system. The INM treatments were as follows; F1: FYM@ 5 t ha^{-1}; F2: Gliricidia @ 3t ha^{-1} (semi dried); F3: RDF; F4: 25% RDF + FYM @ 2.5 t ha^{-1}; F5: 25% RDF + gliricidia @ 1.5 t ha^{-1}, F6: Control with rotation and F7: Absolute control without rotation. The soil samples collected after 5th year of the experiment under these systems were analyzed for predominant chemical, biological and physical soil quality indicators and relative soil quality indices (RSQI) were worked out using deviation method and appropriate ranking technique.

In the first experiment, during the year 2007, sorghum grain yield varied from 1878 to 2242 kg ha^{-1} across the treatments (Table 37).Surface application of 6 t ha^{-1} of sorghum residue recorded highest sorghum grain yield of 2242 kg ha^{-1} which was at par with application of 4 t ha^{-1} of sorghum residue (2020 kg ha^{-1}). The increase in sorghum grain yield over control under these two treatments was 19.8% and 7.98% respectively. While application of sorghum residue @ 2 t ha^{-1} increased the grain yield by 0.51% only.

In the second experiment, seven INM treatments in four predominant cropping systems at Parbhani center were evaluated through 19 soil quality indicators viz., pH, electrical conductivity, organic carbon, available N, P, K, exchangeable Ca, Mg, available S, available Zn, Fe, Cu, Mn, B, dehydrogenase assay, microbial biomass carbon, labile carbon, bulk density and mean weight diameter. Based on the relative soil quality indices (RSQI), the application of FYM @ 5 t ha^{-1} gave the highest RSQI in sorghum + pigeon pea system (RSQI 0.92) and soybean + pigeonpea system (RSQI 0.98). Under cotton + black gram system and green gram – rabi sorghum systems, the integrated use of 25% RDF + gliricidia @ 1.5 t ha^{-1} and 25% RDF + FYM@ 2.5 t ha^{-1} gave RSQI as high as 0.98 and 0.95 respectively and proved superior (Fig 27).

2.5 Alternate land use systems

2.5.1 Agroforestry

2.5.1.1 Influence of different nutrient management practices and agroforestry systems on soil quality in rainfed regions

In rainfed regions, arable crop production is uncertain due to recurring droughts. Agroforestry (AF) systems for rainfed regions have very good ameliorative effects. The effect of different AF trees species on soil fertility is not well understood. A study was undertaken to find out the influence of different tree species of AF system on soil quality, performance of intercrops under tree species and influence of organic and inorganic sources of nutrients on growth and yield of trees in rainfed regions. Two arable crops viz., setaria (PS-4) and finger millet (GPU-28) were sown as sole crops and as intercrops with three tree species, viz., Amla (Anand-2), tamarind (PKM-1) and *Acacia senegal* (planted at 10m X 5m spacing in 1998). Sole trees of the above species were also maintained. Seven nutrient management practices, viz., vermicompost (VC), FYM, inorganic fertilizers (IF), VC + IF, FYM + IF, sunhemp in basin and castor cake were imposed on amla and tamarind.

Setaria grain yields were influenced significantly by the tree species. Setaria intercropped with *A senegal* yielded significantly higher than when the crop was intercropped with amla and tamarind (Table 38). However, the yield reductions were not high in this crop, as the yields with amla and tamarind were 80% of sole crop yield. Significantly higher straw yield of setaria was obtained in sole crop followed by intercrop with *A senegal*, tamarind and amla. The harvest index was significantly higher in

Table 38. Crop yields with different tree species-2007-08

Treatment	Grain Yield kg per ha	Straw yield			Harvest Index
		% of Sole	kg/ha	% of Sole	
Setaria as intercrop					
Amla	674	81	839	35	0.445
Tamarind	653	78	1097	46	0.373
A senegal	870	104	1407	59	0.382
Sole crop	835	100	2401	100	0.258
Mean	758		1436		
SEm ±	35		76		
CD (5%)	96		209		
Finger millet as intercrop					
Amla	577	23	2813	37	0.170
Tamarind	131	5	713	10	0.155
A senegal	1265	49	4631	62	0.215
Sole crop	2561	100	7506	100	0.254
Mean	1134		3916		
SEm ±	76		224		
CD (5%)	212		622		

Table 39. Soil organic carbon (%) with different tree species

Tree Species	Tree Basin	Between Trees	No Trees
Amla	1.08	0.55	0.55
Tamarind	0.81	0.63	0.44
A. senegal	1.09	0.65	

the intercrops with trees than sole crop. Finger millet gave significantly higher grain yields as a sole crop compared with intercrops with trees as there was no competition for moisture in sole crop situation. Finger millet yields were most affected with tamarind recording only 5% yields of sole. The trend in fodder yields was similar to that of grain. Harvest index was better in sole crop over intercrops.

Soil organic carbon (Table 39) was higher in tree basin than between trees in all the three tree species. Further, the area between trees showed higher SOC than sole cropped areas. Amla yielded highest fruits (5313 kg per ha) with application of a combination of FYM and inorganic fertilizers (Table 40), followed by FYM and inorganic fertilizers. Significantly lower amla fruit yields were obtained with castor cake and sunhemp. The fruit quality in terms of vitamin C was highest with vermicompost.

Table 40. Amla fruit yield and quality with different treatments

Treatment	Total (kg ha^{-1})	Vitamin C mg /100 g
Vermicompost (VC)	2913	338
FYM	5189	185
Inorganic Fertilizers (IF)	4070	206
V C+ IF	2542	140
FYM + IF	5313	200
Castor Cake	720	262
Sun hemp in basin	771	185
CD (5%)	2488	

Note: Organics and combinations applied on N equivalent basis

2.5.1.2 Improving the productivity of *Leucaena leucocephala* for biomass production

There is a need to develop technology, which can improve the productivity of leucaena system considering its contribution towards the pulpwood production. A project was initiated this year to develop agronomic practices, which can improve the productivity of leucaena based systems. The project focuses on three specific aspects viz. evaluation of different shade tolerant grass species for growth and biomass production, identification

Table 41. Leucaena tree growth and grass biomass productivity in leucaena based silvi pastoral system

Intercrop	Leucaena tree height (m)	Leucaena DBH (cm)	Grass Productivity (t/ha)
Guinea grass (*Panicum maximum)* variety makuni,	3.37	2.01	7.73
Guinea grass variety riversdale	2.61	1.68	9.43
Guinea grass variety green panic	3.70	2.29	4.53
Congo signal grass (*Brachiaria ruziziensis)*	3.54	2.18	6.18
C*enchrus ciliaris*	3.20	1.90	5.45
CD (0.05)	0.67	0.39	1.64

of optimum dose of fertilizers and suitable tillage practices for enhancing the wood production, and study of the effect of different microbial inoculants on the biomass productivity of leucaena.

Three experiments were initiated in 2007. In the first one, five shade tolerant grasses were sown in *Leucaena leucocephala* var. K636. The grasses are guinea grass (*Panicum maximum*) variety makuni, riversdale, green panic, congo signal grass (*Brachiaria ruziziensis*) and *Cenchrus ciliaris.* Sole trees without grasses and sole grasses without trees were planted as control in a split plot design with three replications. Grasses were transplanted at 40x40 cm spacing. In the second experiment, effect of fertilizers and tillage practices on wood production of leucaena is being studied. The fertilizer treatments are, control (without any fertilizer), 50% removal, 100% removal, 150% removal of nutrients by the tree at the time of harvest. Tillage treatments consist of no tillage, tillage with cultivator twice in a year and tillage with disc plough twice in a year. The experiment was laid in split plot design with tillage treatments in main plots and fertilizers in sub plots with 3 replications. In the third experiment, biofertilizer treatments consisted of Rhizobium alone, VAM alone, PSB alone, fertilizer application alone, fertilizers + Rhizobium, fertilizers + PSB, fertilizers + PSB + Rhizobium with no fertilizer as control. This experiment was laid out in randomized block design with three replications. Trees in all the three experiments were planted at 3x1m spacing.

Guinea grass variety makuni and riversdale produced significantly higher biomass yields over other grasses during the second year of tree growth. Intercropping leucaena with perennial grasses significantly influenced tree growth. Tree height and diameter at breast height was significantly reduced due to perennial grasses. Of the grasses, riversdale and makuni significantly reduced tree growth (Table 41). Reduction in grass population by removing 2 grass rows and 4 grass rows improved tree growth slightly. Differences in growth were not significant. Application of fertilizers and various tillage treatments did not have any influence on the tree height and diameter increment. Similarly, application of fertilizers along with microbial inoculants improved the tree growth but differences were not significant.

2.5.2 Dryland Horticulture

Tree crop interaction, efficient use of rainwater, sustainability during the initial years of orcharding or during juvenile period and primary value addition, rainfed vegetable cultivation and productivity enhancement practices in neglected orchards were the priorities addressed during the year.

2.5.2.1 Rainwater management in fruit trees

A trial was undertaken on efficient rainwater management and intercropping with four fruit species viz. mango, aonla, tamarind and fig. The plantation was done during September 2005, gap filling was done during 2006 and the treatments were imposed during 2007-08 following RBD with four replications. The spacing adopted was 5x5 m for mango, 6x6 m for *aonla*, 7x7 m for tamarind and 2x2 m for fig. Fig was grown as filler crop in mango, tamarind and *aonla* and also as a sole crop. The plants were given protective irrigation (from harvested rainwater) @ 16, 12 & 8 litres/plant/irrigation along with unirrigated control for observing the survival. Good growth and survival was observed with 16 & 12 litre treatments till establishment, which were on par and superior to 8 litre per irrigation treatment. In the established plants, four water management treatments were imposed (I_1 - Irrigation at 0.75 Ep, I_2 - Irrigation at 0.5 Ep, I_3 - Irrigation at 0.25 Ep, I_0 - No irrigation). Fig was severely pruned during August 2007 to impart good shape and more

Table 42. Effect of micronutrients and supplemental irrigation on summer grown vegetable crops

Vegetable	Variety	Yield (q/0.1 ha)		Price (Rs./kg)	Gross income (Rs)	Gross cost (Rs)	Net income (Rs)
		*Improved practice	Farmers' practice				
Bitterground	Nikita	17.5	5.80	12-14	22750	2250	20500
Tomato	Arkavikas	20.20	8.50	8-12	20200	2000	18200
Cooking melon	Oniversi	21.1	14.2	3	6330	750	5580
Brinjal	Bhagyamati	23.1	10.30	5	11550	2000	9550
Ridge ground	Nishant	16.1	4.60	6	9660	1000	8660

*** Interventions:**

- Boron : 0.25%
- Fe : 0.5%
- Zn : 0.5 %
- Ca : 1%

} 50 litres of spray solution was used for 0.1 ha at 25 and 35 days after transplanting along with recommended doses of nutrients

Supplemental irrigation was given at nursery raising, 2, 3, 5, 7 & 9 weeks after sowing / transplanting

fruiting units in the subsequent season. Good growth and yields of intercrops of cowpea, horsegram, cenchrus, stylo, roselle, sweet corn and baby corn were obtained in the interspaces without any irrigation. Roselle calyces were harvested, dried under shade in order to retain good colour. It was also powdered in a small quantity to test its utility for culinary purposes in place of *amchoor* and tamarind. Scope also exists for usage of roselle calyces extract for blending with other natural fruit juices like acid lime, *aonla*, guava, ginger, pineapple etc for good natural colour and taste as a replacement to artificial ones. It also imparts body and pectin to jellies. This species provides ample scope in the dryland regions especially in the orchards during the initial years. Reasonably good crops of sweet corn and baby corn were taken during *kharif* 2007 without any irrigation.

Highest survival of all the fruit species was observed with protective watering while no irrigation led to high mortality. Mango and *aonla* recorded high mortality under complete rainfed conditions while tamarind was able to show better performance. On established plants, irrigation at 0.75 Ep and 0.50 Ep was found to support better growth than 0.25 Ep treatments. Maximum height and canopy diameter of mango, *aonla* and fig were achieved under I_1 while in tamarind the differences were not clear. Fruit setting in fig was noticed even after severe pruning. Percent soil moisture content in different crop species was estimated by taking the soil samples one week after irrigation and estimating the water losses on different sampling dates.

Growing vegetables in the initial years of orcharding may be beneficial for generating incomes. When vegetable crops like brinjal, cauliflower, chilli and tomato were raised as intercrops on conserved moisture in a limited area (0.5 to 0.6 acres) with family labour from a family of two adults and two children, it appears economical in cultivating them and may even support their livelihoods. Sweet corn and baby corn during *kharif* were found more promising without any irrigation. Brinjal was found more promising than other vegetable crops (tomato, cauliflower and chilli) when experimented during *rabi* 2007/2008 when they were sown / the seedlings were raised during the rainy season and three protective irrigations were given with conserved moisture during crop growth stage.

Farmers of dryland watershed regions are switching over to vegetable cultivation for higher incomes and also as a livelihood option in periurban areas. With the advent of supermarkets and hypermarkets in Hyderabad, farmers in nearby Ranga Reddy district are growing vegetables and supplying them to the city and local markets. *Kharif* vegetables were grown without irrigation and *rabi* vegetables were grown on conserved moisture in the watershed areas. Selected farmers were introduced to the supermarkets and training was imparted to them for profitable vegetable cultivation with supplemental irrigation. Bhendi, brinjal, chilli, cucumber, cucurbits and tomato were grown under rainfed conditions. Cabbage, cauliflower, capsicum, bitter gourd were grown under conserved moisture situations under mild winter conditions. Seed production of bitter gourd looked promising. Improved practice consisting of supplemental

irrigation, recommended dose of nutrients and micronutrient sprays gave considerably higher yield than farmers'practice, thus contributing to increased income (Table 42).

2.5.2.2 Productivity enhancement in existing fruit orchards in drought prone area through farmer participatory approach

Survey of orchards in drought prone areas of Mahabubnagar and Ranga Reddy districts was carried out in 2007. The findings of the survey and recommendations given to farmers are as follows:

Mango

Farmers prefer mostly mango for alternate land use systems and dryland horticulture. During survey it was learnt that yields of mango are far below the national average yields. This is mainly because no farmer is applying recommended dose of fertilizers. Due to poor soil fertility conditions, the new plantings are also showing slow growth. Hence farmers were advised to apply recommended dose of fertilizers and FYM according to the age of the plant and to take up *in-situ* water conservation during rainy season. In one case vegetative malformation of mango was observed. For this the farmer was advised to spray NAA at 200 ppm. In all six farmers were identified for improving the productivity of mango of different age groups through farmers' participatory approach in Mahabubnagar district.

Sweet Orange

A sweet orange orchard which is in declining stage has been identified for improving the productivity located in Gundala village in Veldanda mandal. The orchard is planted in gravelly soil and plants are showing multiple nutritional deficiencies. The farmer has been advised to apply recommended dose of fertilizers.

Guava

A declined guava orchard of 20 years in Chintagudem village has been identified for improving the productivity. The farmer has been advised to take up pruning, cleaning of basins and to apply recommended doses of fertilizers.

Vegetative malformation in mango (Ranga Reddy district)

Poor productivity of mango due to non-application of recommended fertilizers (Mahabubnagar district)

Sweet orange planted in gravelly soil showing declining symptoms (Mahabubnagar district)

2.5.3 Medicinal, aromatic and dye plants

2.5.3.1 Crop diversification for sustainability of dry lands through dye crops

Introduction of alternate high value crops for crop diversification has significant scope in drylands. Experiments were conducted for the development of agro techniques of these crops. The dye crop bixa was planted in 2003. Two different pod types of bixa (red and green) and two irrigation (no irrigation and supplemental irrigation) levels were tested. The bixa plants started flowering from second year onwards. The seed yield and bixin content were not significantly influenced by the pod colour. Supplemental irrigation at the time of flowering and capsule formation increased the yields significantly but irrigation did not influence the bixin content. Among fertilizer treatments, combination of vermicompost and NPK recorded highest yield and bixin content. This was followed by FYM+NPK, FYM and vermicompost. Lowest yields were observed in control but bixin content was not significantly influenced by the 'no fertilizer' treatment.

Indigo, an annual crop, was sown in the month of July and harvesting was done at little pod stage. Different organics, inorganic and combination of these fertilizers were tested. The biomass yield was highest in FYM and vermicompost application and application of castor cake and inorganic fertilizers gave the lowest yields. The vermicompost application registered 24, 104, 145% higher dye yield over FYM, castor cake and inorganic fertilizer, respectively. The application of vermicompost and phosphorus increased the indigotin content.

2.5.3.2 Impact of drought management practices and organics on secondary metabolites and yield of medicinal plants

The quality of medicinal plants is influenced by water stress and management practices and the demand for the good quality material of medicinal plants is increasing. So, experiments were conducted to study the impact of drought management practices and organics on secondary metabolites and yield potential of medicinal crops during 2007. Two experiments were laid out in GRF of CRIDA. One experiment was to study the influence of drought management practices with various treatments as listed in the table 43. In all the treatments, the recommended dose of NPK (50-50-30) was applied except in compost treatment where the dose of FYM was applied equivalent to 50 kg N.

The response of crops to drought management practices with respect to yields was significant (Table 43). The leaf yields of senna were higher in paired row+ cover crop and cover crop treatments. In andrographis, the cover crop of horse gram increased the biomass yields and dry matter production. The root yields of ashwagandha were higher with paired row crop + cover crop treatments. Bio nectar and grass application treatments were also effective in increasing yields. Higher andrographolide content was observed with drought management practices viz., life saving irrigation and paired row planting + cover crop.

The second experiment was laid out in split plot design (with tank silt and no tank silt in main plots and organic fertilizers as sub plots) to study the impact of organics on yields of medicinal plants. Tank silt @ 250 M^3 was applied before sowing during summer and was ploughed thoroughly to mix the contents in the soil. Organic fertilizers were equated to the recommended dose of N. Farm yard manure, vermicompost and castor cake were applied 15 days before sowing. Biomix biofertilizer (a mixture of *Trichoderma reseii, Trichoderma harzianum, Phenerochyte chrysosporium, Bacillus subtilis, B. coagualans and Pseudomonas putida*) mixed with FYM was applied at the time sowing. Test crops were senna, andrographis and ashwagandha.

Application of tank silt increased the yields of senna and andrographis by 54.8%, 67%, and 33.8% over no

Table 43. Influence of different drought management practices on yield of medicinal plants

Treatments	Yield kg/ha		
	Senna (Fresh leaves)	Andrographis (Fresh biomass)	Ashwagandha (Dry root)
Life saving irrigation-2 irrigations were given during dry spells	748	1063	484
Grass mulch @ 5 t/ha	994	1070	358
Cover crop- horsegram	2066	1208	653
Paired row + cover crop	3150	569	716
Bionectar*	1549	1122	713
Chitosan anti transpirant spray @2%	503	596	384
Compost @	579	507	546
Control	370	398	276
CD(0.05)	262.01	101.8	133.102

* (mixture of desi cow dung, urine, black jaggery, pulse flour (Chick pea/black gram/green gram) was mixed in ratio of 5:5:1:1:

Table 44. Influence of organics on yield of medicinal plants

Treatments	Yield kg/ha		
	Senna (Fresh leaves)	Andrographis (Fresh biomass)	Ashwagandha (Dry root)
With tank silt	1777	1817	494
Without tank silt	1147	1089	369
CD 0.05	513	132	78
FYM	1205	1504	332
Vermicompost	1216	2128	462
Castor cake	1821	1114	344
Biomix	1325	1512	609
NPK	1943	1246	523
Control	1262	1214	331
CD 0.05	428	189	100

Senna

Andrographis

Aswagandha

tank silt condition. Application of NPK, castor cake and bio mix recorded higher yield in senna (Table 44). The increase in yields was observed with application of vermicompost, Biomix, FYM and NPK in andrographis. Biomix application recorded significantly higher root yields of ashwagandha over all the treatments which was followed by application of NPK. Lowest yields of three crops were recorded in control and FYM treatments.

2.5.3.3 Organic management of medicinal and aromatic crops

The organically grown medicinal plants fetch higher price in the international market and demand for organic product is increasing day by day with increase in awareness of the side effects of the synthetic drugs. Experiments were initiated during 2004 to identify sustainable organic / inorganic practices for higher productivity and quality of medicinal and aromatic plants.

In 2007, organic fertilizers were applied by equating with recommended dose of Nitrogen (50 kg/ha). Farm yard manure, castor and neem cakes were applied 15 days before sowing. Vermicompost and NPK were applied at the time of sowing. Test crops Senna, Andrographis and Ashwagandha were sown in the last fortnight of July. Highest Senna leaf, biomass of Andrographis and Ashwagandha root yields were recorded with the application of vermicompost, neem and

Table 45. Influence of organic nutrients on yield and quality of medicinal crops

Treatments	Yield kg/ha			Andrographolide %
	Senna (Fresh leaves)	Andrographis (Fresh biomass)	Ashwagandha (Dry root)	
FYM	1517	1974	817	1.304
Vermicompost	1926	2666	632	1.032
Castor cake	1285	2258	1011	1.774
Neem cake	1750	2493	512	1.046
NPK	938	1192	451	1.664
Control	1314	747	332	1.008
CD 0.05	407.18	570.7	107.08	

Table 46. Influence of inorganic and organic nutrients on yield and quality of aromatic plants

Treatment	Lemongrass			Palma rosa		
	Fresh biomass	Oil yield L/ha	Citral A (%)	Fresh biomass	Oil yield L/ha	Geraniol (%)
Control	8.4	56	60	12.43	51	84
FYM	11.74	67	68	18.29	72	91
VC	13.79	80	78	21.2	113	84
NC	12.53	77	57	17.99	57	79
CC	13.74	78	63	19.05	84	69
NPK	16.96	92	49	23.08	87	88

Lemongrass

Palmarosa

castor cakes respectively (Table 45). The other organic treatments improved the economic products of medicinal plants over NPK and control treatments. The application of neem cake also improved the quality of Andrographis with respect to andrographolide content in roots.

Aromatic plants lemon grass and palmarosa were planted in 2004. In 2007, Different organic and inorganic nutrients were tested on these crops. The oil was extracted in steam distillation and quality was tested in GLC. The total biomass yields of three cuts of lemon grass and palmarosa and oil were calculated and presented in the Table 46. Lemongrass and palmarosa biomass yields and oil were highest in inorganic fertilizer followed by vermicompost and castor cake application. Control treatment recorded lowest biomass and oil yields. Highest citral A content in lemongrass and geranial in palmarosa were recorded in vermicompost ad castor cake application, and the lowest content was recorded in inorganic fertilizer.

2.5.4 Biofuels

2.5.4.1 Development of climatic and soil – site suitability criteria for *Jatropha curcas* in rainfed regions of India

Jatropha curcas has been identified as the main commodity source for bio-diesel in India and National Mission on Biofuels targeted jatropha plantation in 200 districts in 19 states. However, *Jatropha curcas* requires specific climate and soil-site conditions for optimum growth. The project started in 2006 with the objective of developing climatic and soil-site suitability criteria for *Jatropha curcas* with a view to decide on rational land use for this plant. Details on climate, site, soils and land degradation status of 596 *Jatropha curcas* occurring/ growing locations were collected from 24 states viz . Arunachal Pradesh, Assam, Andhra Pradesh, Chattisgarh, Goa, Gujarat ,Haryana, Himachal Pradesh Jharkhand, J & K, Karnataka, Kerala, Madhya Pradesh. Maharashtra, Manipur, Meghalaya, Nagaland, Orissa, Punjab, Rajasthan. Tamilnadu, Tripura, Uttaranchal and Uttar Pradesh .and also from Andaman Islands. The performance of *Jatropha curcas* in these sites was correlated with the 13 identified climate and soil-site parameters. Mean annual rainfall, maximum and minimum temperature (°C), length of growing period (LGP), frost proneness (days), slope (%), drainage, rooting depth(cm), soil texture, gravelliness (subsoil) and pH were identified as the critical criteria for evaluating land suitability for *Jatropha curcas* cultivation.

2.5.4.2 Collection, evaluation of germplasm, standardization of agro-techniques and pilot demonstrations for *Jatropha curcas* L. in rain shadow districts of Andhra Pradesh

On-farm experiments on assessing the potential of *Jatropha curcas* and *Pongamia pinnata* are being conducted in Mahabubnagar district. The results of these experiments are:

Jatropha

Effect of pruning: The jatropha plants were pruned at 0, 30, 60 cm height from ground level during May. Pruning at 30-60 cm height was better in influencing number of branches, stem girth, canopy spread (Fig 28). The position of plants in any direction of the field did not influence much.

Effect of plant density: Out of 2743 plants, 169 plants (58 in 2mx2m spacing, 91 in 3mx2m and 20 in 4mx2m) developed good growth, flowering and fruiting during the first year itself. Detailed observations have been recorded including yield attributes and yield per plant.

Effect of irrigation and nutrition: Irrigation at 10 days interval to jatropha was significantly superior to irrigation at 20 days interval in promoting the height of plant. Application of 22.5 g N and 50 g P per plant was markedly superior to no nutrition.

Effect of irrigation and soil and water conservation: The effect of irrigation and soil and water conservation was studied in farmers' fields at Chintagudem and Veldanda. The plant height was influenced by soil and water conservation practices. Both crescent shaped basin and trench (45 x 22.5 x 22.5 cm) were significantly superior to the farmers' practice of small basin. Preparation of trench on the upper side of the plant slope was highly beneficial. Good response to all levels of irrigation and soil and water conservation interventions was noticed.

Pongamia

Pongamia seedlings were planted in wasteland (saline soil) in a farmer's field at Telkapally, Mahabubnagar district during October. Two experiments were conducted to study the (i) effect of spacing and irrigation and (ii) effect of nutrition and irrigation. Closer spacing of 5 m x 4 m caused significantly lower height than 6 mx4 m spacing. Height to the first branch from the ground was markedly higher in the widest spacing (6 m x 6 m) over closer spacing. *In-situ* grafting was attempted with elite clone of pongamia having more than 38% oil content. Twenty two percent of bud take was observed when the grafting was done during September 2007.

The following are the highlights of on station research on jatropha, pongamia and simarouba.

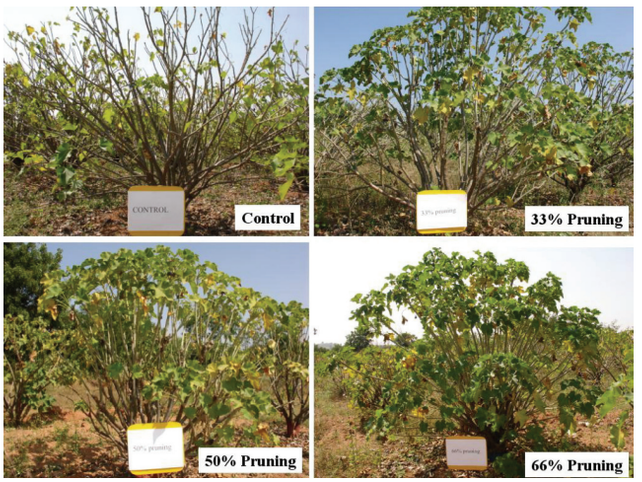
Jatropha

Standardization of Agrotechniques :

Pruning schedule

- First year- cut back the plants to 45cm from ground level.
- Second year- remove 1/2 of each branch
- Third year onwards light thinning as and when needed.
- Heavy thinning from third year onwards reduces the seed yield drastically.

Spacing trial: Out of four treatments (2x2m, 3x2m, 4x2m & 4x3m) evaluated, spacing of Jatropha at 4 x 2m resulted in enhanced seed yield (87.75 g/pl) compared to other treatments at the end of first year.



Jatropha plants with different degrees of pruning, 2 months after pruning

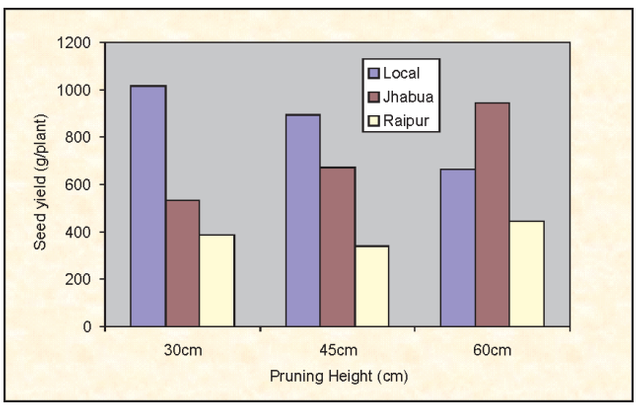


Fig 28. Effect of pruning height on seed yield of jatropha

Irrigation and fertilizer trial: At the end of first year of plantation no significant difference was found with different levels of Irrigation (control, 15days, 30days & 45days interval) & fertilizers (control, 2Kg FYM/pit, 5kg FYM/pit, N10g+P20g+K10g/pit & 2kg FYM+ N10g+P20g+K10g/pit). However growth parameters registered high values with application of N10g+P20g+K10g/pit in combination with irrigation at 30 days interval.

Progeny trial: Six accessions were identified as promising out of 23 accessions evaluated in progeny trial of jatropha depending on the growth and seed yield at the end of second year of plantation. At 16 months after plantation CRIDA-JR-06, NBPGR-GUJ-SKN-0605-SKN-Big, FRI-UA-Teh-1005-DD-EL-1 were found to be promising among 23 elite germplasm accessions of

plantation no significant difference was found with different levels of Irrigation (control, 15days, 30days & 45days interval) & fertilizers (control, 2Kg FYM/pit, 5kg FYM/pit, N10g+P20g+K10g/pit & 2kg FYM+ N10g+P20g+K10g/pit). However growth parameters registered high values with application of N10g+P20g+K10g/pit in combination with irrigation at 30 days interval.

Progeny trial: Six accessions were identified as promising out of 23 accessions evaluated in progeny trial of jatropha depending on the growth and seed yield at

2 year old plantation of elite germplasm of Jatropha at HRF

Damage by stem girdler in Jatropha

the end of second year of plantation. At 16 months after plantation CRIDA-JR-06, NBPGR-GUJ-SKN-0605-SKN-Big, FRI-UA-Teh-1005-DD-EL-1 were found to be promising among 23 elite germplasm accessions of jatropha evaluated in multilocational trial.

Oncideres limpida (Cerambycidae, Coleoptera), the twig girdler was one of the serious pests observed on *J. curcas.* Branches close to ground at 2 feet height and having thickness between 12 and 21 mm were the worst

Fruiting in crossed plants

affected. The adult beetle chews a continuous notch girdling the twig. The girdles are similar to that made by a saw and the ends appear gnawed almost straight across with a faint rounding. The girdled twig soon dries out and breaks off; and the larva develops inside the fallen twig on the ground. The incidence of girdler was recorded mainly during October - November. The number of

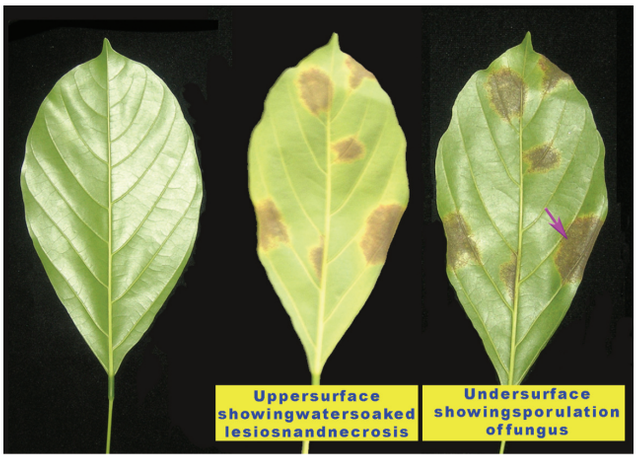
Pigeonpea intercrop in 4 year old jatropha planted at 6 m width

affected branches on each plant was in the range of 2 to 8 and about eight percent of the plants in the experimental block were found affected. This is the first report of *O. limpida* on *J. curcas* in India.

Breeding trials in jatropha: Out of 127 intraspecific (*J.curcas*) crosses attempted, six crosses in wild genotypes and three crosses in elite genotypes resulted in 100% fruit set.

Pongamia

Agri-silvicultural trial : In four year old pongamia,



Leaf spot disease on pongamia

intercrops viz., pigeonpea, castor and blackgram were taken up successfully without significant reduction in crop yield and also no significant negative effect of crops on tree component.

Progeny trial: On the basis of growth parameters three accessions out of 23 accessions of Pongamia evaluated in progeny trial showed superior performance compared to other genotypes.

Disease of pongamia

A leaf spot disease on pongamia was recorded. The disease started as water-soaked lesions on upper side of young foliage during the months of February and March. Later, sporulation of the fungus was noticed on the lower side. The spores were hyaline and two-celled.

2.5.4.3 On-farm trials of biofuel plantations

On farm trials on jatropha and pongamia were continued for the 3rd year in two districts of Andhra Pradesh viz, Nalgonda and Anantapur. The total area taken up under jatropha in two districts was 40 acres whereas 3 acres was covered under pongamia in Anantapur district. The treatments comprised of different

4 year old Simarouba in fruiting at HRF

levels of fertilizers, irrigation, spacing and pruning. So far the initial trends indicated that seed yield was more in 4x2m spacing in combination with 60% pruning in Nalgonda district where as in irrigation and pruning trial in Anantapur district more number of branches was observed in plants pruned at 45cm in combination with irrigation applied at 40% of evapotranspiration.

Simarouba

Fruiting was observed in simarouba grafts in the fourth year after plantation and the fresh yield of fruits was in the range of 140 g to 9 kg per plant. The inter-row spaces of simarouba (6X6m) could be used for raising castor and cowpea without any significant reduction in crop performance.

2.5.5 Livestock management

2.5.5.1 Strategies for enhancing breeding efficiency of dairy animals under rainfed conditions

Long calving interval in dairy animals causes huge economic losses to the farmer and there is an increased concern to check the problem in order to enhance milk production from the dairy animals. A study was taken up in 2007 for examining the metabolic profile of the dairy animals and correlating the results with nutritional status and making corrective measures in feeding management and studying its impact on calving interval, reproductive problems and milk production. Preliminary data on feeding and management practices adopted by the farmers and reproductive problems in their dairy animals from Tallapalli village were collected during 2007. Offered feed samples and blood were also collected and analyzed.

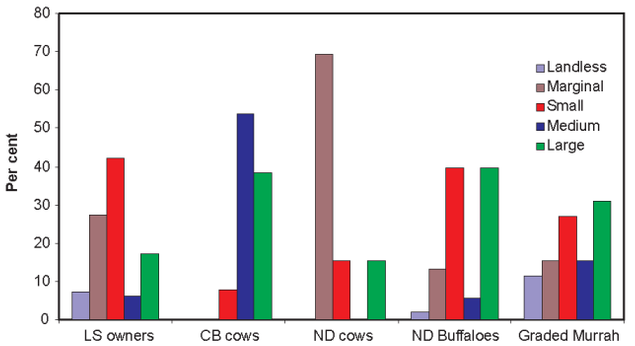


Fig 29. Dairy animal resources with different land holdings in Tallapalli village of Ranga Reddy district

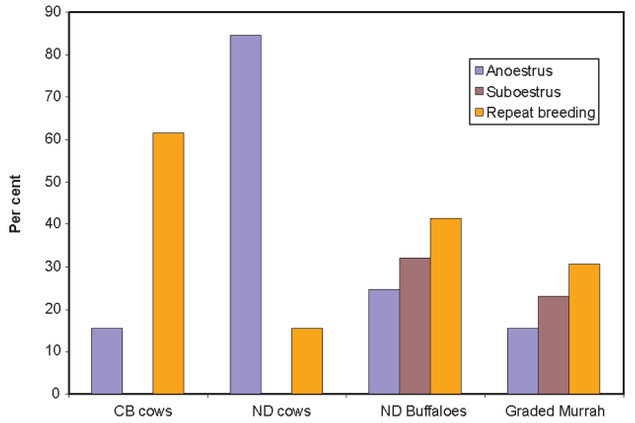


Fig 30. Dairy animals with reproductive problems in Tallapalli village of Ranga Reddy district

In Tallapalli village, 58% of the families are dependent on livestock farming (Fig 29). Cattle and buffaloes constitute 24.8 and 75.4 % of the total dairy animals in the village. Among the dairy animals, 62.9% are non-descript and 12.4% are crossbred cattle. Graded Murrah buffalo population is 24.8% of the total dairy animals. Repeat breeding is the major problem in crossbred cattle, where as anoestrus is the problem in non-descript cattle (Fig 30). Low energy (deficit ranged from 21-38% of the maintenance requirement) and protein intake (deficit ranged from 43-68% of the maintenance requirement) was observed in most of the dairy animals. Low blood plasma urea nitrogen and glucose and higher ketone bodies were observed, reflecting malnutrition with respect to energy and protein in dairy animals.

2.5.5.2 Performance of sheep reared under different management systems

Quantitative and qualitative shortage of feed and fodder resources are becoming major constraints for sustaining a positive growth in the livestock sector, especially in small ruminants. Further, the selection of plant-derived protein sources for use as animal feeds should take human food security interests into account. It would be highly desirable if the foliage from plants like *Leucaena, Gliricidia* etc., which are unfit for human consumption could be used as protein supplement to the small ruminants along with routine basal roughage diet. To find out the effect of various tree fodder supplements on dry matter (DM) intake, digestibility, average daily gain (ADG) and performance of growing lambs fed with roughage (chopped sorghum stover) as basal diet, a study was initiated in 2005. Eighteen Deccani growing lambs were divided into three comparable groups (Group I, II and III) on body weight basis and maintained on intensive system of feeding management with chopped sorghum stover as basal diet and *Leucaena, Gliricidia* leaf meal and concentrate mixture as protein supplement and compared with semi-intensive (Group IV) and extensive (Group V) system of management. The DM intakes, digestibility of nutrients, ADG were compared among the treatment groups.

This year, a feeding trial was conducted on growing Deccani lambs for 120 days under intensive system of management with the fodder (*Stylo* and *Gliricidia*) and sorghum stover produced from different components of watershed area at HRF. The leguminous fodder (*Stylo / Gliricidia*) was used as protein supplement to the basal diet of chopped sorghum stover to feed the lambs and compared with concentrate mixture supplementation on equal nitrogen basis. The intensive system was compared again with semi-intensive and extensive system of management, where in the former, the lambs were fed with concentrate mixture (on equi-nitrogen basis) at evening after grazing and in the later the lambs were allowed to graze for 8 hours without any external supplementation. The crude protein content was significantly higher in *Gliricidia* and *Stylo* being leguminous compared to sorghum stover (Table 47).

The weight gain in lambs was comparable among different types of protein supplemented groups under intensive system of management. The weight gain was significantly ($P < 0.05$) higher under intensive when compare to semi-intensive and semi intensive when compared to extensive system of management (Table 48).

Table 47: Chemical composition (%DM) of feed and fodder offered to the growing lambs

Nutrient	*Stylosanthes hamata*	*Gliricidia sepium*	Sorghum stover	Concentrate mixture
Proximate principles				
Organic matter (OM)	90.86	89.36	87.41	91.02
Crude protein (CP)	13.17	18.64	3.17	16.54
Crude fibre (CF)	27.38	23.50	33.26	9.08
Ether extract (EE)	2.07	2.94	1.44	5.12
NFE	48.24	44.28	49.54	60.28
Total ash	9.14	10.64	12.59	8.98
Cell wall constituents				
Neutral Detergent Fibre (NDF)	67.68	40.15	69.18	32.12
Acid Detergent Fibre (ADF)	43.96	26.22	48.22	17.04
Hemicellulose	23.72	13.93	20.96	15.08
Cellulose	26.41	16.85	41.23	13.13

Table 48. Weight gain, average daily gain (ADG), feed intake and digestibility of nutrients in growing Deccani lambs under different feeding management systems

Parameter	Intensive			Semi-intensive	Extensive
	Stylo supplementation	*Glyricidia* supplementation	Concentrate supplementation		
Initial body weight (kg)	12.7 ± 0.18	12.9 ± 0.21	12.8 ± 0.25	13.0 ± 0.32	12.7 ± 0.24
Final body weight (kg)	22.7 ± 0.31	22.6 ± 0.44	22.9 ± 0.41	21.9 ± 0.28	19.8 ± 0.24
Weight gain (kg)	10.0 ± 0.25	9.7 ± 0.23	10.1 ± 0.22	8.9 ± 0.25	7.1 ± 0.21
ADG (g/day)*	83.3^{c} ± 2.13	80.8^{c} ±2.45	84.2^{c} ± 2.27	74.2^{b} ± 31.7	59.2^{a} ± 3.34
DMI (kg/100kg bw)*	3.96^{b}	3.88^{a}	3.98^{b}	4.12^{c}	4.01^{b}
DMI w $^{0.75}$	2.81	2.76	2.82	2.89	2.83
Digestibility of nutrients (g kg^{-1})					
DM **	667.3^{c}	658.2^{c}	674.8^{c}	612.4^{b}	571.2^{a}
OM*	708.5^{c}	694.1^{c}	720.2^{c}	688.7^{b}	665.7^{a}
CP**	697.1^{c}	694.3^{c}	711.7^{c}	674.6^{b}	613.3^{a}
NDF**	584.3^{c}	585.8^{c}	591.3^{c}	522.1^{b}	465.1^{a}
ADF**	488.6^{c}	477.1^{c}	496.2^{c}	431.6^{b}	401.2^{a}

@ Basal diet of Sorghum stover
Means with different superscripts in same row are differ significantly
* P<0.05
** P<0.01

Similar trend was observed in the average daily gain of Deccani lambs. Dry matter intake of lambs was significantly lower with *Gliricidia* supplementation when compared to either *Leucaena* or concentrate mixture supplementation to the basal sorghum diet under intensive management. The dry matter intake was comparable between the extensive and intensive, where as significantly ($P < 0.05$) higher under semi-intensive management. Digestibility of DM, OM, CP, NDF and ADF were comparable among different types of protein supplementation under intensive management. Digestibility was significantly ($P < 0.01$) lower under semi-intensive when compared to intensive and extensive when compared to semi-intensive management. The results of the study indicate that the *Stylo* and *Gliricidia* leaf

meal could be used as alternate to the concentrate mixture to feed the growing Deccani lambs along with the roughage basal diet (chopped sorghum stover) under intensive system of management for higher live weight gain.

2.5.5.3 Sustainable livestock production in rainfed regions of India

Some promising technologies were demonstrated and promoted in ORP villages of Anantapur and Sholapur for higher production from livestock. These were green fodder cultivation in farmers' fields, conservation and preservation of crop residues, efficient utilization of available feed and fodder resources, mineral mixture supplementation to the milch animals, vaccination against contagious diseases like FMD, deworming of calves and small ruminants and top feed supplementation to the small ruminants during summer.

Co-1 fodder in farmer's field

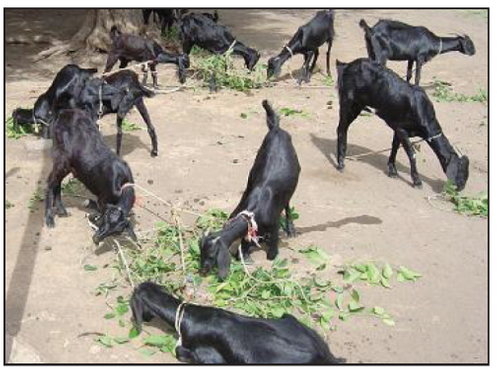
Cultivation of Lucerne during summer

Promotion of green fodder cultivation: To overcome the fodder scarcity problem, it was proposed to introduce some multi-cut perennial fodder grasses like Co-1, annuals like Lucerne and African Tall and cultivation of Para grass on rice field bunds and water logged areas. However, initially many farmers refused to spare their land and only few farmers came forward to take up the suggested fodder production technologies in 1/10 of their lands. Once the fodder was established and grownup in the farmers' field, the farmers realized the importance of green fodder cultivation. The adopted farmers opined that fodder available from their 0.1 to 0.2 ha of land could meet the green fodder requirement of their 3-5 milch animals during summer. Due to availability of green fodder during summer and higher palatability and nutrient content of fodder, milch animals gave more milk (average increase of 1.6 litres/day). This higher milk production resulted in generation of an extra income of Rs.16/day/animal.

Vaccination against contagious diseases like FMD: Prior vaccination against FMD resulted non-stop agricultural operations by bullocks and no disease incidence in the village.

Deworming of calves and small ruminants: Regular deworming resulted in very low morbidity and mortality of calves, especially in males. As per the local veterinary doctor at Hangji, ORP village of Sholapur, the number of cases coming to his hospital has come down by at least 25%. Regular and strategic deworming in small ruminants also resulted in 12-18% higher weights at market age and more income.

Top feed supplementation to the small ruminants during summer: This practice resulted in low mortality in lambs and kids as they could get sufficient milk from the dams and also resulted in higher growth rate in adults.



Top feed supplementation to the small ruminants

2.6 Energy management

2.6.1 Implements for soil management

2.6.1.1 Development of a tractor drawn bed forming machine for rainfed crops

Conservation furrows are recommended for better retention of rainwater in Alfisols. To examine the extent of

Table 49. Grain and fodder yield of sorghum and pigeonpea crops with different moisture conservation practices

Treatment	Sorghum grain yield (kg/ha)		Pigeonpea seed yield (kg/ha)		Sorghum grain equivalent yield (kg/ha)
	Grain	Fodder	Grain	Stem + Fodder	
T1 - Control	2347	4682	410	1555	3811
T2 - Ridge and Furrow	3210	6580	761	2502	5927
T3 - Conservation furrow at 0.9 m spacing	2846	5113	653	2209	5178
T4 - Bed and furrow at 0.9 m spacing	2992	6411	746	2509	5656
T5 - Conservation furrow at 1.35 m spacing	2824	4773	598	2135	4959
T6 - Bed and furrow at 1.35 m spacing	2928	5584	722	2337	5506

soil moisture improvement and yield, an experiment was initiated in 2005 at HRF to study the effect of conservation furrows made with different tools on moisture conservation and its effect on crop yields. During 2007, six treatments were tried with 2 spacings on sorghum (CSV-15) + pigeonpea (PRG 100) intercropping system. Ridge and furrow, and bed and furrow were made using tractor drawn equipment and conservation furrow, using country plough. Soil moisture measurements were recorded using data logger at 5 days interval.

Soil moisture retention was generally higher in treated than control - no conservation plots. Soil moisture stored was higher in ridge and furrow, bed and furrow and conservation furrow plots. However, no clear trend of soil moisture content vis–a–vis furrow spacing could be observed. Sorghum grain equivalent yield differed significantly with treatments. Grain yield varied from 3811 to 5927 kg ha^{-1} .The highest grain yield in sorghum (3210 kg/ha) and pigeonpea (761 kg/ha) were recorded under ridge and furrow system followed by bed and Furrow at 0.9 m and 1.35 m spacing (Table 49).

2.6.1.2 Mechanical incorporation of biomass

Biomass incorporation is a viable practice in rainfed agriculture. However, it is not popular with farmers due to non-availability of suitable implements. Understanding of scientific method of *in-situ* incorporation considering various parameters of decomposition in association with performance of farm implements not only helps in recommending the type of implements but also accelerating the rate of decomposition, which in turn affects soil chemical and physical properties. Work was started in 2004 to develop a prototype for in-situ incorporation of biomass, testing its performance in comparison with existing tools, and to study the overall effect of biomass incorporation with different farm implements on soil properties.

In *kharif* 2007, three cover crops viz., horsegram, sunhemp, and cowpea were grown on experimental plots at HRF for biomass generation. The biomass was incorporated in-situ at 48 DAS with different farm implements and its effect on soil characteristics was studied. The implement treatments were (i) Mold board (MB) plough (control) (ii) MB plough + rotavator (existing) (iii) Improved rotavator (iv) Rotavator (existing). The effect of these treatments on incorporation efficiency, soil N, P, K and organic C was studied. Emission of CO_2 flux was measured at various intervals. Horsegram was sown in biomass incorporated plots in March, 2008. The interactive effect of implements used for biomass incorporation on crop growth performance was studied

The biomass incorporation efficiency was found to be 92% with MB plough+ rotavator, 79% with improved rotavator, 72% with MB plough and 51% with existing rotavator. Though incorporation efficiency of MB plough + rotavator was 13% higher than improved rotavator the overall reduction in cost of operation with improved rotavator was 39% of operational cost for MB plough+ rotavator. Comparing the performance of existing and improved rotavator the incorporation efficiency of improved rotavator was far better than existing rotavator without compromising energy and cost of operation. The analysis on soil properties revealed that the implement treatments have relative effect on available N, P, K and organic carbon across the depth. After 3 year study, the nutrient status in upper layer (0-15 cm) was considerably improved in the plot where biomass was incorporated with improved rotavator. In 0-30 cm, the improvement in nutrient status was relatively higher in plots of MB plough+ rotavator

The decomposition of biomass is expressed in terms of emission of CO_2. The effect of incorporation of biomass on CO_2 flux was studied in relation to various treatments of farm implements given above. There was significant variation in emission of CO_2 flux among the treated plots and was mainly due to variation in amount of soil inversion, soil aggregate structure, rate of decomposition etc. Horsegram was sown in March, 2008. The total amount of rainfall was about 185 mm in this month, which is approximately 35% of average annual rainfall. To capitalize on this unseasonal rainfall, horsegram was sown on experimental plot immediately after the rainfall and crop growth performance was studied. After 15 days of sowing, overall crop growth performance in terms of crop height, germination percentage and biomass yield per plant was considerably improved in biomass incorporated plot compared to normal plots. Among the implement treatments, germination percentage and biomass yield per plant was found to be relatively higher in the plot where biomass was incorporated with improved rotavator.

2.6.1.3 Design and development of self propelled multipurpose machine for small farm mechanisation in drylands

A self propelled multipurpose machine for dryland operations was designed, developed and tested. A 3 hp petrol-start kerosene engine was used as power source (in the changed market trends, petrol engine also can be used). The main frame (90 x 20 cm) was mounted on two ground wheels (50 cm dia) and it has transmission assembly, engine, handle and tool bar mounted on it. Ground wheel speed was brought to 26 rpm, through belt pulley drive and gearbox, by obtaining step-down reduction of 4.6 and 15 times, respectively. Wheel tread (maximum 80 cm) can be adjusted as per requirement of row spacing. Ground wheel is made of mild steel having 50 cm diameter and 20 steel lugs. Engage and dis-engage was done through idler pulley and control of lever.

Three tyne cultivator for tillage, two row planter for sowing and weeder-blades for interculture were attached to the power unit through a specifically designed tool-bar. Its field performance was evaluated. Forward speed of 2.0 km/hr was obtained, though it was designed for 2.3 km/hr of theoretical speed. About 10 per cent of speed reduction due to slippage and losses in power transmission is expected. For turning the machine (at the end of the field), idler pulley was used to reduce speed of ground wheel. However, turning was difficult due to absence of steering mechanism. Since this resulted in overall reduction in field efficiency of the machine, modification was necessary.

This modification was incorporated through M/s Rohit Steel Industries, Pune, with whom CRIDA has a memorandum of understanding (MOU). Modifications carried out were (i) Instead of going for use of "caster wheel' in front of the chassis, a single lever clutch was designed and was mounted. (ii) To overcome slippage, higher traction is to be obtained by increasing the lug height and strength and this was incorporated. (iii) Ground clearance of 35 cm, instead of the (previous) 22.5 cm was done through changing the ground wheel and lugs. Seeding mechanism to suit 2.2 m forward travel for one revolution, instead of the previous 1.0 m travel was obtained. All these changes were incorporated and then prototype was manufactured by the industrial unit at Pune.

2.6.2 Equipment for processing

2.6.2.1 Feasibility of using pongamia and jatropha oil as biodiesel in IC Engines

Experiments were conducted to confirm the earlier results on pretreatment of pongamia and jatropha oil seeds. Biodiesel was prepared from the pretreated oils and tested in the IC engine for performance evaluation. Mini oil expeller was further modified with addition of extruder screw. Biodiesel was extracted from the oil expelled from pongamia and jatropha seed and different blends of pretreated and untreated biodiesel of pongamia and jatropha oils were used to find out their feasibility in compression ignition engine in terms of brake thermal efficiency, brake specific fuel consumption, carbon monoxide (CO), hydrocarbons (HC) and NO_x emissions.

Modifications of oil expeller with extruder screw: A specially designed extruder screw was designed and developed to test the same in mini oil expeller for its feasibility to extract the oil from the pongamia and jatropha seeds. The existing conventional screw in mini oil expeller was replaced with the extruder screw. Oil recovery increased from the 26 % to 28 % for pongamia and 27 % to 29 % for jatropha seeds when compared to the conventional screw. The salient achievements this year are:

Pretreatment of the seed for higher oil recovery and quality: Pretreatments increased the oil recovery on an average by 9% (absolute) when compared to the conventional steaming process. The quality of oil was also improved with reduction in viscosity and free fatty acids. Biodiesel quality is also improved with the pretreatments. Compression ignition engine test results showed that the brake specific fuel consumption of the engine with pretreated biodiesel was less than the untreated biodiesel. Brake thermal efficiency of the engine with pretreated biodiesel was observed to be slightly more than the untreated biodiesel. Carbon monoxide (CO), HC emissions with pretreated biodiesel were comparatively

less than the untreated biodiesel for all the blends for pongamia and jatropha biodiesel.

2.6.2.2 Modifications to CRIDA herbal dryer

A biomass stove was designed and developed for on-farm value addition of high value commercial crops to replace the LPG based system in CRIDA herbal dryer. It consists of a fire chamber in which the fire is controlled by the blower fixed at the bottom in which the biomass is burnt. The flame heats the corrugated plate made of mild steel or copper and thereby hot air is generated above the fire chamber. This hot air is sent to the drying chamber through a suction blower. The biomass stove system is supported by an automatic thermostat based control unit in which the required temperature can be set for drying the product at a fixed temperature. It has a maximum burning capacity of 6 kg biomass/hour. A feeler trial experiment was conducted using curryleaf as a product for drying. It was observed that the leaf is dried in 4.5 hours and 10 kg of commercial grade is obtained from 25 kg of wet curry leaf. The quality of dried curryleaf was superior to the leaf dried in shade drying which is a conventional process.

CRIDA herbal dryer with biomass stove

2.7 Socioeconomic studies

2.7.1 Economic evaluation

2.7.1.1 Sustainability assessment of treated watersheds using GIS and remote sensing

To assess sustainability of treated watersheds in rainfed agro-eco-sub-region AESR 7.2, eight micro-watersheds in four villages were studied in-depth since 2005 using multi – disciplinary sustainability indicators. To assess overall impact of watershed development program (WDP) in these villages, a set of forty-eight sustainability indicators was constructed for evaluation at five spatial levels namely, household, field, watershed, village, and AESR level. Bivariate correlation technique was found to be more useful than a PCA method for identifying critical indicators. The main objective of the study was to evaluate the impact of WDP by comparing the situation in pre-project phase (1998) with that of post-project phase condition (2005, 2006). Impact of WDP was compared with the conditions prevalent in untreated watersheds in the same village. Information collected from the study would be useful for initiating corrective measures by the PIAs. Evaluation of WDP was undertaken for five components of sustainability namely agricultural productivity, economic viability, livelihood security, environmental protection and social acceptability.

To assess sustainability of WDP at three levels – household, field and watershed level, forty-three indicators were constructed while five indicators were constructed for study at village and AESR levels. For evaluation of sustainability at household-level alone, twenty-one indicators were identified. For evaluating sustainability at farm-level, thirty-four indicators were constructed and for watershed-level studies, forty-three indicators were constructed. Evaluation of watersheds was carried out in four treated and four untreated watersheds during the year. Factors and issues affecting agriculture that were identified during the previous year, were analysed and relevant sustainability indicators were identified. Indicators were drawn from multiple disciplines namely, GIS, remote sensing, soil fertility studies, socio-economic surveys, etc., and results and data were stored in a database created specifically for this study in *MS-Access*. As the suite of sustainability indicators was large, a bivariate correlation technique was used to identify critical indicators for evaluating sustainable development.

Studies indicated that, in order to achieve sustainable agricultural productivity at watershed level, it is essential to increase total production in the constituent fields by reducing yield gap and increasing agricultural income by developing irrigation facility and soil and water conservation (S&WC) measures. Study also indicated that at present, sustainable gain was achieved only in case of total agricultural production and in income accrued from agricultural operation. However, in order to achieve sustainable productivity, it is essential to develop irrigation facility, intensify S&WC measures and bridge yield gap by using better seeds and adopting good farming practices.

For ensuring livelihood security, aspects which needed to be emphasised at watershed-level were; increasing agricultural production by undertaking S&WC measures, using tillage and mulches for retaining soil moisture, ensuring irrigation facility for critical phases of crops, maximizing cropped area denoted by Crop Cafeteria Index (CCI), and keeping input costs low. At present farmers have been able to make gains in the area

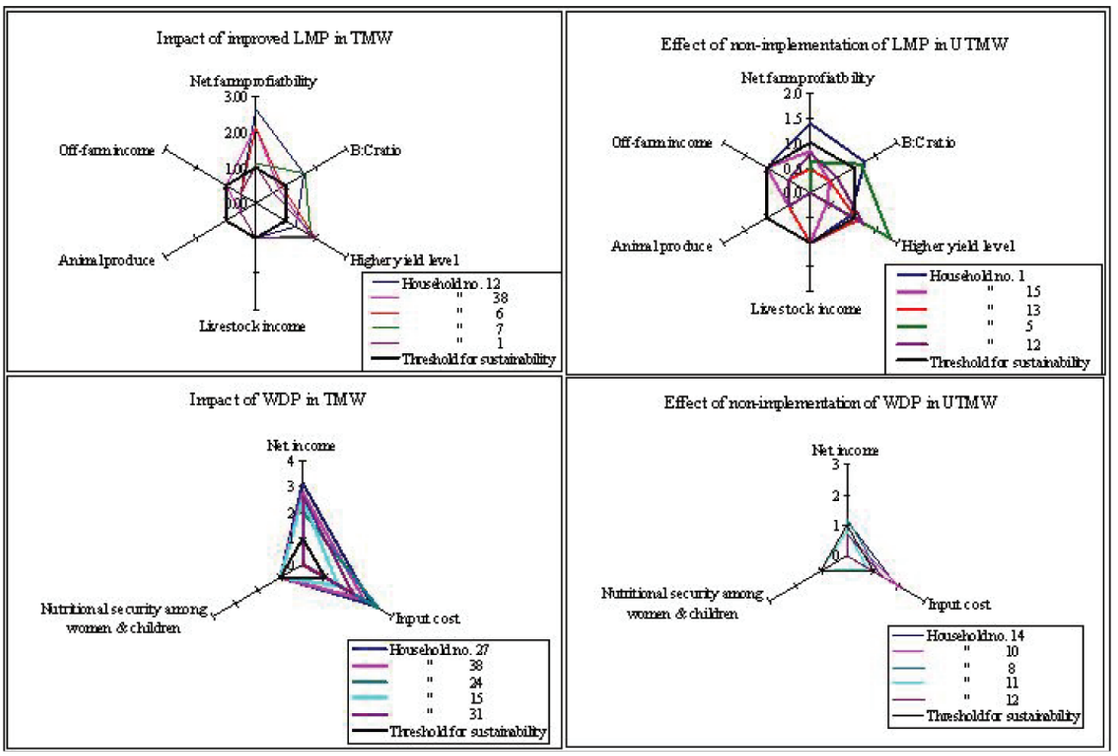


Fig 31. Evaluation of economic viability of farming system on implementation of improved LMP under WDP in Pamana village (Ranga Reddy district) at household level in the year 2006

of agricultural income and total production by maximizing cropped area but have failed to consolidate land holdings, develop suitable S&WC measures, and increasing unit land productivity.

For evaluating contribution of WDP for sustainable environmental protection, it was seen that WDP helped in increasing cropped area denoted by Crop Cafeteria Index (CCI) in each of the farm holding within a treated watershed. But on other counts viz., recycling farm organic matter, protective tillage, adhering to crop contingency plan, S&WC measures, checking deforestation, etc., the program had delivered little.

While evaluating economic viability of farming operations in the rainfed region, it was seen that WDP had only helped in increasing agricultural income while other aspects like increasing efficacy of S&WC, tillage, irrigation facility, lowering input cost and increasing market accessibility with transport network, have not been satisfactorily addressed. Figure 31 indicates the impact of WDP on economic viability of agriculture at watershed level in Pamana village where it was initiated in 1999 and undertaken in two phases. *Evaluation of social acceptability of WDP indicated that while farmers readily participated in the government funded programs for poverty reduction which has helped to check forced migration to urban centres, other aspects of WDP like developing and maintaining S&WC structures, recycling crop residue, or adopting crop contingency plan in the event of drought, etc., have not been very successful.*

Undoubtedly, watershed development program that has been implemented in rainfed regions is absolutely essential for rainfed agriculture. However, studies indicate that the WDP has failed to address various aspects of sustainable development. The study helped in identifying the weak links in the WDP. For instance, to achieve livelihood security it was found that the program must ensure higher income from farming activity by providing water for critical irrigation. Although the projects profess to help in overcoming the constraint of land holding size for achieving higher production levels, no progress has been made towards land consolidation or creation of land banks with farmers as shareholders rather than as stakeholders as at present.

Besides these, for sustaining economic viability of farming, it was found the WDP must generate work to help increase farm income while reducing input cost. This could be achieved only through increasing market accessibility and transport facility. The watershed projects could be sustainable only if it protects the cause of environment through strict implementation of development of irrigation facility, establishing social forestry and fodder cultivation for livestock. Social

acceptability of WDP at household-level is also essential for sustaining the program. If WDP is dovetailed with Govt. aided programs for poverty reduction viz., Food for Work, *Grameen Swarojgar Yojana* (Rural self employment scheme) etc., the impact of WDP could be spread wider.

2.7.1.2 Economic Analysis of Technology Interventions of KVK

In order to promote technology adoption, KVK is making efforts to promote various technological interventions appropriate to the farmers' situation in the villages. Economic viability is a necessary condition for a technology to be adopted by farmers. With this in view, this project was started in 2007 with the main objective of assessing the economic viability of important technologies promoted by KVK.

Table 50. Yield and returns from cotton cultivation in KVK villages, 2007-08

Parameter	FLD	Farmers' practice
Yield (q/ha)	31.5 (1.40)	21.3 (1.26)
Cost of cultivation (Rs/ha)	20380 (482)	19572 (255)
Gross returns (Rs/ha)	66085 (2943)	53224 (2657)
Net returns (Rs/ha)	45705 (2820)	33652 (2659)
BC Ratio	3.24	2.72
Marginal rate of return	15.9	

Figures in parentheses represent standard deviation. The differences are statistically significant at 5 per cent least.

Cotton is an important crop in KVK villages because of the predominance of black cotton soils and the potentially high profitability of the crop. Considering the risk associated with cotton cultivation because of high incidence of pests and diseases, it was considered appropriate to expose the farmers to various crop and pest management technologies for realizing higher productivity. The economic performance of the FLDs as compared to the 'local check' (farmers' practice) is presented in table 50.

It can be seen from the table that higher yield (31.5 q/ha) was realized in FLDs compared to farmers' practice (21.3q/ha). Though there was a small increase in the cost of cultivation by about Rs. 808/ha due to adoption of recommended practices, the increased cost was justified by the marginal rate of return of 15.9. Both the size and rate of returns were high in FLDs as is evident from higher net returns and BC ratios. It can be concluded that these technologies have met the necessary condition to be adopted by farmers. However, other adoption-constraints in terms of awareness, knowledge and availability of necessary inputs have to be addressed for wider adoption of the technologies.

2.7.1.3 Trends and determinants of agricultural diversification in Andhra Pradesh

It is now recognized that diversification is one of the potential sources for enhancing the income of the farmers in the fast changing environmental and economic scenario. Concerns that the recent diversification towards horticultural crops was accompanied by reduction in cereal consumption are also being expressed. An analytical study was initiated in 2007 to examine the nature of and trends in diversification that is taking place in Andhra Pradesh agriculture. Both primary and secondary data are being used to measure diversification in terms of Simpson's index and area under dominant crop.

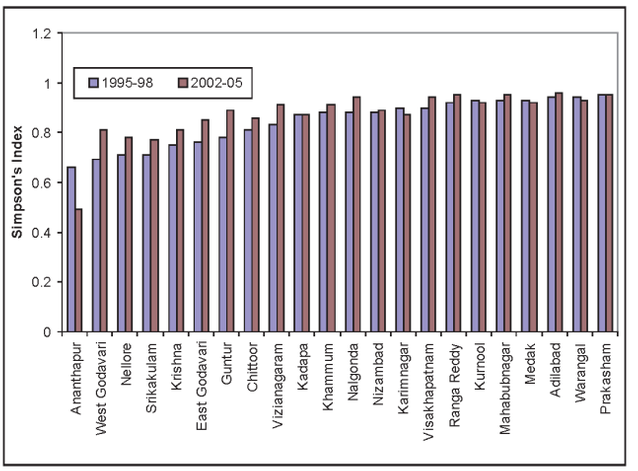


Fig 32. Crop diversification index in Andhra Pradesh between 1995-98 and 2002-05

During this year, Simpson's indices of diversification were computed for the 22 districts in Andhra Pradesh for the periods 1995-98 and 2002-05. Diversification, as measured by Simpson's index, was lowest in Anantapur district during both the periods (Fig 32). In fact, there was a tendency towards more specialization as can be seen from the fall in index from 0.66 to 0.49. Other districts where diversification was relatively less were West Godavari, Nellore, Srikakulam and Krishna. Diversification was found highest in Prakasam during 1995-98 and Adilabad during 2002-05. In the districts with less diversification, dominance of single crop was a significant feature. In Anantapur, groundnut was the most dominant crop whereas in other districts, rice was the more predominant crop. More diversification was observed during 2002-05 compared 1995-98 in about ten districts and diversification weakened in four districts during this period.

Table 51 : Percentage of Incidence of Chronic Energy Deficiency (based on body mass index) in rural women of Ranga Reddy district according to WHO criteria

Villages /Mandals	No.	Grade of Malnutrition(Chronic Energy Deficiency)			
		<16.0 Grade III	16.0-16.9 Grade II	17.0-18.4 Grade I	>18.5 Normal
Ibrahimpatnam	32	15.62	-	18.75	65.63
Seriguda(Ibrahimpatnam mandal)	39	7.69	5.13	5.13	82.05
Manthanagoni (Yacharam mandal)	14	21.43	7.14	14.29	57.14
Japal(Manchal mandal)	29	3.45	3.45	20.69	72.41
Qutbullapur (Hayatnagar mandal)	28	3.57	-	10.71)	85.71
Ghakesar	30	10	6.66	16.67	66.67
Gummadanelli (Kandukur mandal)	30	-	3.33	30	66.67
Tallapalli (Shabad mandal)	28	21.42	8.57	17.86	32.14

Diversification was also examined in terms of dominance by a particular crop in different districts. Rice was the most dominant crop in 14 districts, groundnut and sorghum in 4 districts each during 1995-98 and 2002-05. However, the extent of dominance as measured by per cent area sown to these crops showed a decline during 2002-05 compared to 1995-98. However, the situation with respect to second and third most dominant crop was more variable in a given district over time. Overall, crop production was more diverse during 2002-05 compared to 1995-08.

2.7.2 Gender studies

2.7.2.1 Nutritional status of rural women

A baseline survey was conducted to assess the nutritional status of rural women based on body mass index in Ranga reddy district. A sample of 230 rural women living in 8 mandals of Rangareddy district was selected randomly to assess their nutritional status through anthropometric measurements. All apparently healthy and normal women were measured for height and weight following standard techniques. Body mass index (BMI) was calculated as BMI = Weight (kg)/Height(m^2)

Table 51 provides information about Body mass Index (BMI) of rural women in 8 mandals of Ranga Reddy district and its grading according to WHO 1995 criteria. Maximum no. of women were found in the normal range of BMI. This is followed by 5.13 - 30 % found in the grade I CED range, 3.45 - 8.57 % found in the grade II CED and 3.45 – 21.43 % found in the range of III degree grade malnutrition. On the basis of BMI, chronic energy deficiency (CED) has been defined as the degrees of underweight for a given height and cut-offs at 18.5, 17.0 and 16.0 have been recommended for mild, moderate and severe chronic energy deficiency, respectively. In the present rural women population, around 21% were in the range of II and III grades of malnutrition, therefore there is need to take up a nutritional study and corrective measures to overcome II and III grades of malnutrition in rural women.

2.8 Transfer of technology

2.8.1 Use of ICT in technology transfer

2.8.1.1 Identification and digital documentation of dryland technologies

A project was initiated in 2006 to identify the constraints in adopting the dryland technologies of CRIDA based on feedback from farmers and to document the adopted dryland technologies in a digital (electronic) form. The following technologies have been selected for documentation based on the criteria of more than 50 percent adoption by farmers' in *Nallavelli* and *Manmarri* villages:

Nallavelli (Red soils)

1. Sorghum + pigeon pea cropping system in 5:1
2. Conservation furrows at 1.2 m interval in sorghum system
3. Recommended dose of fertilizers in sorghum system (basal & top dressing)
4. Pest management in pigeon pea – chemical component only
5. Late sown horse gram/ castor/ green gram (in case of delayed onset of rains)
6. Castor intercropped with cowpea
7. Recommended dose of fertilizers in castor system
8. Pest management in castor – chemical component only

9. Potash application in rice

Manmarri (Black soils)

1. Maize + pigeon pea cropping system in 5:1
2. Recommended dose of fertilizers in maize system (basal & top dressing)
3. Introduction of *Bt* cotton
4. Pest management in cotton – chemical component only (Bt & non-Bt)

Final preparation of CD i.e., information base in electronic form is in progress.

2.8.1.2 ICTs as a tool of agricultural extension for technology dissemination— A critical analysis

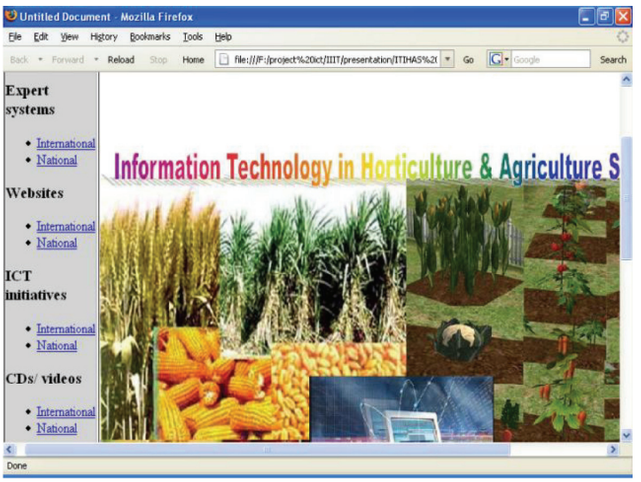
A study was initiated in 2006 to document the ICT's potential for technology dissemination operated by different organizations and to study the constraints in operationalizing the ICT technologies for rural poor. The project attempted to assess the impact created by ICTs which are used as tools of agricultural extension for technology dissemination. Pre testing was done and the reliability of the data collection instrument was found to be 0.89. Pre-testing revealed the relevance of variables awareness, nature of content, access, timely updating language, capacity building, maintenance, partnership, affordability and sustenance, which were chosen for the study. Data was collected from DAATC center, Ranga Reddy district, an extension system from ANGR Agricultural University to establish liaison with all stakeholders for dissemination of the information. Comparative data analysis of DAATC's is being made

Screenshots of RAINS

with ICT enabled extension systems like e-Sagu, weather based agroadvisory services of CRIDA, Kisan Call Centres, Ikisan etc.

2.8.1.3 Rainfed Agricultural Information System (RAINS)

Rainfed Agricultural Information System (RAINS) is a decision support information system on rainfed crops and efforts were made to build the information system of pigeonpea, an important rainfed crop. The RAINS for pigeonpea crop is basically a decision support system for framers and extension personnel which displays information related to package of practices to be followed, management of pests and diseases, post harvest handling, etc., with a single mouse click. It helps people access, display and use information that has content and



Screenshot of ITIHAAS

meaning. The system is web based, advising the efficient management of the resources for increased crop production. It will greatly improve the farmers' capability to adopt the latest and most innovative agricultural research outcomes suggested through RAINS to assist crop management and therefore enhance production and minimize losses.

2.8.1.4 Information Technology In Horticutural, Agricultural & Allied Sciences (ITIHAAS)

Information is a prerequisite to empower the farmers in terms of technology utilization. Access to information will also reduce burden on the traditional extension system in the developing countries like India where skilled manpower is a major constraint. Hence attempts were made to design web enabled services with digital content collected and delivered to clientele in the form of ITIHAAS with an aim to build a common e-platform of ICT products. This e-registry will hoard the agricultural information on ICT products as a digital content from agricultural universities, research organizations, private initiatives,

NGOs, etc., for the benefit of different stakeholders identified in the project.

2.8.1.5 SWOT analysis of eSagu

eSagu has emerged as one of the best and established ICTs in Agriculture with a unique concept of building a cost effective and scalable agricultural expert advice dissemination system aiming to provide a timely and personalised scientific agricultural advice to the farmers. Hence an attempt was made to analyze eSagu through SWOT (Strength, Weakness, Opportunity and Threats) analysis in order to understand the situation, functioning of the technology/ organisation and its current status. The study aims to answer the following questions.

1. How eSagu is different from other ICT technologies already in the field in disseminating latest technologies to the farmer? (Strengths)
2. What problems eSagu has not been able to address at grass root level? (Weaknesses)
3. What is the potential of eSagu in upscaling or replicating the uses? (Opportunites)
4. What are the barriers / constraints faced by eSagu in implementation? (Threats)
5. How the issues of sustainability are answered in eSagu?

Strengths, Weaknesses, Opportunities and Threats of eSagu were analysed in terms of various factors like technological aspects, environment, resources and hidden/unforeseen factors influencing the technological development. Based on the implications of SWOT analysis, suitable extension strategies were suggested for replicating the useful findings of eSagu to similar ICT projects.

2.8.2 Capacity builiding

2.8.2.1 Capacity building of ORPs in rainfed agroecosystem: An action research project

To meet the needs of rainfed agriculture research and for integrating NRM research and livelihood issues, institutionalizing a process to enhance the effectiveness of Operational Research Projects (ORP) is required. A project was initiated in 2005 with the objective of redefining the concept and capacity building of ORPs through action research at 8 ORPs viz., Anantapur, Arjia, Ballowal-Saunkhri, Bangalore, Hisar, Indore, Ranchi and Solapur under AICRPDA Network. During the period, ORP could establish strong linkage for institutional and support systems, with AICRPDA main center in respect of programme planning and implementation, state line departments (agriculture, animal husbandry, horticulture, forestry etc), NABARD, and banks guidelines were developed for selection of new villages, collection of basic information at village and individual level. The ORP and AICRPDA scientists were facilitated to look critically into the process of technology adoption and diffusion. Expert intervention was made available to them to analyze reasons for non-adoption of technologies. This has enabled the ORP and main centre scientists to jointly develop participatory research and extension plans for addressing the issue of technology upscaling. Six ORPs viz., Anantapur, Arjia, Ballowal Saunkhri, Hisar, Indore and Ranchi will select new sites. Guidelines were developed for selection of new villages, collection of basic information at village level and individual level. Scientists identified two technologies for upscaling and two technologies for participatory technology development. Participatory action plan and strategies for and technology upscaling for ORP. Technical workshops on participatory technology development and participatory action plan were organized at Arjia, Anantapur, Ranchi and Solapur. Action

Technical Workshops on Participatory Technology Development and at K.Agraharam (ORP village), and Main Centre, (ARS, Anantapur)

plans for XI plan were implemented for the first year at Arjia, Anantapur and Solapur. For capacity building of the scientists of ORPs and Main Centres, two training programmes viz., Farming Systems Approach for Livelihood Improvement of Rainfed Farmers (December 4-14, 2007) and ICT Applications in Agricultural Research (March 24-29, 2008) were organized jointly by CRIDA and ICRISAT at CRIDA, Hyderabad. The changes observed at the behavioral and organizational level were encouraging for strengthening ORP activities.

2.8.2.2 Development of Rainfed Agri–Knowledge Network (RAKNet)

Over the years, enormous knowledge was generated by the coordinating centers of AICRPDA and AICRPAM and there is a need for storing and accessing this knowledge when needed. A project was initiated in 2007 for developing rainfed agricultural knowledge network across the AICRPDA and AICRPAM networks by using state of the art information and communication technologies (ICTs). This will help create a digital repository of knowledge of rainfed agriculture across different agroecological sub regions. The methodology involves five stages, viz., determination of ICT readiness of the coordinating centres, sensitization, capacity building, deployment of information on the network and evaluation.

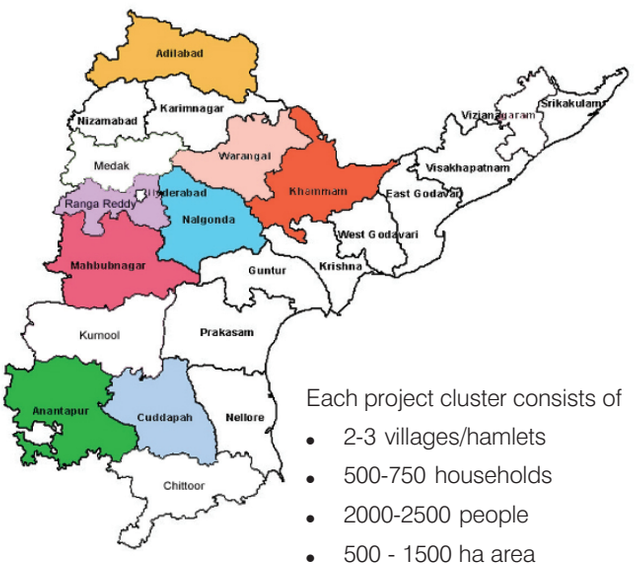
Information was sought from all the coordinating centres of AICRPDA and AICRPAM to know the status of availability of computers, requisite accessories, internet connectivity and capability to handle computers. Barring two centers in AICRPDA, all the centers have the requisite hardware capability while many AICRPDA centers expressed that they need training on the use of computers. Based on the need a one-week training course was organized for the scientists of AICRPDA and ORPs. The training programme was rated as 'very good' and the trainees desired to have at least one such training every year to keep themselves abreast of developments in ICTs.

2.9 Sustainable rural livelihoods

Sustainable rural livelihoods through enhanced farming systems productivity and efficient support systems in rainfed areas (National Agricultural Innovation Project Component-3)

CRIDA launched the consortium project on "Sustainable rural livelihoods through enhanced farming systems productivity and efficient support systems in rainfed areas" under Component-3 of the National Agricultural Innovation Project (NAIP) on 1st September, 2007. This project was approved with an outlay of Rs.15.38 crores involving 10 partner institutions as members of the consortium. The project is being implemented in 8 backward districts of Andhra Pradesh for a period of 5 years. CRIDA is the Lead Center and other consortium partners are Acharya NG Ranga Agricultural University(ANGRAU), Hyderabad; International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Watershed Support Services Action Network (WASSAN), Secunderabad; Centre for World Solidarity (CWS), Secunderabad; Modern Architects for Rural India (MARI), Warangal; Shri Aurovindo Institute for Rural Development (SAIRD), Nalgonda; BAIF Institute of Rural Development (BIRD), Hyderabad; Akruthi Agricultural Associate of India (AAI), Kadapa and Ikisan Limited, Hyderabad. This is the first project of its kind involving institutions from public, private and non governmental sectors. The project is carrying out participatory action research in selected village clusters in the target districts to understand constraints in technology transfer and its adoption at farm level. Besides participatory technology generation and refinement, the project also attempts to innovate processes for establishing market linkages and providing off farm livelihood opportunities for rural youth with the over all aim of improving the livelihood security. The salient objectives of the project are:

- To improve the livelihoods of the rural poor through efficient management of natural resources and increased productivity, profitability and diversity of the farming systems.



Each project cluster consists of

- 2-3 villages/hamlets
- 500-750 households
- 2000-2500 people
- 500 - 1500 ha area

Eight selected districts of A.P. in which the project sites are located

- To facilitate agro processing, value addition and market linkages for enhanced on farm and off-farm income and employment generation.
- Capacity building and skill development of primary and secondary stakeholders through knowledge sharing, collective action and use of modern ICTs.
- To build a policy framework, institutional mechanisms and support systems for scaling up of the successful approaches.

Project location

The action research pilot project is being carried out in a cluster of 2-3 villages/ hamlets falling under one Grampanchayat in 8 backward districts (Adilabad, Warangal, Khammam, Rangareddy, Nalgonda, Mahabubnagar, Cuddapah and Ananthapur) of A.P. falling in Telangana and Rayalaseema. The project sites are selected based on the criteria of predominantly rainfed farming, high tribal, SC and ST population, low household income and poor infrastructure.

Through technology transfer and institutional innovations at the cluster level, the project envisages the following deliverables:

- A 25% increase in profitability for farmers involved in crop and livestock production in the target area and upto 30% increase in household income of the land less.
- A new institutional mechanism for improving the access and management of natural resources in the watershed, in particular social regulation on use of ground water.
- A 30% reduction in cost of cultivation of high input intensive crops in distress prone districts like Warangal, Nalgonda and Adilabad through judicious water, nutrient and pest management strategies.
- A farming system module for small and marginal holdings (based on small ruminants) that would ensure food and nutritional security.
- A farmer friendly insurance product to cover drought risk based on scientific analysis of rainfall and crop productivity data in the clusters.
- Few successful contract farming and market linkage models for key commodities grown in the districts which can be upscaled.

Project progress

In all the clusters, stakeholders meets were organized and and detailed PRAs were conducted. Based on this information, the technical programme was finalized and implementation began from October, 2007. The interventions included introduction of new technologies, institutional innovations and market linkages. A brief summary of few selected interventions and the innovative elements in them is given below.

Technology interventions: These interventions cover crop production, NRM, livestock and horticulture.

a. *Village level seed production:* Recognising the importance of quality seed, village level seed production was taken up as a key intervention in 6 clusters covering 4 crops and about 100 farmers. The crops covered were groundnut in Jamisthapur and Pampanur clusters (20 ha.), pearlmillet in B.Yerragudi cluster (20 ha.) and green gram in Jaffergudem cluster (25 ha.). The major focus was on formation of farmers groups, training them on seed production, storage, processing and using during the next season. The actual success and response from this interventions will be known by August, 2008.

b. *Resource conservation/NRM:* In all the clusters, detailed mapping of the critical soil and water conservation works was made which are to be done during May – June, 2008. The key innovation in this intervention will be linking with NREGP and formation of area groups covering the micro watersheds. In Jaffergudem cluster, zero tillage maize was introduced as a summer crop after kharif rice which received very encouraging response. Reduction in cost of production and saving of water are being quantified.

c. *Soil fertility management:* Recognising this as a critical intervention, an innovative approach was followed in all the clusters which was piloted by ICRISAT wherein 100 soil samples based on a toposequence in a watershed were collected from each cluster by farmers themselves. After analysis by ICRISAT, participatory on-farm trials on balanced nutrition will be taken up during 2008. The innovation is the complete involvement of the farmers themselves in the soil fertility assessment and making the initial 15 farmers from each cluster as trainers and making the trial plots as demonstration fields to spread the awareness to others in the cluster.

d. *Custom hiring centers:* Need based farm machinery interventions were made through establishment of custom hiring centers through panchayats in 3 clusters or trained unemployed youth (in 5 clusters).

The latter case was linked to bank loan utilizing the subsidy component of the Dept. of Agriculture.

e. *Horticulture:* In B.Yerragudi, post harvest handling intervention in mango through farmers groups was taken up and a new brand of high quality mangoes from the cluster is being promoted. The grading center is completed through farmers contribution and bank linkages at Konampet village. In Nalgonda cluster, organic vegetable cultivation covering 100 tribal farmers and sericulture covering 50 farmers were taken up. The key innovation here is to form cropwise groups and organize both input production (vermicompost etc.) and micro irrigation installations and link with local markets with a well defined MOU.

f. *Backyard poultry:* The dual purpose Vanaraja birds have become quite popular in rural areas of A.P. However, it could not be upscaled as a livelihood option because of poor retention of birds and inability to multiply them at village level. To encourage the families for high retention and making it as viable enterprise for a family, different innovations are being tried which include giving different numbers of four weeks old chicks (female and male) to determine the optimum size. Simple technique of partial enclosure are being tried at village level to prevent cross breeding with local birds so that pure Vanaraja birds can be produced by the women. These interventions are started in 6 of the 8 clusters.

g. *Animal feed:* House hold level *Azolla* production has been initiated with low cost methods in 5 of the 6 clusters covering 50 farmers. This has excellent scope for upscaling.

Capacity building: The following activities were completed.

a. Exposure visit of 300 farmers from 6 clusters to nearest agriculture research centers.

b. Training on off-farm skill development for 25 rural youth at Sri Ramananda Tirtha Institute, Pochampally. This training became a big hit and all the 25 youth were placed in jobs in different computer related companies.

c. Training of 28 rural youth as para vets at livestock training center, Mahabubnagar jointly with BAIF. All of them have completed training and were provided kits. It is expected that local veterinary services will provide them the livelihood within the village and also fill the critical gap of timely veterinary health care.

d. Training of women self help groups (60) on vermicomposting and biomass raising at ICRISAT.

e. Training for 15 rural youth on motor winding and electrical pump repairs (under progress).

f. Formation of 80 self help/commodity/farmers groups was completed and basic training given on the interventions and group management/ accounting etc.

Market linkages: After a survey of the production of different commodities and possible improvements in marketing channels, the following linkages have been established.

a. With reliance retail for milk procurement in Jamisthapur cluster.

b. With Subiksha for vegetable procurement in Dupad cluster.

c. With Heritage for mango procurement in Yerragudi cluster.

d. Discussions under progress for tie up with Brij health care for apiary as micro enterprise in 6 clusters and tie up for procurement of honey.

Training programmes/workshops conducted

1. Launch workshop on 1-2 September, 2007.
2. First review workshop organized at CRIDA on 19th November, 2007.
3. Interaction meeting for planning soil sampling and INM interventions organized at CRIDA on 18th December, 2007.
4. Six stake holders workshops organized in 6 clusters between December, 2007 and March, 2008.
5. Hands on training for all contractual staff for designing of NRM structures at CRIDA on 11th March, 2008.
6. Training for rural youth (22) on para veterinary services at livestock center Mahabubnagar between 10 March to 15 May, 2008.
7. Training on basic computer knowledge for educated rural youth (25) at SRTTI, Pochampally.
8. Twenty eight farmers training programmes on different subjects organized by the partners so far.
9. Exposure visit for all the cluster anchoring personnel

on Azolla cultivation in Jaffergudem cluster on 16th April, 2008.

Linkages developed

1. With PD, DWMA and PO, ITDA for NRM interventions through NREGP in three clusters.
2. With State Bank of India and PNB for financing horticulture grading/seed processing plants in two clusters.
3. With ICICI Lombard/AIC for piloting weather insurance.
4. With animal husbandry joint directors in all the clusters for livestock related interventions and capacity building.
5. With leading retail chains for horticulture and pulses marketing in 3 clusters.

3 AICRP/ Coordination Units

3.1 All India Coordinated Research Project for Dryland Agriculture (AICRPDA)

The All India Co-ordinated Research Project for Dryland Agriculture has a network of 25 centers representing arid, semi-arid, sub-humid, humid and per-humid climates with diverse biophysical and socio-economic settings of the rainfed agro-ecologies of the country. The project has mandate to generate location specific technologies through on-station research focusing on rain water management/ soil and water conservation, integrated nutrient management (INM), cropping systems, crop improvement, energy management, alternate land use - and farming systems, in rainfed rice, maize, oilseeds, cotton and nutritious cereals (finger millet, pearl millet and sorghum) based production systems. The resultant technologies are subsequently assessed on farmers' fields under 8 Operational Research Projects. Outreach programs like Frontline demonstrations (FLDs) on pulses and oilseeds and on-farm trials through externally funded projects like AP Cess schemes, are also undertaken. A total of 469 experiments were conducted at the 24 centers with a percentage of 22.8, 14.1, 11.5, 12.8, 25.4, 0.4, 7.5, 1.3 and 4.2 under INM, soil and water conservation, energy management, cropping systems; crop improvement; integrated weed management; alternate land use; integrated farming system and other experiments respectively. These include 117 experiments on rice production system (Jagdalpur, Jorhat, Faizabad, Phulbani, Ranchi and Varanasi), 48 on maize production system (Arjia, Ballowal-Saunkhri, Rakh Dhiansar), 89 on oilseeds production system (Indore, Rewa (soybean based) and Anantapur, Rajkot (groundnut based), 32 on cotton production system (Akola, Kovilpatti, Parbhani) and 231 on nutritious cereals production system (Bellary, Bijapur, Solapur (*Rabi* sorghum based), Agra, SK Nagar, Hisar (Pearlmillet based); Bangalore (Fingermillet based). Salient findings of these experiments are given in Table 52 and 53.

Table 52. Salient findings from on-station experiments conducted at AICRPDA centers

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
Rain Water Management		
Jorhat	Potato	Two irrigations (one at stolon formation and the other at tuber formation) for Potato (75700 kg/ha)
Varanasi	Rice	Life saving irrigation recorded maximum yield of 1481kg/ha
Ranchi	Lentil	Mulching @ 10 t/ha had given maximum yield of lentil (779 kg/ha)
Bijapur	Green gram	Pebble mulch of 50% of surface application had given highest yield of 510 kg/ha
SK Nagar	Castor	Two life saving irrigations + FYM @ 5 t/ha and ridges and furrows had given yield of 800 kg/ha
	Castor	Crop residue mulch (1209 kg/ha)
Hisar	Pearlmillet	Polythene mulch had given additional grain yield of 552 kg/ha of pearlmillet
Bangalore	Fingermillet	Nase live barrier at upside of the plot (2050 kg/ha)
Rakh Dhiansar	Maize	Life saving irrigation + 100% recommended fertilizer recorded grain yield (1556 kg/ha) and net income of Rs. 2769/ha
	Mustard	Life saving irrigation + one irrigation at branching + 100% recommended fertilizer recorded 1649 kg/ha of grain yield and net income of Rs. 19879/ha.
Ballowal Saunkhri.	Maize	Sugarcane trash as a mulch gave 3351 kg/ha of yield and net income of Rs. 16026/ha
	Wheat and African sarson	Paddy straw mulch had recorded for wheat (2910 kg/ha) and African sarson (1740 kg/ha) and net income of Rs. 19090 and Rs. 22867/ha

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
Cropping system		
Phulbani	Turmeric + pigeonpea	Turmeric + pigeonpea (10:2) recorded highest net income of Rs. 24434/ha
Faizabad	Pigeonpea	Pigeonpea + Kalmegh gave the highest maize grain yield of 7621 kg/ha and net income of Rs. 45726/ha
Rajkot	Cotton	Cotton-Sesame recorded highest gross income of Rs. 27964/ha
Anantapur	Groundnut	Sowing in second fortnight of July recorded highest net income of Rs. 11730/ha and gave highest grain yield of 1029 kg/ha
Rajkot	Sesame, blackgram, castor, cotton and spreading groundnut	Sowing at onset of monsoon gave 333 kg/ha and Rs. 1108/ha of gross income for sesame, blackgram (593 kg/ha), castor (1789 kg/ha), cotton (848 kg/ha) and spreading groundnut (715 kg/ha)
	Bunch groundnut and pigeonpea	15 days after onset of monsoon had given an yield of 619 kg/ha
Indore	Soybean + pigeonpea	Sowing at onset of monsoon recorded 3997 kg/ha of soybean equivalent yield.
Akola	Cotton	Cotton (Rajat) + pigeonpea (AKT-8811) recorded highest net income of Rs. 20373/ha
Parbhani	Sorghum + pigeonpea	Sorghum + pigeonpea (4:2) gave highest sorghum grain equivalent of 2799 kg/ha
Balowal Saunkhri	Blackgram-raya	Blackgram-raya has given highest maize equivalent yield of 6675 kg/ha and net income of Rs. 40489/ha
Arjia	Sorghum and Maize	Sorghum in half donar area + maize in half receiver area with 150% of recommended N and P recorded highest maize equivalent yield of 2815 kg/ha and net income of Rs. 17400/ha
Rakh Dhiansar	Wheat	Sowing on 14th November given grain yield of 3367 kg/ha and net income of Rs. 2733/ha
	Mustard	Sowing on 5th October gave 992 kg/ha of yield and net income of Rs. 8968/ha
Ballowal Saunkhri	Maize, pearlmillet, ackgram and greengram	Sowing on 16th July had given highest yields of maize (457 kg/ha), pearlmillet (2056 kg/ha), blackgram (1624 kg/ha) and greengram (958 kg/ha)
	Mustard	Sowing on 16th November gave 1500 kg/ha yield with net income of Rs. 19955/ha
	Chickpea	Sowing on 8th November gave 1760 kg/ha of yield and net income of Rs. 24944/ha/ha
Solapur	Pearlmillet + pigeonpea	Pearlmillet + pigeonpea (2:1) proved as best intercropping system
Agra	Clusterbean + pearlmillet	Clusterbean + pearlmillet (6:1) recorded 787 and 146 kg/ha of grain yields with a net income of Rs. 8440/ha
SK Nagar	Cotton + blackgram	Cotton + blackgram (1:1) performed better with cotton equivalent yield of 2063/ha and net income of Rs. 46411/ha
Hisar	Mothbean	Mothbean Paired rows (30 & 60 cm) + 1 row of clusterbean recorded mothbean equivalent yield of 1329 kg/ha and net income of Rs. 18815/ha

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
	Pearlmillet + green gram	Pearlmillet + green gram (8:4) with a row spacing of 30 cm gave 3214 kg/ha pearlmillet equivalent and net income of Rs. 8338/ha.
	Pearl millet (early sown)	Dhaincha for green manuring 30 DAS gave 3028 pearlmillet equivalent yield and net income of Rs. 5189/ha
	Pearl millet (late sown)	Removing 3rd row at 30 DAS for fodder and making furrows of 45 cm width recorded 2469 kg/ha pearlmillet equivalent yield and net income of Rs.1831/ha
Bangalore	Chilli	Chilli + castor (3:1) with nipping recorded yield of 2286 kg/ha
	Castor	Early sowing (27th May) recorded 2258 kg/ha of yield and net income of Rs. 20177/ha
Nutrient management		
Jagdalpur	Greengram and mustard	Lime @ 20% of lime requirement + FYM @ 5 t/ha gave 741 kg/ha with Rs. 6101/ha
Phulbani	Rice	15 kg N (FYM) + 20 kg N/ha (urea) gave 2269 kg/ha of yield with gross income of Rs. 15042/ha
	Blackgram	15 kg N (FYM) + 10 kg N/ha (urea) recorded 980 kg/ha yield and net income of Rs. 14870/ha
Ranchi	Blackgram + Rice	15 kg N (compost) + 10 kg N (green leaf) + 10 kg N/ha (farm residue) had given blackgram yield of 825 kg/ha and 3022 kg/ha of rice
Faizabad	Maize	25 kg/ N (compost) recorded 574 kg/ha of yield
Rajkot	Groundnut	25 kg N/ha (compost) recorded 944 kg/ha of yield and net income of Rs. 9670/ha
	Pearlmillet	100% recommended N gave 794 kg/ha and net income of Rs. 3277/ha.
	Soybean, groundnut and greengram	100% recommended fertilizer recorded the yields of soybean (1182 kg/ha), groundnut (694 kg/ha) and greengram (389 kg/ha)
Rajkot	Blackgram	100% RDF recorded 694 kg/ha of yield and net income of Rs. 4898/ha
Indore	Soybean	Jabhua rockphosphate @ 60 kg/ha + 10 grams PSM/kg seed treatment + 3 kg PSM blended with 50 kg FYM/ha recorded 2269 kg/ha of yield and net income of Rs. 23945/ha
		100% recommended fertilizer + sulphur @ 40 kg/ha (gypsum) gave an yield of 2463 kg/ha and net income of Rs. 26243/ha
Rewa	Rice, blackgram	100% N (compost) recorded the yield of 4782 kg/ha of rice equivalent yield with net income of Rs. 4971/ha
	Wheat	50% N (urea) + 50% N (compost) + Azotobactor gave 1990 kg/ha of wheat yield with a net income of Rs. 24324/ha
	Mustard	60 kg N + sulphur @ 45 kg/ha gave 560 kg/ha of yield with net income of Rs. 7038/ha
Kovilpatti	Pearlmillet	20 kg N (FYM) + 20 kg N/ha (urea) + 10 kg P/ha gave 1220 kg/ha of grain yield with net income of Rs. 2934/ha
	Sorghum + cotton	100% recommended N (urea) + recommended P enriched (FYM) gave a net income of Rs. 7041/ha
	Sorghum + cowpea	15 kg N (compost) + (inorganic) gave 2542 kg/ha of sorghum equivalent yield

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
	Greengram - *rabi* sorghum	FYM @ 2.5 t/ha + 50% recommended fertilizer recorded 3708 kg/ha of sorghum equivalent yield
	Sorghum + pegionpea, cotton + blackgram	100% recommended fertilizer (inorganic)6298 and 6073 kg/ha of sorghum equivalent yield
Rakh Dhiansar	Maize	100% recommended N (inorganic) gave 2268 kg/ha of yield with net income of Rs. 1081/ha
	Black gram	15 kg N (green leaf) + 20 kg N/ha (inorganic) gave yield of 1138 kg/ha and net income of Rs. 1940/ha
	Gobi sarson (Maize-gobi sarson)	FYM @ 10 t/ha recorded highest net income of Rs. 12280/ha
	Wheat	FYM @ 10t/ha + 40 kg N/ha + recommended PK gave 2430 kg/ha of yield and net income of Rs. 17442/ha
Ballowal Saunkhri	Maize, blackgram, wheat	100% N (inorganic) gave yields of Maize (2780 kg/ha), blackgram (1000 kg/ha) and wheat (2860 kg/ha)
	Lentil	15 kg N (green leaf) + 20 kg N/ha (inorganic) recorded an yield of 1270 kg/ha and net income of Rs. 25575/ha
Arjia	Maize	15 kg N (compost) + 20 kg N/ha (inorganic) gave an yield of 3031 kg/ha with net income of Rs. 1905/ha
Solapur	Chickpea	15 kg N (compost & crop residue) + 20 kg N/ha (urea) gave an yield of 1441 kg/ha and gross income of Rs. 3469/ha
Bijapur	Chickpea	15 kg N (compost) + 20 kg N (urea) recorded 1131 kg/ha of grain yield
	Sunflower	100% RDF + FYM @ 5 t/ha had given a grain yield of 1626 kg/ha
Bellary	*Rabi* sorghum and chickpea	15 kg N (compost) + 10 kg N (green leaf) recorded 792 kg/ha of *rabi* sorghum and 711 kg/ha of chickpea yields
Agra	Pearl millet	50% N (urea) + 50% N (FYM) recorded an yield of 1382 kg/ha
	Cluster bean	15 kg N (compost) + 20 kg N (inorganic) had given 915 kg/ha yield
	Pearl millet + cluster bean	100% N (urea) i.e., 60 kg N/ha recorded 1969 kg/ha of pearlmillet equivalent grain yield
	Pearlmillet	75 kg N + 50 kg P + 50 kg K/ha + zinc + boron + magnesium recorded 1585 kg/ha of grain yield and 3550 kg/ha of fodder yield
Hisar	Pearlmillet	100 kg N/ha + FYM @ 8 t/ha + seed treatment with HT-54 recorded 1714 kg/ha of grain yield
	Green gram, pearlmillet + green gram	100% recommended (urea) had given 4421 kg/ha of pearlmillet equivalent yield and net income of Rs. 22137/ha
Bangalore	Fingermillet (FYM Block)	FYM @ 10 t/ha + 50 % NPK recorded 2073 kg/ha of yield with net income of Rs. 9161/ha
	Fingermillet (Maize Residue block)	Maize residue @ 5 t/ha + 100% recommended NPK (571 kg/ha)
	Fingermillet	100% recommended N and K + lime @ 300 kg/ha + $MgCO_3$ @ 500 kg/ha + boron @ 10 kg/ha recorded 924 kg/ha of grain yield and 1779 kg/ha of fodder yield

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
Energy Management		
Faizabad	Rice-Lentil	Conventional tillage + hand weeding twice + 100% N (organic) gave 1496 kg/ha of rice and 1259 kg/ha of lentil yields
Varanasi	Rice	Disc harrowing twice + one cultivator + 100% N (inorganic) had given 2218 kg/ha of grain yield
Jagadalpur	Rice	Dry line sowing by seed drill together with recommended fertilizer + post-mergence weedicide given yield of 3650 kg/ha with net income of Rs. 20100/ ha
Rajkot	Groundnut	Conventional tillage + 100% N (organic) recorded an yield of 847 kg/ha and net income of Rs. 10235/ha
Rewa	Soybean	Low tillage + weedicide + interculture recorded the yield 1745 kg/ha with net income of Rs. 17113/ha
Indore	Soybean	Conventional tillage + hand weeding given 2334 kg/ha of yield
Kovilpatti	Sunflower	Conventional tillage + interculture + 50% N (organic) + 50% N (urea) recorded 532 kg/ha yield
Parbhani	Sorghum	Conventional tillage + interculture + 100% recommended fertilizer recorded 5603 kg/ha of sorghum equivalent yield
Solapur	Pearl millet	Conventional tillage + 100% N (inorganic) gave 1933 kg/ha yield and Rs. 6569/ha net income
Bellary	*Rabi* sorghum	Conventional tillage + 50% N (FYM) + 50% N (urea) gave 2125 kg/ha of yield
Bijapur	*Rabi* sorghum	Conventional tillage + farmer's practice had given 2235 kg/ha of yield
Agra	Pearlmillet	Conventional tillage + interculture + 100% N (organic) recorded 1259 kg/ ha of yield and net income of Rs. 2047/ha
Hisar	Pearlmillet	Conventional tillage + 2 intercultures + 100% N (inorganic) recorded 1842 kg/ha of yield and net income of Rs. 2487/ha
SK Nagar	Pearlmillet	Low tillage + weedicide + one interculture together with 50% N (urea) + 50% N (FYM) recorded grain yield of 638 kg/ha and fodder yield of 4378 kg/ha
	Cotton	Deep ploughing with disc plough recorded highest kapas yield of 41540 kg/ha
Hisar	Pearlmillet, chickpea and mustard	Ridger seeder for seeding recorded maximum pearlmillet yield of 1830 kg/ha and 869 kg/ha of chickpea
Bangalore	Fingermillet, Pigeonpea	Power tiller operated reaper gave an advantage in time taken per acre of 1 hr 15 min.
	Fingermilet	Tractor drawn interculture hoe given advantage of time of interculture operation (1 hr 55 min)
Alternate Land Use systems		
Indore	Soybean	Drumstick + soybean (994 kg/ha) of soybean equivalent yield
Kovilpatti		Sapota + greengram (2173 kg/ha) of sorghum equivalent yield
Rakh Dhiansar	Aonla + green fodder	Aonla + green fodder 24380 kg/ha of fodder yield and Rs. 8233/ha of net income.
Ballowal Saunkhri	Lemon grass	60 x 30 cm gave kg/ha of oil yield in *Kharif* and 71 kg/ha in summer

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
Solapur	Aonla	Aonla + pearlmillet + pigeonpea (2:1) 1455 kg/ha Aonala equivalent yield and net income of Rs. 13886/ha
	Jatropha	75 kg N + 37.5 kg P + 37.5 kg K/ha + irrigation of 10 lt/plant recorded 201 kg/ha of seed yield had given maximum
Bellary	*Jatropha*	JJ-cutting had given maximum canopy spread (82.0 cm) and number of branches (11)
	Jatropha	JU-seedling (plant height (71.8 cm) and collar diameter 4.9 cm)
Agra	Mustard	Sowing of mustard during 11-20 October and maintaining 100% plant population given 1596 kg/ha of mustard yield
	Aonla	Aonla + cluserbean in *kharif* and aonla + mustard in *rabi* recorded a maximum net income of Rs. 5696/ha and Rs. 8712/ha
SK Nagar	Aonla	Aonla + *stylosanthes hamata* had recorded a net income of Rs. 18712/ha
	Castor + Cowpea	Castor + Cowpea had recorded highest gross income of Rs. 4790/ha and Rs. 6350/ha
Crop Improvement		
Jagdalpur	Sesame (RT-54) 503 kg/ha, Groundnut (J-11) 254 kg/ha and net income of Rs. 4523/ha and Rs. 1936/ha	
Ranchi	Rice (Vandana) (2578 kg/ha), Linseed (BAU-2K-16) (412 kg/ha), Groundnut (BAU-20) (2933 kg/ha), Horse gram (Madhu) (737 kg/ha), Sesame (RT-125) (556 kg/ha), Fingermillet (GPU-28) (2619 kg/ha), Sorghum (CSH-16) (2550 kg/ha), Maize (BVM-10) (2646 kg/ha), Chickpea (Birsa Chana-3) (1796 – 1926 kg/ha)	
Varanasi	Green gram (Narendra mung-1) (1361 kg/ha), Pigeonpea (Malaviya arhar-6) (1641 kg/ha), Lentil (LR-409) (972 kg/ha)	
Anantapur	Groundnut (Narayani) (600 kg/ha)	
Rajkot	Groundnut (GG-11C) (1106 kg/ha), Sesame (G Til-3) (640 kg/ha), Greengram (GM-4) (393 kg/ha)	
Indore	Soybean (JS 93-05) (1641 kg/ha), Pigeonpea (ICP-8863) (2125 kg/ha), Chickpea (JG-16) (1666 kg/ha), Niger (BNS-10) (427 kg/ha)	
Rewa	Greengram (TM-99-50) (1740 kg/ha), Black gram (IVU-486) (1427 kg/ha), Chickpea (JG-130) (2522 kg/ha), Lentil (JL-2) (1399kg/ha)	
Kovilpatti	Cotton (KH-138) (953 kg/ha)	
Parbhani	Cotton (K-2) (1830 kg/ha)	
Arjia	Maize (EH-1496) (4658 kg/ha), Sesame (AT-28) (699 kg/ha), Horsegram (HG-3) (756 kg/ha), Black gram (AU-3) (826 kg/ha), Sorghum (SPV-1342) (4251 kg/ha)	
Ballowal Saunkhri	Maize (Parkash hybrid) (3900 kg/ha)	
Solapur	Horse gram (HG-1) (729kg/ha), Cluster bean (G-6)(1552 kg/ha)	
Bijapur	Sunflower (SB-275) (2345 kg/ha), Foxtail millet (FMLT-1) (1645 kg/ha), Barnyard millet (BMLT-8) (1110 kg/ha), Prosomillet (PMLT-2) (814 kg/ha), Cowpea (T-1) (614 kg/ha), Linseed (NS-157) (6900 kg/ha), Mustard (GPM-25) (1347 kg/ha), Horse gram (GPM 100935) (846 kg/ha), (Mulberry (S-1635) (22378 kg/ha)	
Agra	Cluster bean (G-45) (1147 kg/ha)	
Hisar	Pearl millet (DSH-5 hybrid) (1667 kg/ha), Moth bean (MB-1) (1025 kg/ha)	
Bangalore	Green gram (TM-7) (727 kg/ha), Black gram (UB-3 and BDU-4) (645 and 995 kg/ha), Cowpea (KM-6 and PKB-4) (893 and 12950 kg/ha), Chilli (BKADDI and PP-9737-3) (2454 and 1764 kg/ha), Maize (NAH-2049) (7019 kg/ha)	

Table 53. Salient findings from Operational Research Project

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
Nutrient Management		
Bangalore	Fingermillet	Balanced use of NPK + bio-fertilizers enhanced the productivity of 1144 kg/ha and net returns of Rs. 3566/ha
Arjia	Maize	60 kg P/ha given additional net returns of Rs. 1662/ha
	Groundnut	30 kg P/ha had given Rs. 4299/ha of net returns
Ballowal Saunkhri	Maize	50% N (organic) + 50% N (inorganic) recorded 2819 kg/ha of yield and net income of Rs. 11961/ha
Indore	Soybean	30 kg N + 60 kg P + 30 kg/ha of Sulphur (gypsum) had given 1403 kg/ha of yield and net income of Rs. 9771/ha.
Hisar	Pearlmillet and mustard	20 kg N/ha + azotobacter recorded 1300 kg/ha of yield and Rs. 4135 /ha of income
Ranchi	Upland rice	20 kg N + 20 kg P + 40 kg K/ha gave an yield of 1820 kg/ha and net returns of Rs. 2585/ha
Crop Improvement		
Arjia	Maize	PHEM-2 (2309 kg/ha and Rs.12575/ha)
	Groundnut	TAG-24 (15151 kg/ha and Rs. 18904/ha)
	Horse gram	AK-1 (650 kg/ha and Rs. 4235/ha)
Ballowal Saunkhri	Maize	Parkash hybrid (1535 kg/ha and Rs. 731/ha)
	Bunch groundnut	SG-9 (1668 kg/ha and Rs. 22314/ha)
	Greengram	SML-668 (439 kg/ha)
	Pearl millet	PHB-2168 (1313 kg/ha and Rs. 7709/ha)
	Wheat	PBW-527 (3113 kg/ha and Rs. 22501/ha)
	Raya	RLM-609 (394 kg/ha and Rs. 566/ha)
Hisar	Pearlmillet	HHB-67-2 (1400 kg/ha and Rs. 4405/ha)
	Mustard	RH-9304 (940 kg/ha and Rs. 6273/ha)
	Barley	BH-393 (2960 kg/ha and Rs. 7680/ha)
Ranchi	Fingermillet	A-404 (1986 kg/ha and Rs. 5325/ha)
	Rice	Vandana (1872 kg/ha and Rs. 3223/ha)
	Pea	VRP-6 (6233 kg/ha and Rs. 25425/ha)
	Wheat	K-9107 (3784 kg/ha and Rs. 22380/ha)
	Mustard	Shivani (824 kg/ha and Rs. 10654/ha)
Bangalore	Fingermillet	L-5
	Green chilli	Samrudhi
	Pigeonpea	BRG-1
	Cowpea	IT-38956-1

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
Solapur	*Rabi* sorghum	Mauli (Shallow and medium vertisols) Phule Yasoda (Deep vertisols)
Cropping system		
Arjia	Maize	Maize + blackgram (2:2) (2342 kg/ha and maize equivalent yield and Rs. 11644 of net returns
Bangalore	Fingermillet	Fingermillet + pigeonpea (10:2) gave Rs. 1695/ha of net returns
Ballowal Saunkhri	Lentil + raya	Lentil+ raya (Rs. 9983/ha of net returns
Hisar	Pearlmillet	Pearlmillet + greengram (8:4) (30 cm) recorded 850 + 260 kg/ha with net returns of Rs. 4209/ha
Ranchi	Rice	Pigeonpea +rice (1:3) recorded net returns of Rs. 3979/ha
Solapur	Sunflower + Pigeonpea	Sunflower + pigeonpea (2:1) gave stable productivity
Rain Water Management		
Arjia	Groundnut + sesame (6:2)	Supplemental irrigation of 40 mm applied at 55 DAS (1410 kg/ha of groundnut equivalent with Rs. 15749/ha of net returns
	Maize	Deep tillage + ridging after sowing + 100% recommended N (FYM) recorded highest yield of 2217 kg/ha
	Groundnut + pigeonpea (8:2)	Conservation furrows between paired rows of pigeonpea 587 kg/ha of groundnut and 515 kg/ha of pigeonpea yield
Bangalore	Fingermillet + pigeonpea (10:2)	Staggered moisture conservation furrows within paired rows of pigeonpea (1100 kg/ha of fingermillet grain equivalent yield)
Hisar	Pearlmillet	Harvesting of every 3rd row of pearlmillet at 30 DAS enhanced the profitability of Rs. 1910/ha
Energy Management		
Ballowal Saunkhri	Maize	Maize planter enhanced the yield by 128 kg/ha and net returns of Rs. 1228/ha
	Wheat	Seed-cum-fertilizer drill gave higher net returns of Rs. 3200/ha
Hisar	Chickpea	Disc harrow and blade harrow enhanced net returns by Rs. 2705/ha
Ranchi	Upland rice	Pre-emergence application of butachlor @ 1.5 kg/ha, two ploughings with Birsa Ridger plough gave maximum net returns of Rs. 4219/ha
	Wheat	Sowing with Dutch hoe proved the productivity of 196 kg/ha
Hisar	Pearlmillet and mustard	Weeding with wheel hand hoe gave higher net returns of Rs. 1100/ha
	Soybean	Spraying of post-emergence weedicide of Chlorimuran ethyl 25 WP @ 37 g/ha (kloban 25 WP) at 18-20 DAS gave highest net returns of Rs. 3993/ha
Indore	Wheat	Ethyl easter @ 1 kg ai/ha at 35-40 DAS has increased seed yield of greengram by 28%
Ballowal Saunkhri	Green gram	Pre-emergence application of pendimethalin @ 1.5 lt/ha

Center	Test Crop / Cropping System	Salient Finding/Promising Technology
Alternate Land Use Systems		
Arjia	Maize, sorghum, Blackgram, horsegram, Groundnut, sesame	Improved bio-diverse farming system gave maximum maize equivalent yield of 1197 kg/ha over traditional farmers of 653 kg/ha
Bangalore	Mango	Finger millet + pigeonpea (10:2) recorded the yield of 65 + 158 kg/ha
Ballowal Saunkhri		dhek based agro-forestry model with guinea grass recorded 7000 kg/ha of yield
	Agri-horti system	Green gram and cluster bean as intercrops 370 and 520 kg/ha
Demonstrations		
Hisar	Green gram, cluster bean, moth bean and sesame	With Improved package of practices, the net returns of crops ranged from Rs. 4345 to Rs. 6963/ha

3.2 All India Coordinated Research Project on Agrometeorology (AICRPAM)

The All India Coordinated Research Project on Agrometeorology was initiated by ICAR in May 1983 with the establishment of Coordinating Cell at the Central Research Institute for Dryland Agriculture, Hyderabad and 12 Cooperating Centres at various State Agricultural Universities. After evaluating the progress made by the project and realizing the importance of Agrometeorological Research support for enhancing food production, ICAR had extended the Cooperating Centres to the remaining 13 Agricultural Universities of the country with effect from April, 1995. The network of 25 Agrometeorological Cooperating Centres are Akola, Anantapur, Anand, Arjia, Bangalore, Bhubaneswar, Bijapur, Dapoli, Faizabad, Hisar, Jabalpur, Jorhat, Kanpur, Kovilpatti, Ludhiana, Mohanpur, Palampur, Parbhani, Raipur, Rakh Dhiansar, Ranchi, Ranichauri, Samastipur, Solapur and Thrissur.

3.2.1 Agro climatic characterization:

- At Hisar, the historical weather data of Bawal region was compiled and analyzed. The annual rainfall at Bawal station varied between 229mm to 1010mm with a mean amount of 577mm with 32 mean rainy days. It was found that May (41.3°C) and June (40.5°C) were the hottest months. The annual wind rose for morning and evening hours of this station indicated that west and south originating winds had a sway. Further, the Atmospheric demand and Bawal was highest in the month of June (14.6 mm / day).
- Crop weather calendars were prepared for the major crops Viz, Rice and Kharif maize for the agro climatic Zone 3 of the Punjab. The weather, crop and disease data was utilized for preparation of these calendars, which are very helpful in preparing agro advisories.
- Fifty years rainfall data (1958-2006) of Anand station was analyzed for its variability and trend. The ten years moving average suggested existence of decadal variability of annual rainfall up to 1996, Thereafter higher variability in annual rainfall was observed (Fig. 33).

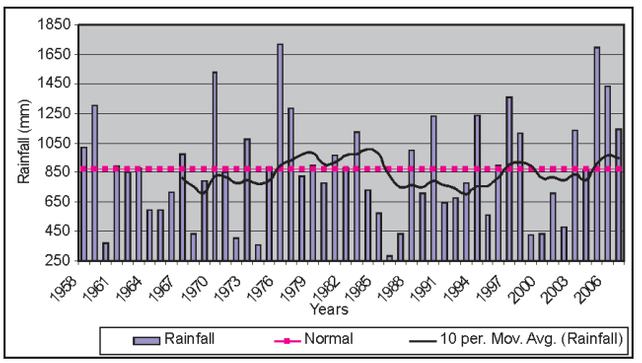


Fig.33 Annual rainfall variation at Anand during 1958 to 2007

- Trend analysis for maximum and minimum temperature (1971-2005) of Raipur suggested that there is an increase in maximum temperature in the month of November and December.
- One day peak rainfall events of 100mm or more at Bijapur were observed for total fifteen days in 73 years of data from 1928-2000 and distributed in different years. Rainfall shift within the season was observed among two groups of rainfall data viz., 1971-1990 (G1) and 1991-2006(G2). The increase

in mean rainfall was observed during the month of July from 155.1 mm (G1) to 204.0 mm (G2) and in September from 82.3mm (G1) to 101.3 mm (G2). Interestingly, there is drastic reduction of rainfall during the month of October and November in the post monsoon season which was in the order from 20.5 (G1) to 3.9 mm (G2) and 22.1 (G1) to 0.5 mm (G2), respectively. December and January rains also reduced from mean of 4.7(G1) to 0.4 mm (G2) and 3.9 (G1) to 2.9 mm (G2), respectively.

3.2.2. Crop-weather relationships:

Rabi:

Wheat

- A multiple regression model was developed at Hisar for predicting wheat yields (CVC 306) using different weather parameters viz., Maximum Temperature (X1), Minimum temperature (X2), Mean RH (X3) bright sunshine hours (X4) and Evaporation (X5). The equation is as follows:

  $Y = -63672 + 1961.7X_1 - 8950.2\ X_2 + 821.6\ X_3 - 7545.4X4 + 34061.6\ X_5$ $R^2=0.76$ (significant at 0.01 level)

- At Ludhiana, it was observed that the Intercepted Photo Synthetically Active Radiation (IPAR) was high in flat bed sowing (88.7%) in comparision to raised bed sowing (82.6%) in wheat crop at grain filling stage, where as net radiation was higher in raised bed sowing (642 W/m2) in comparision to flat bed sowing (630 W/m2)

- A polynomial equation was developed at Faizabad to predict grain yield (Y) of wheat at Faizabad using average temperature (X) in degree C at flowering stage (Fig. 34). The equation is given below which explains 85% variation in yield.

  $Y = -0.0435X_3 + 0.6401X_2 - 1.6088 + 39.732$
  $R^2 = 0.85$

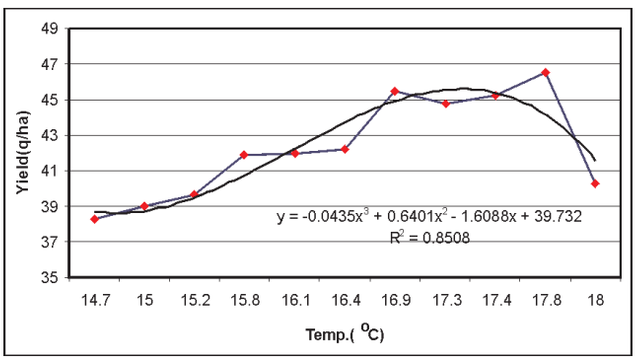


Fig 34. Effect of average temp. during flowering on grain yield of wheat

Chickpea:

- Linear equations were developed to predict number of pods and no. of seed per plant and yield in chickpea using average temperature in first two cases and maximum temperature at reproductive stage in third case respectively. The models are given below.

  $Y = 0.0439\ X + 0.9778$
  $R^2=0.942$ (number of seeds/plant)

  $Y = 2.0379\ X + 37.112$
  $R^2=0.809$ (number of pods/plant)

  $Y = -0.1821\ X + 25.817$ $R^2=0.4974$ (yield)

- A relationship was developed between GDD and seed yield of chickpea at Jabalpur

  $Y = 0.0185\ X + 4.5922$ $R^2=0.4126$

Wheat:

- At Ranchi, the yield and weather data was used to calculate HUE and LUE. It was observed from the results that maximum HUE of 2.39 kg grain ha-1 and maximum LUE of 3.26 kg grains / ha-1 hr-1 BSS were attained in the normal sowing conditions of the wheat crop.

Mustard

- Delayed sowing caused reduction in consumptive use (CU) and water use efficiency (WUE). The highest CU (194.6mm) and WUE (11.4 kg/ha/mm) were recorded in 5th October 2007 sown crop.

Maize

- Lysimetric studies were conducted in maize crop at Udaipur. Crop Coefficients (Kc) were estimated in different phenological stages. The KC value recorded highest (1.35) at milky stage and then it declined up to 0.33 at maturity of the crop.

Kharif :

Rice

- Cumulative Bright sunshine hours of 133 to 153 hrs during flowering to dough stage recorded highest yield of rice at Faizabad. The polynomial relation developed is presented below.

  $Y = -0.0307X^4 - 2.2501X^3 + 57.264X^2 - 294.02X + 4020.4$ $R^2 = 0.7025$

3.2.3 Crop growth modeling

- At Faizabad, eleven years data sets of rice crop and weather were used for developing regression models to predict yields at 90 Days after transplantation. The model was given below.

  $Y = 17.188 + 0.225\ T\ max + 0.522\ T\ min + 0.002\ RF \quad R^2 = 0.83$

Evaluation of "SOYGRO" model for soybean crop under Hisar conditions

- The yield and yield attributes of soybean cultivar (PK-416) with different dates of sowing was simulated using "SOYGRO" model. Pods per plant, number of grains per pod and 100 seed weight decreased with subsequent delay in sowing from 7th June onward. Grain yield, straw yield and biological yield were highest in 7th June 2006 sowing as compared to 5th July 2006 sown. Phenology of the crop predicted by "SOYGRO" model was within the limit (<10%).

3.2.4 Weather effects on pests and diseases

Crop pest and weather relationship studies at Faizabad

- At Faizabad, Highest population of pod borer in chickpea was recorded with evening RH 35-49 % and minimum temperature around 12 °C. The pod borer incidence increased with increase in minimum temperature from 4.5 to 12.1 °C which explains 87 % variation in pod borer population

  $Y = 0.0919x^2 - 0.3417x + 0.8322$ $R2 = 0.8784$.

- Highest paddy blight disease intensity was recorded with morning relative humidity 84.6%, evening RH 56.2%, min. temperature of 23.3°C and maximum temperature of 33.3°C.

- Highest BPH (13 per hill) was recorded during 37th and 38th week (10-23 September) with min. temperature of 25.7°C, max. temperature 34.5°C, morning relative humidity (81.8 – 86.5%), evening RH 59.4% and bright sun shine hours of 8.8.

Effect of weather on Karnal bunt disease at Karnal (Hisar Centre)

- The average infection (%) of Karnal bunt disease and meteorological parameters of 1st to 12th standard met. week for 25 crop seasons (1981-82 to 2004-05) of Karnal staion were correlated for most sensitive period corresponding ear emergence and subsequent crop growth stages. The results revealed that, rainfall during the 3rd week of January showed strong relationship (R=0.51) indicating favourable role in the formation and further multiplication of secondary spordia. However, during 9th week maximum temperature (R=-0.48), relative humidity (R=0.64), rainfall (R=0.32), sunshine hours (R=-0.28) showed high correlations for karnal bunt disease.

Weather and mustard aphid population at Udaipur Centre

- At Udaipur, analysis of three years aphid infestation and weather data revealed that aphid incidence occurred from 14th December to 25th January where minimum temperature and RH ranged from 13.7 to 17.2 ° C and 55 to 60 % respectively. The temperature range of 17.7 to 20.4 °C and RH of 56 to 61 % was most congenial for the multiplication of aphids.

Weather parameters and hopper incidence in Alphonso mango in Dapoli Centre

- The incidence of mango hopper started from 51st standard week and attained maximum value in the 6th meteorological week. This increase in incidence of mango hopper was due to the increase in minimum temperature and sudden increase in afternoon humidity from 46 to 52 per cent and decrease in maximum temperature from 33.4 to 30.1°C.

Aphid population in safflower and weather relationship at Akola Centre

- At Akola minimum temperature (20-22°C) and morning relative humidity (75-80%) of current and previous week influenced the aphid population significantly.

Weather and rice hispa incidence in Rice at Kalyani Centre

- The experiment was conducted to find relationship between weather parameters and rice hispa population during 2006 at Kalyani. Peak incidence was noticed between 8th August and 5th September 2006. The pest infection occurred during mid August coincided with the active tillering stage of the crop. The peak rice hispa activity was associated with the following weather conditions.

Max. temp: 33.5 – 34.3°C; Min. temp: 23.8 – 26.6°C; RHI: 98-99%; RHII – 68-94%

Development of pest and disease predicting model at ANGRAU, Rajendranagar, Hyderabad

- A model was developed for predicting the leaf miner pest in groundnut and validated. The same is being utilized for giving the forewarning in the weather based agro advisory services. Similarly, a model predicting powdery mildew incidence in different varieties of ber was developed and validated.

Weather and cotton bollworm incidence in cotton at Parbhani Centre

- The weather and pest interaction studies at Parbhani showed that the congenial weather parameters causing outbreak of bollworm are min. temp of past one week (>17.6°C), RH-I of past one week (>83%), BSS of current week (<8.4 hrs) and past one week (<8.3 hrs).

3.2.5. Agro advisory services

Usefulness of agro advisory services at Dapoli

The evaluation of usefulness of agro advisories revealed that advisory based on weather forecasts are mostly useful for plant protection (83%) followed by planning of farm operations (74.5%), fertilizer applications (53.5%) and harvesting (38.2%). In general agro advisory bulletins was rated as excellent (20.4%), very good (32.6%), good (36.2%) and satisfactory (10.8%).

Economic impact of agro advisory services at Bangalore Centre

Three years study (2004-05 to 2006-07) at Bangalore Centre indicated that the farmers who adopted the agro advisory services have realized a grain yield of 2323 kg/ha in the case of finger millet and 1289 kg/ha in the case of red gram over control farmers who realized 2148 kg/ha and 1118 kg/ha respectively. Similarly, AAS farmers also realized the increased yield of 227 kg /ha in case of field bean and 561 kg/ha in case of tomato over control farmers.

4 Technologies assessed and transferred

4.1. Frontline Demonstrations

The (Krishi Vigyan Kendra) KVK conducted 805 (FLDs) during *kharif* in an area of 322 ha covering important oilseeds, pulses and other crops such as soybean (100), pigeonpea (105), cotton (100) and maize (500). The programme was taken up in the villages of Ranga Reddy and Nizamabad districts. The improved production technologies were demonstrated to the farmers with their active involvement and spot guidance / advice / training provided by the KVK scientists. The collaborating organizations in the FLD programme were Directorate of Maize Reserach, National Research Centre for Soybean, Central Institute for Cotton Research and Indian Institute of Pulses Research. The results of FLDs conducted by the KVK are given in Table 54.

Frontline demonstrations of maize and soybean

4.2.Training Programmes

The KVK organized 58 need based and skill oriented training programmes on various aspects of improved farm technologies which were attended by 1945 clients including farmers, farmwomen, rural youth and field level extension functionaries (Table 55).

Table 54. Frontline demonstrations conducted by KVK (2007-08)

Crop	No. of farmers	Area (ha)	Average yield (kg/ha)		Average income yield over local (%)	Average additional profit (Rs.)
			Improved practice	Farmers Practice		
Maize (K)	500	200	61.39	47.10	30.34	12600
Cotton	100	40	31.50	25.00	26.00	10800
Pigeonpea	105	42	18.70	14.00	33.57	8706
Soybean	100	40	20.18	16.00	26.13	6270

Table 55. Training programmes conducted by KVK

Discipline	No. of programmes			No. of participants		Total
	On-Station	Off-station	Total	Male	Female	
Agronomy	02	07	09	170	42	212
Horticulture	01	05	06	398	104	502
Plant Protection	02	06	08	666	111	777
Agricultural Extension	01	08	09	158	35	193
Home Science	04	12	16	0	138	138
Agricultural Engineering and others	03	07	10	93	30	123
Total	13	45	58	1485	460	1945

Table 56. Sponsored training programmes organized by KVK

S. No.	Training title	Duration and Dates	Number of participants Total (male/ female)	Sponsored by
1	Rural Entrepreneurship Development Programme for women on *Zardosi* Embroidery work	90 days / June 20 - September 20, 2007	30 (0/30)	NABARD, Hyderabad
2	Maize Production Technology (for extension personnel)	2 days October 26-27, 2007	15 (12/3)	DMR, New Delhi.
3	Maize Production Technology (for extension personnel)	2 days November 29-30,2007	15 (13/2)	DMR, New Delhi.
4	Production of HNPV, SNPV and NSKE and its use (for rural youth)	6 days April 2 – 7, 2007	12 (12/0)	NABARD, Hyderabad
5	Horticulture Production Technology for the members of *Rytu* clubs of Tamil Nadu	3 days December 18-20, 2007	21 (18/3)	NABARD, Chennai

HNPV – Helicoverpa Nuclear Polyhedrosis Virus; SNPV – Spodoptera Nuclear Polyhedrosis Virus; NSKE – Neem Seed Kernel Extract

Training on farm equipment

Rural entrepreneurship development programme for women

Training on biopesticides

Training farm women

4.3. Extension activities

Table 57. Extension activities of KVK

Activity	Date	Venue
Farmers' Day (CRIDA)	September 19, 2007	HRF, CRIDA
Field Day (Maize)	September 29, 2007	Enkatala Village
Field Day (Cotton)	October 10, 2007	Mariapuram Village
Field Day (Maize)	October 10, 2007	Mariapuram Village
Field Day (Redgram)	October 18, 2007	Muddemguda Village
Women in Agriculture Day	December 4, 2007	Thimmareddyguda Village
Kissan Gosti (on the occasion of ICAR foundation day)	July 16, 2007	HRF, CRIDA
Rural crafts *mela* exhibition	December 15-17, 2007	NIRD, Hyderabad
Krishi *Vaibhav* exhibition	December 12-16, 2007	Pune, Maharashtra

Field Day (Maize)

Field Day (Cotton)

4.4. Women empowerment

KVK under CRIDA carried out many activities for empowerment of farm women.

Training programmes :

Sixteen training programmes were conducted in Shabad mandal, Ranga Reddy District in which 138 women farmers and farm women were provided need based, skill oriented training for rural livelihood, food and nutrition, home improvement.

Women in Agriculture Day was celebrated on 4th December, 2007 in Timmareddyguda, Shabad Mandal. About 70 women farmers participated and were educated about drudgery reduction by demonstrating various farm implements.

Members from Republic of Mozambique visiting KVK

Table 58. Visitors to KVK

Nature of visitors and their affiliation	Number
Farmers from Tamil Nadu (Krishnagiri district)	50
Students from Tamil Nadu Agriculture University	50
ToT trainees	25
Delegation of Members from Republic of Mozambique	05
Farmers from Nalgonda district	30
Participants of winter school on Bio-resources	15
Farmers from Guntur district	50
Trainees from SAMETI, Hyderabad	15
Rytu Mahila from SAMETI, Hyderabad (Rangareddy and Medak district)	20
Rytu Mahila from SAMETI, Hyderabad (Nalgonda district)	10
Rytu Mahila from SAMETI, Hyderabad	14
Adarsha Rytu Mahila from Warangal district through SAMETI, Hyderabad	17
Rytu Mahila from SAMETI, Hyderabad (Nizamabad district)	25
Farmers from Tripura state through DRR, Hyd	100
Rytu Mahila from SAMETI, Hyderabad (Khammam district)	25
Farmers from Tamil Nadu (Kanchivaram district) through WALAMTARI, Hyderabad	30
Farmwomen from SAMETI, Hyderabad	25
Farmwomen from FTC, Hyderabad	20
Farm women from different SHGs of Shadnagar mandal of Mahabubnagar district	50

5 Education and Training

5.1 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

5.1.1. Post graduate research

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

Scientist acting as advisor	Student	Discipline	Institute/University
G. R. M. Sankar	A. Girija	Mathematics	JNTU
B Venkateswarlu	Abdul Rasul	Microbiology	Osmania University
B Venkateswarlu	Sk. Z. Ali	Microbiology	Osmania University
B Venkateswarlu	V. Sandhya Rao	Microbiology	Osmania University
B Venkateswarlu	E. Leo Daniel Amalraj	Microbiology	JNTU
K. L. Sharma	J. Kusuma Grace	Environmental Sciences	JNTU
K. L. Sharma	K. Usha Rani	Environmental Sciences	JNTU
S Desai	G. Praveen Kumar	Microbiology	Osmania University
S Desai	Sk. Mir Hassan Ahmed	Microbiology	Osmania University
S Desai	S.V.N. Chandana	Microbiology	Periyar University
S Desai	Ch. Jyothi Kumari	Microbiology	Periyar University
S.K. Yadav	M. Gopala Krishna	Genetics	Osmania University
S.K. Yadav	P.Sreenu	Genetics	Osmania University
YG Prasad	Ch. Lakshmi	Microbiology	Osmania University
YG Prasad	P. Naveen Kumar	Microbiology	Osmania University
M. Vanaja	N. Sunil	Genetics	Osmania University
M. Vanaja	D. Ashok Vardhan	Genetics	Osmania University
M. Vanaja	Babu Abraham	Botany	Osmania University
M. Prabhakar	G Ramakrishna	Biotechnology	Osmania University
M. Prabhakar	S.B. Asma	Biotechnology	Andhra University

5.1.2. Higher studies

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

Scientists	University
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

K. Sreedevi Shankar completed Ph. D. (Food and Nutrition) from ANGRAU, Rajendranagar, Hyderabad-500 030

5.2. Training received

The following scientists and technical officers acquired need-based training during 2007-08.

5.2.1. Deputation within India

Name	Title	Duration	Venue
K. Srinivas	Environmental Impact Assessment	July 9-13, 2007	IIPM, Kolkata
G. Nirmala	Enhancing Human Capabilities at Work, organized by NAARM	December 8-14, 2007	CRIDA, Hyderabad
G. Nirmala	Pulse Production Technology	January 8-11, 2008	RARS, Lam, Guntur
G. Nirmala	SPSS training	February 11-13, 2008	JNTU, Hyderabad
G. Nirmala	Gender Sensibility for Vertical Integration of Officers in the Women Hierarchy including women farmers	March 13-15, 2008	MANAGE, Hyderabad
K. Sreedevi Shankar	Enhancing Human Capabilities at Work, organized by NAARM	December 8-14, 2007	CRIDA, Hyderabad
K. Sreedevi Shankar	GIS based Decision Support Systems for Sustainable Agriculture	February 1-21, 2008	NAARM, Hyderabad
S S Balloli	Training programme on Principles and Practices of Ecological Agriculture	December 5-7, 2007	EPTRI, Hyderabad
K. Ravi Shankar	Training programme on Statistical Package for Social Sciences (SPSS) – 15.0	September 7-9, 2007	JNTU, Hyderabad
K. Ravi Shankar	Winter School on Organic Farming in Rainfed and Tribal Areas	November 1-21, 2007	CRIDA, Hyderabad
K. Ravi Shankar	Training course on Enhancing Water Productivity in Rainfed Agriculture for Improved Livelihoods	March 14-27, 2008	CRIDA, Hyderabad
M. Prabhakar	Decision Support Tools and Techniques	March 17-21, 2008	ASCI, Hyderabad
K. Nagasree	Training programme on Statistical Package for Social Sciences (SPSS)	February 11-13, 2008	JNTU, Hyderabad
I. Srinivas	Capacity Building for Intellectual Property Protection and Technology Licensing in Agriculture under Indo-US Agricultural Knowledge Initiative	February 14-16, 2008	NAARM, Hyderabad
G. Pratibha	Introduction to GIS and its applications	April 9 – May 4, 2007	NRSA, Hyderabad
S.M.Vidyasekhar	National Workshop on Knowledge Management	August 20-22, 2007	NIRD, Hyderabad
S.M.Vidyasekhar	Enhancing Human Capabilities at Work.	December 10-15, 2007	CRIDA, Hyderabad (Conducted by NAARM, Hyderabad)
P.R.Singh	Upgradation of Managerial skills	November 30-December 4, 2007	EEI, Hyderabad

5.2.2. Deputation abroad

Name	Programme	Duration	Country
Dr Desai	'Chitin modifying enzymes from soil bacteria'	April 19-Jun 21, 2007	Germany
Dr. V. Maruthi	Agriculture in transition: design, analysis and sustainability of farming systems "	June 18 - 29, 2007	Wageningen International, Wageningen, Netherlands
Dr. Y.S. Ramakrishna	International Workshop on Semi-Arid Land Surface-Atmosphere Interaction	August 9-13, 2007	Lanzhou, China
Dr. Y.S. Ramakrishna	Workshop on Oasis Pre-proposal	August 20-22, 2007	Montpelier, France
Dr. G. Rajeshwara Rao	International Workshop on "Tree for farmers: Improving Strategies for Germplasm Supply"	October 29-November 2, 2007	Nairobi, Kenya.
Dr. I. Srinivas	International Agricultural Scientist & Technology Fellowship Programme	November 1 - December 21, 2007	University of Missouri, U.S.A

6 Women in Agriculture

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.

6.1 Farm women

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

6.1.1 Organic farming demonstrations

Fifty Eight training programmes under KVK were conducted including 16 programmes in which Four Hundred and Fifteen women were provided with need-based, skill oriented training in various aspects of agricultural development.

- To improve the nutritional security and assured additional income 552 farmwomen were trained in backyard poultry & supplied 2208 Vanaraja and Gramapriya birds.

- Organised 14 training programmes out of which 5 and 9 are on and off farm organized for 301 no.of farm women during the period (details are given in the following table) on the topics like preservation of fruit and vegetable, livelihood activities, organic compost making, neem seed extracts, human nutrition etc,.

S. No.	Name of the training	On/Off campus	Duration (days)	No. of trainees	No. of programmes
1	Preservation of fruits and vegetables	On	2	38	2
2	Preparation of different organic composts	On	1	56	2
3	Preparation of white phenyl	Off	1	19	
4	Raising and maintenance of nutrition garden	Off	1	19	
5	Purification water for drinking purpose	Off	1	21	
6	Importance of green leafy vegetables in daily diet	Off	1	15	
7	Training programme on prevention of anemia	Off	1	14	
8	Awareness training on income generating activities	On	3	40	
9	Preparation of vermicompost and its application	Off	1	23	
10	Rural bakery for farm women and rural youth	Off	1	14	
11	Collection, storage and use of neem seeds for fertilizer management of dryland crops	Off	2	22	
12	Preparation and marketing of washing powder, white phenyl and Vaseline	Off	1	20	

6.1.2 Special Events

Celebration of Women in Agriculture Day

"Women in Agriculture Day" programme was conducted on December 4th in Thimmareddyguda village. About 200 farmwomen participated in the event and trained under following themes

1) The main theme was cxating awareness on removal of drudgery of farmwomen through gadgets like bhendi plucker for plucking bhendi with less fatigue and speedy work.

2) Cotton collection bag, which is designed by Home Science College, PG centre,

for collecting cotton in the field which does not strain the person while plucking as well as bearing the load.

3) A trolly to carry water pots 2-4 in number to carry water from distant places.

Rural Enterpreneurship Development Programme (REDP)

REDP for women on Zardosi Embroidery work for a duration 90 days (20-06-07 to 20-09-07 was organized as an off farm entrepreneurial activity promotion. A total no. of 30 women participated in the event. This programme was sponsored by NABARD, Hyderabad and was conducted at Yacharam village, R.R.district.

Exhibitions

Farm women of KVK participated in Rural Crafts Mela held at NIRD, Rajendranagar, Hyderabad during 15-17th December 2007 the farm women exhibited the products prepared by them during the training programmes given by KVK

6.1.3 Farm women visitors

S.No.	Name & address of the visitors	Date & Month	No. of trainees
1	Rythu Mahilas from Rangareddy & Medak district for organic farming training programme. They visited Integrated Bio-resource centre and compost unit. – Organised by SAMETi, Malakpet, Hyderabad.	29-11-07	20
2	Farmwomen from Nalgonda district for organic farming training programme. They visited Integrated Bio-resource centre and compost unit. – Organised by SAMETi, Malakpet, Hyderabad.	01-12-07	10
3	Farmwomen from different districts for organic farming training programme. They visited Integrated Bio-resource centre and compost unit. – Organised by SAMETi, Malakpet, Hyderabad.	07-12-07	30
4	Farmwomen from different districts for organic farming training programme. They visited Integrated Bio-resource centre and compost unit. – Organised by SAMETi, Malakpet, Hyderabad.	13-12-07	17
5	Farmwomen from different districts for organic farming training programme. They visited Integrated Bio-resource centre and compost unit. – Organised by SAMETi, Malakpet, Hyderabad.	15-12-07	25
6	Adarsha Rythu Mahila's from Khammam district for visited to see KVK activities.	18-12-07	25
7	Farmwomen from different districts for organic farming training programme. They visited Vermicompost unit. – Organised by SAMETi, Malakpet, Hyderabad.	28-12-07	25
8	Farmwomen from FTC, Warangal under gender cell programme.	07-02-08	20
9	Farmwomen farmers of SHG groups from Shadnagar mandal of Mahabubnagar district	14-02-08	50
10	Farmwomen from FTC, Nizambad district unde ANTWA Programme.	25-03-08	50

6.2 Women in CRIDA

It is a matter of pride to the institute to report that Dr. (Mrs.) Dr. Kausalya Ramachandran, National Fellow, was bestowed with the prestigious Punjabrao Deshmukh Women Agril. Scientist Award 2006 by ICAR

Dr. K. Nagasree, Scientist (SS), (Agril.Extn.) was selected for summer post doctoral research award by IIIT –H for two months post doctoral training at IT lab for agriculture and rural development in International Institute for Information Technology (IIIT-H), Hyderabad from 23.05.2007 to 21.07.2007

6.2.1 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.

Sl.No.	Project title	Handled as 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
5	Impact of drought Management practices and organics on yield and secondary metabolites f medicinal plants	Pratibha.G
Institute funded		
1.	Organic management for sustainable production of medicinal and aromatic plants	G.Pratibha
2.	Crop diversification for sustainability of drylands through dye yielding crops	G.Pratibha
3.	Mechanism of drought tolerance in rainfed short duration pluses	N.Jyothi Lakshmi
4.	Studies on root characteristics of greengram and horsegram crops in relation to resource use	V. Maruthi
5.	ICTs as a tool of agricultural extension for technology dissemination – a critical analysis	K. Nagasree
6.	Development of farming situation-based extension for Ranga Reddy district	G.Nirmala
7.	Gender analysis in watershed development programmes of Andhra Pradesh	G. Nirmala
8.	Studies on Enrichment of Quality & utilization of Palmyra fruit	K. Sreedevi Shankar

6.2.2 Human resource development

One woman scientist attained international training. Five 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.) Dr. V. Maruthi, Senior Scientist (Agronomy) attended training on "Agriculture in Transition at Netherlands from 18.06.2007 to 29.06.2007.

6.2.3 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).

6.3 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)

7 Awards and Recognition

- Dr. Kausalya Ramachandran, National Fellow, was awarded the Punjabrao Deshmukh Women Agril. Scientist Award 2006 by ICAR The award was presented during ICAR foundation day celebrations at New Delhi on 16 July ,2007

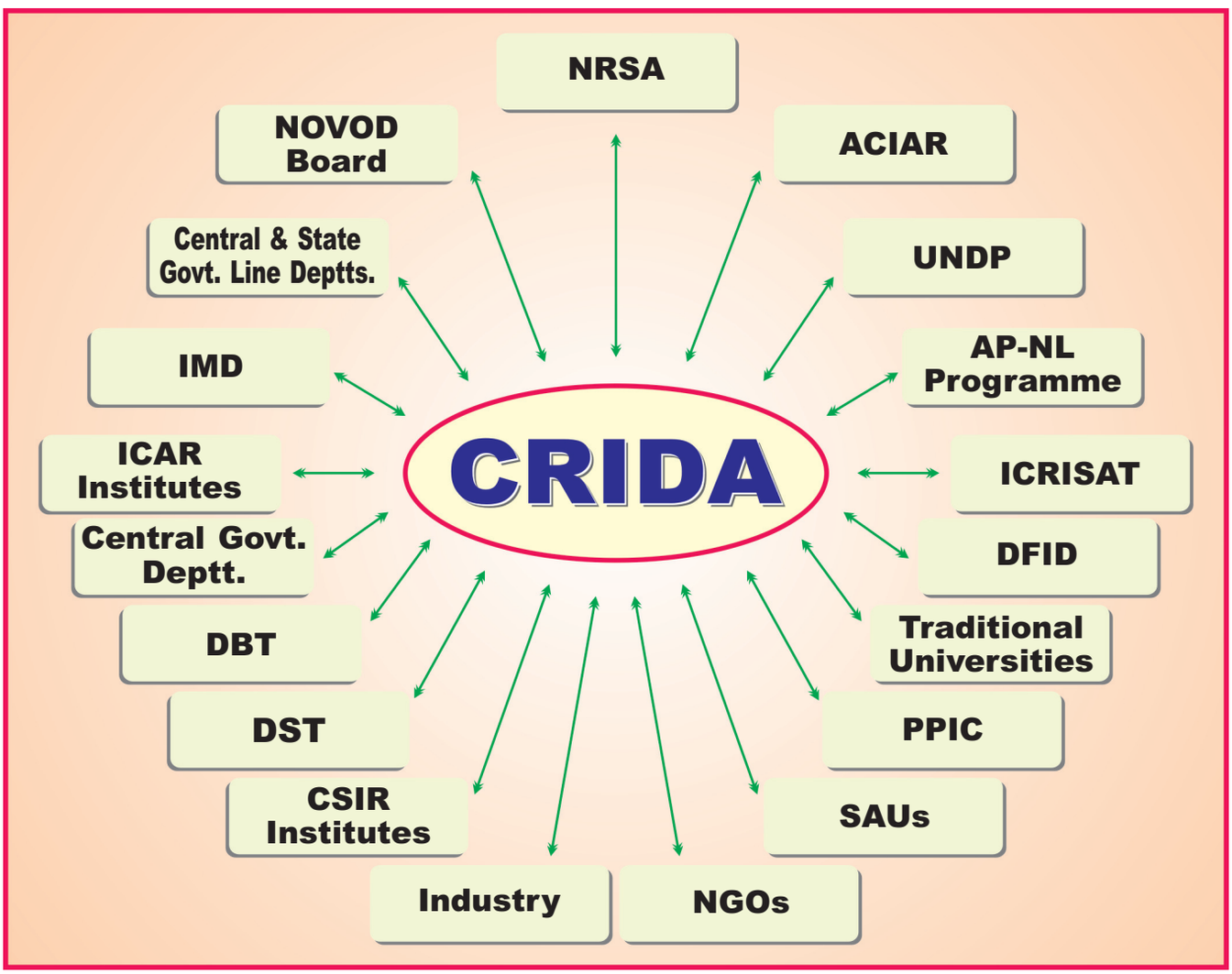
Photo Dr.Kausalya Ramachanran receiving award

- Dr.Sreenath Dixit Sr. Scientist (Ag.Extn.) and Team Leader, SEPR was presented with the ISEE young Scientist Award at the National Seminar on Appropriate Extension Strategies for Management of Rural Resources organised by ISEE in collaboration with Department of Agricultural Extension Education, University of Agricultural Sciences, Dharwad from December 18-20, 2007.
- Dr. K. Nagasree, Scientist (SS), (Agril.Extn.) was selected for Summer Post doctoral Research Award by IIIT –H for two months post doctoral training at IT lab for agriculture and rural development in International Institute for Information Technology (IIIT-H), Hyderabad from 23.05.2007 to 21.07.2007
- A research paper "Crop diversification opportunities through food legumes in rainfed production systems" by Drs G Ravindrachary, G R M Sankar, C A Rama Rao, K P R Vittal, G S Reddy and Y S Ramakrishna won the First Prize in Poster presentation at the National Symposium on "Legumes for Ecological Sustainability: Emerging Challenges and Opportunities" held at the Indian Institute of Pulses Research during November 3-5, 2007.
- Best poster award for Alleviation of elevated temperature effects on sorghum seedlings through inoculation with *Pseudomonas putida* by S K Z Ali and B Venkateswarlu during the International Symposium on Agrometerorology and Food Security organized at CRIDA during 18-21 February, 2008
- The research paper on 'Physiological and yield responses of hybrids and their parents to limited water availability in sorghum and pearl millet' authored by Maheswari, M., T. Vijayalakshmi, , M. Vanaja, N. Jyothi Lakshmi, A., Jainander and S.K. Yadav, presented in the International Symposium on 'Agro-meteorology and Food Security' organized at CRIDA during 18-21 February, 2008 was awarded Second best poster.
- Third Best Poster Award for the poster by K. Usha Rani, K. L. Sharma, K. Srinivas, G. R. Korwar, K. Nagasri and K. Sridevi Shankar on 'Assessment of sewage water quality under Musi river basin of Hyderabad in Andhra Pradesh' in the thematic area of Soil Health at the National Seminar on Integrated Nutrient Management in Rainfed Agro-ecosystems held during 3-4, March 2008 at CRIDA, Hyderabad
- CRIDA was awarded First prize for the Best Maintained Institutional Rosary of Hyderabad. CRIDA won two first prizes, one second prize and three third prizes in different categories of Annual Rose Competition in Rose Show organized by Hyderabad Rose Society during December 8-9, 2007.
- Dr M. Maheswari was awarded with *Samaikya Bharat Gaurav Satkar* of Madras Telugu Academy for achievements as agricultural scientist on 29th April 2007
- Dr Kausalya Ramachandran was elected as Advisor to Centre for Applied Research in Geomatics (CARG), Hyderabad.

8 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.



9 Publications

9.1 Research papers

Balaji, V., Shaik, N. Mira. and Dixit, S. 2007. ICT-enabled knowledge sharing in support of extension: addressing the agrarian challenges of the developing world threatened by climate change, with a case study from India. Journal of SAT Agricultural Research (e-journal). 4 (1) available at http://www.icrisat.org/journal/ SpecialProject/sp9.pdf

Balloli, S.S., Sharma, K.L., Kausalya Ramachandran, Ramesh, V., Venkateswarlu, B. and Ramakrishna, Y. S. 2007. Impact of land use practices on soil fertility status of dryland soils. Indian Journal of Dryland Agricultural Research and Development. 22(2): 163-167.

Behera, B., Maruthi Sankar, G.R., Mohanty, S.K., Pal, A.K., Ravindra Chary, G., Subba Reddy, G. and Ramakrishna, Y.S. 2007. Sustainable fertilizer practices for upland rice from permanent manorial trials under sub-humid alfisols. Indian Journal of Agronomy, 52 (2): 33 – 38.

Bhardwaj, A.K., Mandal, U.K., Bar-Tal, A., Gilboa, A. and Levy, G.J. 2008. Replacing saline–sodic irrigation water with treated wastewater: effects on saturated hydraulic conductivity, slaking, and swelling. Irrigation Science, 26: 139-146.

Desai, S., Narayanaiah, Ch., Kranthi Kumari, Ch., Reddy, M.S., Rao, G.R. and Venketeswarlu, B. 2007. Seed inoculation with *Bacillus* spp. improves seedling vigour in oil seed plant *Jatropha curcas* (L.) Biology and Fertility of Soils, 44:229-234.

Dixit, S. and Balaji, V. 2007. ICTs for 'Second Green Revolution' in Rainfed agro-ecosystem: issues and strategies. International Journal of Extension Education. 3:80-88

Dixit, S., Dileepkumar, G. and Balaji, V. 2007. ICT mediated agricultural extension: A case study. MANAGE Extension Reserach Reviews, 7(2): 101-108.

Dixit, S., Tewari, J.C., Wani, S.P., Vineela, C., Chaurasia, A. K. and Panchal, H.B. 2007. Participatory and conventional biodiversity assessments: creating awareness for better natural resource management. Annals of Arid Zone, 46 (2):197-204.

Dixit, S., Wani, S.P., Rego, T.J. and Pardhasardhi, G. 2007. Knowledge-based entry point and innovative up scaling strategy for watershed development projects. Indian Journal of Dryland Agricultural Research and Development, 22(1): 22-31.

Kaushalya Ramachandran, Gayatri, M., Bhasker, V., Srinivas, G., Venkatravamma, K., Srinivas, T., and Sankar Rao, M., (2007): Evaluating Livelihood Security of Farm Household in Treated Watershed in Semi – arid Region. Indian Journal of Dryland Agricultural Research and Development,22(1): 95-108

Mandal, U.K., Bhardwaj, A.K., Warrington, D.N., Goldstein, D., Bar Tal, A. and Levy, G.J. 2008. Changes in soil hydraulic conductivity, runoff, and soil loss due to irrigation with different types of saline-sodic water. Geoderma ,144: 509-516.

Mandal, U.K., Victor, U.S., Srivastava, N.N., Sharma, K.L., Ramesh, V., Vanaja, M., Korwar, G.R., Ramakrishna, Y.S. 2007. Estimating yield of sorghum using root zone water balance model and spectral characteristics of crop in a dryland alfisol. Agricultural Water Management, 87:315-327.

Mandal, U.K., Warrington, D.N., Bhardwaj, A.K., Bar-Tal, A., Kautsky, L., Minz, D. and Levy, G.J. 2008. Evaluating impact of irrigation water quality on a calcareous clay soil using principal component analysis. Geoderma, 144: 189-197.

Maruthi Sankar, G.R., Thyagaraj, C.R., Ravindra Chary, G., Kaushalya Ramachandran and Girija, A. 2007. Characterization of rainfed pigeonpea growing regions based on soil, climate, crop and socio-economic parameters. Indian Journal of Dryland Agriculture Research & Development, 22(1): 57–68.

Maruthi, V., Srinivas, K., Reddy, G.S., Reddy, B.S., Reddy, K.S., Reddy, P.R., Sudhakar, R. and Ramakrishna, Y.S. 2008. Value addition to crop residues: An indigenous resource conserving and soil fertility enhancing technology of India. Journal of Sustainable Agriculture 31(4): 5-27.

Maruthi, V., Subba Reddy, G., Reddy, K.S., Sanjeeva Reddy, B., Reddy, B. M. K., Srivastava, N.N., Victor, U.S. and Ramakrishna,Y.S. 2007. Indigenous raingauge (Rolu): A tool to measure rainfall. Indian Journal of Dryland Agricultural Research and Development, 22 (2): 182 – 188.

Misra, A.K., Rama Rao, C.A., Subrahmanyam. K.V., Vijay Sankar Babu, M., Shivarudrappa, B. and Ramakrishna, Y.S. 2007. Strategies for livestock development in rainfed agro-ecosystem of India. Livestock Research for Rural Development 19 (6) (On-line Journal).

Mohanty, S.K., Maruthi Sankar, G.R., Behera, B., Mishra, A., Pal, A.K. and Subudhi, C.R. 2008. Statistical evaluation and optimization of fertilizer requirement of upland rice (*Oryza sativa*) genotypes at varying levels of crop seasonal rainfall under moist sub-humid alfisols. Indian Journal of Agricultural Sciences, 78 (3): 18 – 23.

Nagasree, K., Subrahmanyam, K.V., Sharma, K.L., Usha Rani, K. and Ramana D.B.V. 2008. Protein security through milk: strategies for enhanced productivity and use. Green Farming 1 (5): 37-40.

Nema, A.K., Maruthi Sankar, G.R. and Chauhan, S.P.S. 2008. Selection of superior tillage and fertilizer practices based on rainfall and soil moisture effects on pearl millet yield under semi-arid inceptisols. Journal of Irrigation and Drainage Engineering (ASCE), 134 (3).

Prasad, Y.G., Nagalakshmi, T., Prabhakar, M., Yella reddy, D., Rao, N.H.P., Prasada Rao, M.P., Srinivasa Rao, M., Desai, S., Rao, G.G.S.N. and Ramakrishna, Y.S. 2007. Development of prediction models for bacterial leaf blight *Xanthomonas axonopodis pv. malvacearum* of cotton (*Gossipium hirsutum*) in Andhra Pradesh and Maharashtra. Indian Journal of Agricultural Sciences 77: 752-756.

Pratibha, G., Korwar, G.R., PalaniKumar, D. and Vaishnavi Jois. 2007. Effect of planting materials, fertilizers and microsite improvement on yield and quality of henna (*Lawsonia inermis)* in alfisols of semi-arid regions Indian Journal of Agricultural Sciences 77: 721-725.

Rai, P., Ramana, D.B.V., Rao, G.R., Yadav, R.S., Handa, A.K. and Chaturvedi, O.P. 2007. Growth and production of *Anogeissus pendula* (Edgw.) – based silvopastoral system under different pruning managements. Annals of Arid zone, 46: 65-72.

Rajeswari, M., Maruthi Sankar, G.R., Ranghaswami, M.V. and Mishra, P.K. 2007. Screening of soil amendments for efficient water holding capacity based on a rainfall-infiltration model in a vertisol. Journal of Irrigation and Drainage Engineering (ASCE), 133 (5) : 468 – 474.

Rama Rao, C.A. and Reddy, Y.V.R. 2007. Economics of crop production in different agro-climatic regions of A.P. Agricultural Situation in India, 63(10) 577-583.

Rama Rao, C.A., Reddy, Y V R, Sastry, G and Ramakrishna Y S 2007. Performance evaluation of watershed development programmes in different agro-ecological regions of India. Indian Journal of Dryland Agriculture and Development 22(1) 74-81

Rama Rao, C.A., Srinivasa Rao, M., Naraiah, P., Malathi, B. and Reddy, Y.V.R. 2007. Profitability of cotton on a pest management continuum in Guntur district of Andhra Pradesh. Agricultural Economics Research Review. 20(2) 273-282.

Rama Rao, C.A., Srinivasa Rao, M., Naraiah, P., Malathi, B. and Reddy, Y. V. R. 2008. An Economic Analysis of Adoption of Integrated Pest Management in Groundnut. Indian Journal of Agricultural Economics. 63(1) 97-107

Ramesh, V., Korwar, G., Uttam Kumar Mandal, Sharma, K.L., and Venkanna, K. 2007. Optimizing fly-ash dose for better tree growth and nutrient supply in an agroforestry system in semi-arid tropical India. Communications in Soil Science and Plant Analysis 38 (19): 2747-2766.

Ramesh, V., Korwar, G.R., Mandal, U.K., Prasad, J.V.N.S, Sharma, K.L., Ramakrishna, Y.S. and Venkanna, K. 2008. Influence of fly ash mixtures on early tree growth and physicochemical properties of soil in semi-arid tropical Alfisols. Agroforestry Systems 73(1):13-22.

Ramesh, V., Korwar, G.R., Uttam Kumar Mandal, Sharma, K.L. and Venkanna, K. 2008. Influence of fly ash mixtures on early tree growth and physico chemical properties of soil in semi-arid tropical Alfisols, Agroforestry Systems. 73: 13-22.

Rao, V.S. and Maruthi Sankar, G.R. 2007. Effects of clay mineral application on soil moisture status, physiological traits and yield of rainfed tomato under semi-arid alfisols. Journal of Horticultural Sciences, 2 (1) : 26 – 33.

Ravi Shankar, K., Subrahmanyam, K.V., Reddy, B.M.K. and Sharma, K.D. 2007. Farmers' perceptions and adoption patterns of soil and water conservation measures: A case in Nalgonda district of Andhra Pradesh. Indian Journal of Dryland Agricultural Research and Development, 22 (2): 197-200.

Ravindra Chary, G., Dixit, S., Vittal, K.P.R., Subba Reddy, G. and Maruthi Sankar, G.R. 2007. Technology diffusion and up-scaling in rainfed agro ecosystem: policy and institutional approaches. Indian Journal of Dryland Agricultural Research and Development. 22 (2): 132-146.

Senthil Kumar, P., Ramana Reddy, Y., Ramesh, S., Gobinath, S and Ramana, D.B.V. 2007. Evaluation of pigment extracted annatto seed (B*ixa orellana*) by chemical, *in-vitro* and *in-sacco* techniques in buffaloes. Buffalo Bulletin 26 (1): 5-9.

Sharma, K.L., Ramakrishna, Y.S., Korwar, G.R., Mandal, U.K., Srinivas, K. and Kusuma Grace, J. 2007. Strategies for improving the productivity and income of rainfed marginal and small farms – needs for technological and policy interventions. Green Farming 1 (2): 1-6.

Sharma, K.L., Guled, M.B., Vittal, K.P.R., Subba Reddy, G., Maruthi Sankar, G., Ravindra Chary, G., Kusuma Grace, J., Mandal, U. K., Srinivas, K., Pravin N. Gajbhiye and Madhavi, M. 2007. Soil quality assessment using deviation method under different soil and management practices in rainfed vertisol. Indian Journal of Dryland Agricultural Research and Development, 22(2): 173-181.

Sharma, K.L., Kusuma Grace, J., Korwar G.R. and Ramakrishna Y.S. 2007. Strategies for soil quality restoration and its maintenance in rainfed areas. Green Farming 1 (1): 10-13.

Sharma, K.L., Neelaveni, K., Srinivas, K., Katyal, J.C., Srinivasa Raju, A., Kusuma Grace, J., and Madhavi, M. 2007. Recycling of different organic wastes through vermicomposting and evaluating their efficacy on yield and N uptake in sunflower (*Helianthus annuus* L.) crop. Indian Journal of Dryland Agricultural Research and Development, 22(2): 189-196.

Sharma, K.L., Srinivas, K., Mandal, U.K., Ramakrishna, Y.S., Vittal, K.P.R., Das, S.K., Martin, D., Kusuma Grace, J. and Balloli, S.S. 2007. Kinetics of decomposition of un-conventional farm-based residues and their composting and quality monitoring. Communications in Soil Science and Plant Analysis 38 (17): 2423-2444.

Srinivasa Rao, M., Rama Rao, C.A., Sreevani, G. and Anjaiah, E. 2007. Impact of crop-crop diversity on pod-borer (*Helicoverpa armigera)* of pigeonpea (*Cajanua cajan*). Indian Journal of Agricultural Sciences, 77(8) 495-501.

Usha Rani, K., Sharma, K.L., Kausalya Ramachandran and Hima Bindu, V. 2007. Assessment of ground water quality in different villages situated near Musi River basin in Ghatkesar mandal of Ranga Reddy district in Andhra Pradesh. Indian Journal of Dryland Agricultural Research and Development, 22(1): 89-94.

Vanaja, M., Raghuram Reddy, P., Jyothi Lakshmi, N., Maheshwari, M., Yadav, S.K. and Venkateswarlu, B. 2007. Germination and seedling response of pulse crops to elevated CO_2. Journal of Food legumes. 20 (2): 165-168.

Vanaja, M., Jyothi, M., Ratnakumar, P., Vagheera, P., Raghuram Reddy, P., Jyothi Lakshmi, N., Yadav, S.K., Maheshwari, M. and Venkateswarlu. B., 2008. Growth and yield responses of castor bean (*Ricinus communis* L.) at two enhanced CO_2 levels. Plant Soil and Environment 54 (2): 38-46.

Vanaja, M., Reddy, P.R., Jyothi Lakshmi, N., Maheswari, M., Vagheera, P., Ratnakumar, P., Jyothi, M., Yadav, S.K., and Venkateswarlu, B. 2007. Effect of elevated atmospheric CO_2 concentrations on growth and yield of blackgram (*Vigna mungo* L. Hepper)-a rainfed pulse crop. Plant, Soil and Environment 53: 81-88.

Varalaxmi, Y., Vijayalakshmi, A., Yadav, S.K., Venkateswarlu, B. and Maheshwari, M. 2007. Efficient plant regeneration from cotyledons of *Vigna mungo* L. Hepper. Indian Journal of Biotechnology 6: 414-417.

Venkateswarlu, B., Srinivasa Rao, Ch, Ramesh, G., Venkateswarlu, S. and. Katyal, J.C. (2007). Effects of long term – legume cover crop incorporation on soil organic carbon, microbial biomass, nutrient build up and grain yields of sorghum / sunflower under rainfed conditions. Soil Use and Management, vol. 23, 100-107.

Venkateswarlu, B., Medeleine Pirat, Kishore, N, and Abdul Rasul (2007). Mycorrhizal inoculation in neem (Azadirachta indica) enhances azadirachtin content in seed kernels. World Journal of Microbiology and Biotechnology, DOI–10.1007/s 11274-007-9593-2.

Vikas Abrol, Maruthi Sankar, G.R., Mahinder Singh and Jamwal, J.S. 2007. Optimization of fertilizer requirement of maize based on yield and rainfall variations from permanent manorial trials under dry-sub humid inceptisols. Indian Journal of Dryland Agriculture Research & Development, 22(1):15–21.

Vikas Abrol, Vikas Sharma, Peeyush Sharma, Deepak Khar, Vittal, K.P.R., and Sharma, K.L. 2007. Direct and residual effect of organic an inorganic sources of nutrients on maize (*Zea mays*)- mustard (*Brassica napus*) cropping sequence under rainfed conditions. Indian Journal of Dryland Agricultural Research and Development, 22(1): 82-88.

Yadav, S.K., Korwar, G.R., Vanaja, M., Pratibha, G. and Venkateswarlu, B. 2007. Curry leaf essence: a high value low volume product for rainfed farmers. Indian

Journal of Dryland Agricultural Research and Development 22 (1): 48-51.

Books/reports/bulletins/brochures

Balloli, S.S., Venkateshwarlu, B., Korwar G.R. and Ramakrishna, Y.S. Bhoosara Pariksha Karyakramamu (Telugu) pp

Kareemulla, K., Rama Rao, C.A., Sreenath Dixit, Ramana, D.B.V., Venkateswarlu, B. and Ramakrishna, Y.S. 2008. A profile of target districts in Andhra Pradesh: demography, land use and agriculture. NAIP-SRL Series-1. Central Research Institute for Dryland Agriculturte, Hyderabad. pp.32.

Maruthi, V., Srinivas, K., Reddy, G.S., Ramakrishna, Y.S., Reddy, K.S., Reddy, B.M.K., Reddy, B.S., Reddy, P.R. and Venkateswarlu, B. 2008. Value addition to crop residues: a case study of groundnut shell. Research Bulletin No. TB/01/08. Central Research Institute for Dryland Agriculture, Hyderabad.pp. 12.

Maruthi, V., Srinivas, K., Subba Reddy, G., Ramakrishna, Y.S., Reddy, K.S., Reddy, B.M.K., Reddy, B.S., Reddy, P.R and Venkateswarlu, B., 2008. Value addition to crop residues: A Case study of Groundnut shell (English) pp

Prasad M.S., Reddy, B.M.K., Reddy, N.N., Reddy, Y.V.R 2007Maize Production Technology'. pp192 Agro tech publishing academy, Udaipur.

Prasad, M.S., Dixit, S. and Ramakrishna, Y.S. 2007. Contribution of krishi vigyan kendra in Rangareddy district. Krishi Vigyan Kendra, CRIDA, Hyderabad pp48

Prasad, M.S., Mayade, V.M., Ramakrishna, Y.S. and Reddy, Y.V.R.2007 Krishi Vigyan Kendras for rural transformation. pp192 Agro tech publishing academy, Udaipur.

Pratibha, G., Korwar, G.R., .Srinivas, I., Srinivasa Rao, M., Yadav, S.K., Venkateswarlu, B. and Ramakrishna, Y.S. 2007. Crop diversification with dye crops for sustainability of drylands. Technical bulletin. pp. 24.

Pratibha, G., Korwar, G.R., Srinivas, I., Srinivasa Rao, M., Yadav, S. K., Venkateswarlu, B. and Ramakrishna, Y.S. 2007. Crop diversification with medicinal & aromatic plants for sustainability of drylands. A technical bulletin. CRIDA, Hyderabad. pp.24.

Pratibha, G., Korwar, G.R, Srinivas, I., Srinivasa Rao, M. and Ramakrishna. Y.S. 2007. Metta praanthalaku anuvaina pratyamnaya pantalu. Technical bulletin pp. 24.

Rama Rao, C.A. and Ramakrishna, Y.S. 2007. Production and marketing of coarse cereals in Andhra Pradesh. Research Bulletin / Ag. Econ/1/2007, CRIDA, Hyderabad, pp.32.

Rama Rao, C.A. Kareemulla, K., Dixit, S., Venkateswarlu, B. and Ramakrishna, Y.S. 2007. Participatory farming systems analysis – An innovative tool for designing livelihood interventions. CRIDA, Hyderabad .pp 4

Rama Rao, C.A., Srinivasa Rao, M., Srinivas, K. and Ramakrishna, Y.S. 2007. Adoption and impact of integrated pest management in cotton, groundnut and pigeonpea. Research Bulletin. Ag. Econ/2/2007.pp32.

Ramesh,V., Wani, S.P., Tego, T.J., Sharma, K.L., Bhattacharyya, T., Sahrawat, K.L., Padmaja, K.V., Gangadhar Rao, D., Venkateswarlu, B., Vanaja, M., Manna, M.C., Srinivas, K. and Maruthi, V. (2007). Chemical Characterization of Selected Benchmark Spots for C sequestration in the Semi-Arid Tropics, India. Global Theme on Agroecosystems Report no. 32. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi Arid Tropics (ICRISAT); and New Delhi, India: Indian Council of Agricultural Research (ICAR). pp.106.

Ravi Shankar, K., Pochaiah Maraty., Murthy, V.R.K., and Ramakrishna, Y.S. 2008. Indigenous rain forecasting in Andhra Pradesh. CRIDA, Hyderabad pp67. ISBN: 978-81-904360-5-2.

Singh, P.R., Prasad, M.S., Rao, V.S., Reddy, N.N. and Ramakrishna, Y.S. 2007. Poola Thotallo Adikotpathi ki Yajamanya Paddathulu, Bulletin No.12, Krishi Vigyan Kendra, CRIDA, Hyderabad, pp.16.

Subba Reddy. G, Reddy YVR, Vittal KPR, Thyagaraj C.R., Ramakrishna, Y.S. and Somani LL, 2008, Dryland Agriculture. Published by Agrotech Publishing Academy, Udaipur .pp 368.

Venkateswarlu, B., Balloli, S.S. and Ramakrishna Y.S. 2008. Organic Farming in Rainfed Agriculture: Opportunities and Constraints, Central Research Institute for Dryland Agriculture, Hyderabad. pp.185.

Venkateswarlu B and Ramakrishna Y.S. (2007). Sustainable Rural Livelihoods Through Enhanced Farming Systems Productivity and Efficient Support System,s in Rainfed Areas, Project brochure, NAIP pp:8.

Venkateswarlu B., Subba Reddy G., Prabhakar M., Mayande V.M., Korwar G.R., Ramakrishna Y.S. 2008. Rainfed farming: A profile of doable technologies, CRIDA, Hyderabad. pp:1-47.

Yadav, S.K., Maheswari, M., Vanaja, M. and Venkateswarlu, B. 2007. Genetic transformation of green gram for enhancing abiotic stress tolerance. A technical bulletin. CRIDA, Hyderabad. pp.8.

Yadav, S.K., Maheswari, M., Vanaja, M. and Venkateswarlu, B. 2007. Improving abiotic stress tolerance in black gram . A technical bulletin. CRIDA, Hyderabad .pp.8.

Book chapters

Jyothi lakshmi, N., Maheswari, M., Vanaja, M., Yadav, S.K., Raghuram Reddy, P., Venkateshwarlu, B. and Subba Reddy, G. 2007. Influence of water deficit at flowering stage on grain yield of green gram (*Vigna radiata* L.Wilczek) *In* Proceedings of the International Food Legumes Research Conference- IV. Food Legumes for Nutritional Security and Sustainable Agriculture, IARI, New Delhi. pp.61-66.

Nirmala, G. 2008. Extension services for the development of agriculture and allied activities. *In* Enterprises and Technologies for Rural Development (Y.V.R. Reddy, Y.S. Ramakrishna and L.L. Somani. eds) Agrotech Publishing Academy, Udaipur. pp.384-387

Prasad, M.S., Ramakrishna, Y.S., and Reddy, Y.V.R.2007. Krishi vigyan kendra for rural development. Souvenir of Silver Jubilee Celebrations of the Telangana Agricultural Officers' Association, Hyderabad. pp. 49-56.

Pratibha, G., Korwar, G.R., Venkateswarlu, B., Srinivasa Rao, M. and Yadav, S.K. 2007. Production potential and agro techniques for natural dye yielding crops for rainfed regions. *In* Advances in Medicinal Plants *(*K.J. Reddy, Bir Bahudur, Bhadhrayya and M.L.N. Rao eds) University Press (India) Pvt. Ltd Hyderabad pp. 233-247.

Rama Rao C.A. 2008 Maize economy of India. *In* Maize production technology. (Reddy, Y.V.R., Somani, L.L. and Ramakrishna, Y.S.eds)Agrotech Publishing Academy, Udaipur, pp 167-173 (ISBN:81-8321-102-X).

Rama Rao, C.A. 2008. Profile of Rangareddy district. *In* Enterprises and technologies for rural development. (Y V R Reddy, L L Somani and Y S Ramakrishna.eds) Agrotech Publishing Academy, Udaipur, pp20-37 (ISBN:81-8321-103-8)

Rao, G.G.S.N., Rao, A.V.M.S., Vanaja, M., Rao, V.U.M. and Ramakrishna Y.S. 2008. Impact of regional climate change over India. *In*: Climate Change and Agriculture over India. (Prasada Rao, G.S.L.H.V., Rao, G.G.S.N., Rao V.U.M. and Ramakrishna, Y.S.eds) AICRP on Agrometeorology and Kerala Agricultural University. , pp 13-48.

Rao, G.R. 2007. Criteria to be followed for DUS testing for Neem. *In*: Discussion Note of National Level Consultative Meeting on DUS Testing of Trees. FC&RI, TNAU, Mettupalayam.p.56.

Rao, J.V., Rao, G.R., Chary, G.R., Srinivas, I. and Ramakrishna Y.S. 2007. On-farm research experiences on biofuel establishments in Andhra Pradesh. *In:* Proceedings of National Workshop on Production, Methodologies, Utilization Techniques and Challenges Ahead. MERADO, Ludhiana. p.163-170.

Reddy, B.M.K., Reddy, N.N., Rama Rao, C.A. and Maruthi, V. 2008. Problems and prospects for rural enterprises.. *In:* Enterprises and technologies for rural development. (Reddy, Y.V.R. Somani, L.L. and Ramakrishna, Y.S.eds) Agrotech Publishing Academy, Udaipur, pp155-165 (ISBN:81-8321-103-8)

Sharma, K.L., Vittal, K.P.R., Ramakrishna, Y.S., Srinivas, K., Venkateswarlu, B., and Kusuma Grace, J. 2007. Fertilizer use constraints and management in rainfed areas with special emphasis on nitrogen use efficiency. *In* Agricultural Nitrogen Use and Its Environmental Implications. (Y. P. Abrol, N. Raghuram and M. S. Sachdev eds), I. K. International Publishing House, Pvt., Ltd. New Delhi. pp 121-138.

Srinivasa Rao, M. 2007. Microclimate and insect relationships in dryland crops. *In* Agricultural Drought: Aspects of micrometeorology (Y.S. Ramakrishna, G.G.S.N. Rao P.S.N. Sastry and V.U.M. Rao.eds) ISBN NO:978-81-904360-0-7.pp 267-273.

Srinivasa Rao, M., Pratibha, G., Korwar, G.R. and Venkateshwarlu, B. 2007 Medicinal and aromatic plants and their extracts in insect pest management: A Review. *In* Advances in Medicinal Plants.(Janardhan Reddy K, Bir Bahadur and Rao M.L.N. eds.) University Press (India) Pvt. Ltd Hyderabad pp269-280.

Vanaja, M. 2007. Measuring plant water potential, stomata conductance and photosynthetic rate. *In:* Agricultural Drought: Aspects of Micrometeorology. (Ramakrishna, Y.S., Rao, G.G.S.N., Sastry, P.S.N. and Rao, V.U.M.eds) ISBN NO: 978-81-904360-0-7.pp 348-353.

Vanaja, M., Ramakrishna, Y.S., Rao, G.G.S.N., Rao, K.V. and Subba Rao, A.V.M. 2007. Climate change and dryland agriculture. *In:*Dryland Ecosystem: Indian Perspective. (Vittal, K.P.R., Srivastava, R.L., Joshi,

N.L., Amal Kar, Tewari, V.P. and Kathju, S.eds) Central Arid Zone Research Institute, Jodhpur and Arid Forest Research Institute, Jodhpur. pp 23-34.

Venkateswarlu, B. (2007). Nitrogen fixation in arid and semi-arid agriculture : Opportunities and constraints. In Agricultural Nitrogen Use and Its Environmental Implications (Eds.Y.P.Abrol, N.Raghuram, M.S.Sachdev), I.K. International Publishing House Pvt. Ltd. New Delhi. pp.415-436.

Vittal, K.P.R. and Ravindra Chary, G 2007 Horizontal and vertical Diversifications of rainfed cropping system in India. *In* Dryland Ecosystem – Indian Perspective (Vittal, K.P.R., Srivastava, R.L.,.Joshi, N.L., Amal Kar, Tewari, V.P. Kathju, S. eds) Central Arid Zone Research Institute and Arid Forest Research Institute, Jodhpur.pp

Technical/popular articles

Dixit, S. 2007. Come, let us research. Adike Patrike. 19 (7): 33-34.

Dixit, S., 2007. Whither rainfed agriculture? Adike Patrike. 19 (5): 30.

Dixit, S., Kishtappa, V., Ravindra Chary, G. and Ramamohan, R.V. (2007). Social regulation: A viable option for groundwater management. LEISA India 9 (1): 18-19.

Maruthi, V., Srinivas, K. and Dixit, S. 2007. Excellent manure from groundnut shell Adike Patrike. 19 (6): 34-35.

Nagasree, K., Subrahmanyam, K.V., Sharma, K.L., Usha Rani, K. and Ramana D.B.V. 2008. Protein security through milk: strategies for enhanced productivity and use, Green Farming Sustainable Agriculture Special: 1(5): pp

Nagasree, K., Subrahmanyam, K.V., Reddy, B.M.K. and Subbareddy, G. 2007 Fertiliser management in Castor (In Telugu). Amudam pantalo yeruvula yajamanyam Padipantalu pp 30.38.

Ramana, D.B.V. 2007. Neeti parivaahika pramtaallo pasu poshana dhwara adhika aadhayam. Annadata (Telugu), 4: 8-11.

Rao, J.V., Srivasthava, N.N., Victor, U.S. and Ravindra Chary, G. 2007 Dakshina Telangana pranthapu varshadhara boomulo vathavaranamu nanusarinchina prathnamnaya pantala ejamanyam. Padipantalu (Telugu) Vol. 65(2): 14-18, 2007.

Ravi Shankar, K. and Prasad, M.S. 2007. Mokkajonna Panta Yajamanyam . Padi Pantalu, (Telugu), 65(4): 41-42.

Ravi Shankar, K. and Prasad, M.S. 2007. Nela neeti samrakshana. Padi Pantalu(in Telugu), 64 (9): 9-10.

Sharma, K.L., Ramakrishna, Y.S., Korwar, G.R., Mandal, U.K., Srinivas, K. and Grace, K. 2007. Strategies for improving the productivity and income of rainfed marginal and small farms – Needs for technological and policy interventions. Green Farming 1(2): 1-6.

Sharma, K.L., Kusuma Grace, J., Korwar, G.R. and Ramakrishna, Y.S. (2007) Strategies for soil quality restoration and its maintenance in rainfed areas. Green Farming 1(1): 10-13.

Sharma, K.L., Ramakrishna, Y.S., Korwar, G.R. and Srinivas, K. 2008. Enhanced use of organics is must in arid and semi-arid farms for improving organic matter in soil: Part – I. Green Farming 1(4): 1-4.

Sharma, K.L., Ramakrishna, Y.S., Korwar, G.R., Srinivas, K. and Balloli, S.S. 2008. Enhanced use of organics in arid and semi-arid farms for improving soil organic matter: Part – II. Green Farming 1(5): 1-4.

Usha Rani, K., Sharma, K.L., Srinivas, K., Korwar, G.R., Nagasri, K. and Shankar, K.S. 2008. How safe is the sewage water irrigation under Musi river basin of Hyderabad, Andhra Pradesh. Green Farming 1(4): 10-12.

Yadav, Sushil Kumar and Venkatesswarlu, B. 2007. Balancing Food Imbalances. Agriculture Today(English) 2007. pp. 27-28.

Radio/TV

Ramana, D.B.V., Karuvu paristitulalo pasuvulu, jeevala yajamanyam (in Telugu) 17th April, 2007 AIR, Hyderabad.

Rami Reddy, R.D. Botanical pesticides and its use in plant protection15-12-2007 AIR, Hyd.

Sanjeeva Reddy, B. Tractor tho Mettapantalu Vitthe Parikaram. 22nd October, 2007 at 18.30hrs. Annapurna Programme, TV – 5 Telugu Channel.

Sanjeeva Reddy, B., Aruvarusallo Vittanalu Veyu Tractor tho Panicheyu CRIDA Parikaram. 13th June, 2007 at 18.30hrs. D.D. Saptagiri Telugu Channel.

Sanjeeva Reddy, B., Poddutirugudu Pulanundi Vitthanalu Verucheche Parikaramu. 24th October, 2007 at 18.30hrs. Annapurna Programme, TV – 5 Telugu Channel.

Sanjeeva Reddy, B., Vyavasayamlo Mahilala Shrama Tagginche Parikaralu. 6th October, 2007 at 18.30hrs. Annapurna Programme, TV – 5 Telugu Channel.

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.Srinivas 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
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

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
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/NM/03	Efficient management of gliricidia on field bunds	**K. Srinivas** K.L. Sharma M. Srinivasa Rao	2007	2010
10. 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
11. RM/RM/02	Watershed based NRM strategies for rainfed area of Prakasam district in Andhra Pradesh	**M. Osman** K.V.Rao	2006	2008
12. RM/RM/03	Standardization of agri-techniques of perennial castor	**M. Osman** M. Vanaja P.R. Reddy	2006	2010
13. 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
14. ICAR Adhoc Scheme (under 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
15. Externally Funded (NOVOD)	National Network project on integrated development of Jatropha and Pongamia	**G. Rajeshwar Rao** G.R. Korwar M. Prabhakar	2004	2008
16. 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
17. 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
18. Externally Funded (Ministry of Water Resources, GOI)	Rainfall-runoff-ground water dynamics in semi-arid regions	**K.V. Rao** U.K. Mandal	2004	2007

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
19. RM/NM/04	Improving the productivity of *Leucaena leucocephala* for industrial biomass production	**J.V.N.S. Prasad** G.R. Korwar B. Venkateswarlu	2007	2009
DIVISION OF CROP SCIENCE				
20. 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
21. CS/CP/09	Genetic transformation of greengram for enhancing abiotic stress tolerance	**S.K.Yadav** M.Maheswari B.Venkateswarlu N.Jyothi Lakshmi M.Vanaja P.R.Reddy	2004	2009 (merged with DBT project)
22. 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
23. DST project	Nitrate uptake and assimilation in crop plants under elevated CO_2	N. Jyothi Lakshmi	2006	2009
24. 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
25. CS/CP/16	Evaluation of chlorophyll fluorescence as an indicator for drought tolerance in selected dryland crops	**Arun Kumar Shanker** M. Maheswari G.R. Rao	2007	2010
26. CS/CP/17	Nutrient and hormonal management for manipu-lation of flowering, fruiting and seed set in Pongamia pinnata (L.) Pierre	**Arun Kumar Shanker** G.R. Rao M. Maheswari S.K.Yadav	2007	2010
27. 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

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
28. CS/CP/18	Evaluation of horsegram mutants in multi-locational AICRP trials	**P.R.Reddy**	2007	2010
29. 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	2008
30. CS/CP/12	Drought management practices in castor	**S.Venkateswarlu** G.Subba Reddy	2004	2007
31. 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
32. 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
33. CS/CP/14	Impact of INM on productivity of niger	**B.M.K. Reddy** G.R. Maruthi Sankar K. Srinivas	2005	2008
34. CS/PP/12	Utilization of candidate microbial isolates for management of dryland insect pests	**Y.G.Prasad** M.Prabhakar B.Venkateswarlu G.R.Rao I.Srinivasa Rao S.Dixit	2007	2010
35. Externally funded (APNL)	Generation of data for registration of Achaea janata Baculovirus (AP-NL)	**Y.G. Prasad** M. Prabhakar B. Venkateswarlu	2005	2007
36. Externally funded (WWF)	Sustainable Cotton Initiative in Warangal district of Andhra Pradesh	**Y.G. Prasad** K.V. Rao M. Prabhakar	2006	2009
37. 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
38. ICAR Net work project	Application of micro organisms in Agriculture and allied sectors (AMAAS)	**B. Venkateswarlu** S. Desai S.K.Yadav	2006	2008
39. CS/PP/10	Integrated disease management in groundnut based production systems	**S. Desai**	2005	2010

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
40. DST Project	Threshold temperatures, thermal constants and development models for major pests of dryland crops	**M. Prabhakar**	2005	2007
41. 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
42. 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
43. CS/PP/11	Impact of elevated CO_2 on Bt cotton and boll worms	**M. Srinivasa Rao** K. Srinivas M. Vanaja	2007	2009
44. CS/PP/13	Development and evaluation of Low External Input IPM modules in pigeonpea and castor	**M.Srinivasa Rao** C.A.Rama Rao V.Maruthi	2007	2009
45. NPCC project	Impact of elevated CO2 and temperature on host herbivore interaction	**M.Srinivasa Rao** K.SrinivasM.Vanaja	2004	2008
46. CS/CP/16	Studies on root characteristics of greengram and horsegram crops in relation to resource use	**V. Maruthi** K. Srinivas Arun Kumar Shankar B. Sanjeeva Reddy	2007	2009
47. 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
48. 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 MV. Padmanabhan	2005	2010
49. CS/Horti/04	Productivity enhancement in existing fruit orchards in drought prone areas	**V.S. Rao** N.N. Reddy K. Srinivas Reddy	2006	2008
50. RSAD (J) MBNR	Collection, evaluation of standardization of agro-techniques and pilot demonstrations of Jatropha & Pongamia	**J.V.Rao** G.R.Rao	2005	2008

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
SECTION OF TRANSFER OF TECHNOLOGY				
51. 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
52. TOT/LM/1	Performance of sheep reared under different management systems	**D.B.V. Ramana** G.R. Rao K.V. Subrahmaniam A.R. Sen, NRCM	2005	2008
53. 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, Sholapur	2006	2009
54. TOT/LM/3	Strategies for enhancing breeding efficiency of dairy animals under rainfed conditions	**D.B.V. Ramana** A.K Mishra G. Nirmala	2007	2010
55. 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
56. 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				
57. DA/AE/02	Development of farming situation-based extension for Ranga Reddy district	**G.Nirmala** M.S.Prasad	2004	2007
58. DA/AE/03	Gender analysis in watershed development programmes of Andhra Pradesh	**G. Nirmala** S. Dixit	2007	2009
59. DA/AE/04	Trends and determinants of agricultural diversification in Andhra Pradesh	**C.A Rama Rao** V. Maruthi K. Ravi Shankar K. Kareemulla	2007	2009

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
60. DA/AE/05	Economic Analysis of Technology Interventions of KVK	**C.A. Rama Rao** M.S. Prasad G. Nirmala	2007	2009
61. DA/AE/06	Strategies to enhance profitability in backyard poultry through use of non conventional feed sources – An on-farm participatory action research	**S. Dixit** D.B.V. Ramana M. Prabhakar Y.G. Prasad	2007	2009
62. DA/AE/07	Development of Rainfed Agri-Knowledge Network (RAKNet)	**S. Dixit** G. Ravindra Chary A.V.M. Subba Rao K.V. Rao	2007	2010
63. DA/FN/08	Studies on Enrichment of Quality & utilization of Palmyra fruit	**K. Sreedevi Shankar** N.N. Reddy B. Venkateswarlu	2007	2009
AICRPDA				
64. 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 (NBPGR),Scientists from AICRPDA Centres, L.G.K. Naidu(NBSSLUP, Bangalore)	2006	2008
65. 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
66. 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				
67. 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

Institute Code No	Title of the Project	Investigators	Year of Start	Likely year of termination
68. AGMET/01	Agroclimatic resource characterization of Andhra Pradesh	**V.U.M. Rao** Y.S. Ramakrishna G.G.S.N. Rao A.V.M.Subba Rao K.V. Rao D. Raji Reddy	2007	2010
NATIONAL FELLOW				
69. 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
70. 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
71. Externally Funded (AP-Cess)	Assessing soil quality key indicator 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
NAIP				
72. Externally funded (NAIP)	Sustainable rural livelihoods through enhanced farming system productivity and efficient support systems in rainfed areas	**B. Venkateswarlu** Sreenath Dixit	2007	2012
73. Externally funded (NAIP)	Value chain model for bioethanol production from sweet sorghum in rainfed areas through collective action and partnership	**I Srinivas** B. Sanjeeva Reddy R. Adake G.R. Korwar	2008	2012

11 Consultancy, patents and commercialization

Consultancy

The Planning Commission, Government of India identified CRIDA as a Technical Support Institution (TSI) fro preparation of comprehensive district plans for the XI plan period for the backward region grant fund (BRGF) districts of Chittoor, Cuddapah and Mahbubnagar in Andhra Pradesh. The work was done in a consultancy mode with a budget of Rs. 5 lakhs for each district.Scientists G. G. S. N. Rao, G. R. Korwar, B. Venkateswarlu, K. Kareemulla, K. S. Reddy, K. Srinivas, G. S. Reddy, C. A. Rama Rao, B. M. K. Reddy, J. V. Rao, M. Osman, G. R. Chary, K. V. Rao and Technical Officers S. M. Vidyasekhar, M. Swamy and Sheikh Haffis were involved in this activity.

YG Prasad, KV Rao, M. Prabhakar took up Consultancy work for World Wide Fund – India (WWF-India) project on "Monitoring and evaluation: Sustainable Cotton Initiative in Warangal District of Andhra Pradesh" for the year 2007-08 at a cost of Rs 7.33 lakhs.

Commercialization

The following industries have signed Memorandum of Understanding with CRIDA for manufacturing of CRIDA implements

1. M/s Hindusthan Agro Industries
   Malout-152107 (Punjab)
2. M/s LCT Feeder's (P) Ltd.
   Balapur, Hyderabad -500 079

12 RAC, Management Committee, SRC, SAC

12.1 Research Advisory Committee Meeting (RAC):

The XVI RAC meeting was held on 12.4.2007 at CRIDA, under the Chairmanship of Dr N.N.Goswami, Retd. Joint Director, IARI and Former Vice Chancellor, CSAUAT, Kanpur. The meeting was attended by Dr. S.R. Verma, Ex-Dean, College of Agril. Engg., PAU, Ludhiana, Dr. P.S.N. Sastri, Principal Scientist (Retired), IARI, Dr. N. Khajuria, Dean, Post Graduate Studies, SKAUSI, Jammu besides Dr. Y.S. Ramakrishna, Director CRIDA, Dr. J.V. Rao, Member Secretary, Dr. V.M. Mayande, Zonal Coordinator, Special invitees from CRIDA Detailed discussions were held on XI-FYP programmes of CRIDA and its centers, recommendations of QRT of CRIDA and recommendations of practical significance were conveyed to the ICAR.

XVI RAC Meeting held at CRIDA on 12.4.2007

12.2.Staff Research Council (SRC)

The annual SRC meeting was held 24, 25-27 May and 9, 10, 11,& 15 June, 2007 under the Chairmanship of Dr. Y.S. Ramakrishna, Director, CRIDA. The meeting has discussed the QRT and RAC recommendations, reviewed the progress of institute on-going project, considered new project proposals and also reviewed the AICRPDA and AICRPAM activities. There were 18 new project proposals out of which 17 were approved with major/minor modifications Besides reviewing the progress of on-going projects, the PC and Heads, Divisions/Sections presented a road map of future research to be carried out. Fifteen institute funded projects and nine external funded projects were concluded since their objectives were met.

12.3 Institute Management Committee (IMC)

The 37th IMC was held on 9 October, 2007 at CRIDA under the Chairmanship of Dr. Y.S. Ramakrishna, Director, CRIDA. The meeting was attended by Dr.V.M. Mayande, Zonal Coordinator, Zone-V, Shri D. Rama Krishna Reddy, Vice President, Federation of Farmers Association, Dr. B. Venkateswarlu, Head, DCS, Dr. Kaushalya Ramachandran, National Fellow, Dr. G. Pratibha, Senior Scientist, Shri L. Suguna Prasad, Addl. Director of Agriculture, Shri V.S. Subramanian, FAO, NAARM and SAO, CRIDA alongwith special invitees from CRIDA. The Committee reviewed the progress of works, expenditure, research activities of the Institute and approved the prioritization of works, equipments, etc.

12.4 Scientific Advisory Committee (SAC) Meeting:

Two SAC meetings of KVK were held on April 20, 2007 and June 16,2007 at Hayathnagar Research Farm under the chairmanship of Dr.Y.S.Ramakrishna, Director, CRIDA. The meeting were 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 in Rabi 2006-2007 and reviewed the action plan for kharif 2007 to be taken up by KVK.

13 Participation of scientists in conferences, meetings, workshops and symposia

Scientist	Topic	Period	Venue
Kaushalya Ramachandran,	Indian Science Congress,	January, 3-7, 2007	Visakhapatnam
Kaushalya Ramachandran	Map World Forum,	January, 27-29, 2007	Hyderabad.
G. R. Korwar, K.V.Rao	21s Biennial Workshop of All India Coordinated Research Project for Dryland agriculture	May 2-5, 2007	SKUAT, Jammu
G. R. Chary	Sir Dorabji TATA Trust – ICRISAT- ICAR Project Consortium Partners Consultation Workshop	July 9-10, 2007	ICRISAT, Hyderabad
M. Srinivasa Rao, M. Vanaja	National conference on Impacts of Climate Change with Particular Reference to Agriculture	August 22-24,2007	TNAU, Coimbatore
U. K. Madal	Conference on Dissemination of space technology for agricultural development	August 24, 2007	Nalgonda, Andhra Pradesh
K.L.Sharma, UKMandal	Workshop on Water Management Strategies for Food Security and Environment Quality"	September 17-19, 2007	PAU, Ludhiana
G. R. Korwar	DST sponsored Fodder and Feed Workshop	September 27-28, 2007	CRIDA, Hyderabad,
KV Rao	New paradigm for rainfed farming - support systems and incentives	September 27-29, 2007	NASC Complex, New Delhi
CR Thyagaraj	Second National Symposium on System of Rice Intensification (SRI) in India	October, 3-5, 2007	SIPARD, Agartala, Tripura
M. Srinivasa Rao, M. Vanaja	National Conference on Climate Change and Indian Agriculture and Annual workshop of ICAR Network project on Impact, Adaptation and Vulnerability of Rainfed Ecosystem to Climate Change	October 12-15, 2007	NASC Complex, New Delhi
C A Rama Rao	15th Annual Conference of Agricultural Economics Association (India)	October 25-26, 2007	University of Agricultural Sciences, Dharwad
G. R. Korwar	Special Interactive Workshop on "Administrative and Financial Matters"	October 26-27, 2007	NIANP (ICAR), Bangalore.
S.K.Yadav	Seminar on Outlook on biotech/GM crops	October 29, 2007	DRR, Hyderabad
U. K. Madal, S.S.Balloli	National Seminar on 'Developments in Soil Science -2007	November 2-5, 2007	Birsa Agricultural University, Ranchi

Scientist	Topic	Period	Venue
S.K.Yadav	National Symposium on Plant Molecular Biology and Biotechnology- Prospectives	November 16-17, 2007	Osmania University, Hyderabad
K. Srinivas M.SrinivasaRao G .Pratibha	International Symposium on 'Organic Farming and Renewable Sources of Energy for Sustainable Agriculture"	November 19-21, 2007	MPUAT, Udaipur
YG Prasad	International Conference on Biopesticides	November 28-30, 2007	Palayamkottai, Tamilnadu
G. Nirmala	Visioning Workshop on 'ICT for Community Development'	December 5-7, 2007	Pondicherry
G. R. Korwar	Bangalore Nano 2007-Bridging the Research-Industry Gap in Nanotechnology"	December 6-7, 2007	Dept IT, BT and S&T Govt. of Karnataka, Bangalore
S. Desai	2nd Asian Congress of Mycology and Plant Pathology on "Microbial Diversity for Asian Prosperity"	December 19-22, 2007	Osmania University, Hyderabad
S. Desai	One day meeting on Revision of WMD Act 2005	January 29, 2008	CCMB, Hyderabad
B. S. Reddy	One day Workshop on Gender related Action Research Studies	January 29,2008	SAMETI,Hyderabad
G. R. Korwar	National Workshop on Jatropha	February 1, 2008	ICAR, NASC, New Delhi
B. S. Reddy	Indian Society of Agricultural Engineers XLII Annual Convention and Symposium	February 1-3, 2008	CIAE, Bhopal
G. R. Rao	5th International Biofuels Conference	February 7-8, 2008	WINROCK International India, New Delhi
M. Prabhakar	Hyperspectral Remote Sensing and Spectral Signature Database Management System-HYPERSPEC- 2008	February 13- 15, 2008	Annamalai University, Chidambaram
G.R. Korwar, K.L.Sharma, G.R.Rao, S.Desai, S.K.Yadav , YGPrasad K. Srinivas, M.Srinivasa Rao, K.V Rao K.RaviShankar, R.V.Adake,	International Symposium on Agrometeorology and Food Security	February 18-21, 2008	CRIDA, Hyderabad

Scientist	Topic	Period	Venue
MPrabhakar, UK Mandal, M.Vanaja, V.Maruthi, K.Nagasree, I.Srinivas JVNSPrasad, VSRao, CRThyagaraj			
M. Prabhakar	Second Insect Science Congress	February 21-22, 2008	PAU, Ludhiana
G.R.Korwar, G.R.Rao, S.K.Yadav, G.Nirmala, K.Srinivas M.Srinivasa Rao, B.S.Reddy, R.V.Adake, S.Venkateswarlu, VMaruthi, K.Nagasree, K.V.Rao I.Srinivas. JVNSPrasad, ASambrajyam, Kushalya ramachandran, KLSharma	National Seminar on Integrated Nutrient Management in Rainfed Agro-ecosystems	March 3-4, 2008	CRIDA, Hyderabad
S.K.Yadav	National Seminar on Advances in Legume Research	March 6-7, 2008	Annamalai University, Chidambaram
B. S. Reddy	Gender Sensibility for Vertical Integration of Officers in Women Hierarchy including Women farmers.	March 10-12, 2008	MANAGE, Hyderabad
S. Desai	One-day "National Agricultural Biosecurity Workshop"	March 25, 2008	NBPGR, New Delhi
M. Vanaja	National Conference on Environmental Issues and Challenges-21st Century	March 28-29, 2008	Osmania University, Hyderabad

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
Workshop on understanding of the support system required for adoption of technologies through participatory action research and refinement of technologies for up scaling in a wider area	February,8-9, 2007	ORP Village Hanjagi, Tehsil, Akkalkot
A training programme on "Production and use of bio-pesticides for eco-friendly management of pests in rainfed crops" sponsored by NABARD	April 2-8, 2007	KVK, CRIDA, Hayatnagar.
Twenty-first Biennial Workshop of All India Coordinated Research Project for Dryland Agriculture	May, 2 - 5 2007	Sher-E-Kashmir University of Agricultural Sciences & Technology, Jammu
Technical Workshop on Development of Participatory Action Plan and Strategies for and Technology Up- Scaling for ORP, Anantapur	June 20-21, 2007	K Agraharam village, Garladinne Mandal, Anantapur and ARS Anantapur
Training programme on "Farm Implements and Machinery " for undergraduate students of B.Tech (Agricultural Engineering).	June, 01 – 30th 2007	CRIDA, Hyderabad
A seminar on 'Awareness on IPR issues in ICAR' has been organized by CRIDA & NAARM Scientists	July, 3 ,2007	CRIDA, Hyderabad
Participatory Planning Workshop as part of AP Cess Fund Project "Capacity building of ORP's – An Action Research Project",	August 6-8, 2007	Hanjagi, ORP Village, Solapur
NAIP First Consortium Implementation Committee Meeting/ Launch Workshop	September 1-2, 2007	CRIDA, Hyderabad
Model training Course on "Soil and Moisture Conservation Techniques for Dryland Agriculture" sponsored by the Directorate of Extension, Ministry of Agriculture, Govt. of India	September 18-25, 2007	CRIDA, Hyderabad
Technical Workshop on Development of Participatory Action Plan and Strategies for and Technology Up- Scaling for ORP.	October 24-25, 2007	Kochariya village, Suwana tehsil, Bhilwara district and AICRPDA Main Centre, Arjia
Training Programme on Farming Systems Approach for Livelihood Improvement of Rainfed Farmers	December 4-14, 2007	CRIDA and ICRISAT, Hyderabad
Seminar-cum-Brainstorming session on 'Strategies for enhancing Agriculture Production, Profitability and Livelihood opportunities of dryland farming communities – A.P.	December, 27, 2007	KVK, CRIDA, Hyderabad

Programme	Period	Venue
Workshop on Tank Silt as an Amendment for improving Soil and Water Productivity funded by MoWR, Govt. of India under FPARP	February,4th , 2008	CRIDA, Hyderabad
Off-farm skill development training course for rural youth representing 8 NAIP clusters,	February 6 – April 4, 2008	Swamy Ramanda Tirtha Rural Institute, Pochampally, Nalgonda district
International Symposium on Agro meteorology and Food Security	February ,18-21 2008	CRIDA, Hyderabad
National Seminar on "Integrated Nutrient Management in Rainfed Agro-ecosystems" sponsored by Dept. of Agriculture and Cooperation, Ministry of Agriculture, GOI	March, 3-4 , 2008	CRIDA, Hyderabad
ICAR sponsored training course "Enhancing Water Productivity in Rainfed Agriculture for Improved Livelihoods"	March 14-27, 2008.	CRIDA, Hyderabad
Organized one day Workshop on evaluation of Capacity building	March 19, 2008	Hanjagi, ORP Village, Solapur
Training Programme on ICT Applications in Agricultural Research jointly organized by CRIDA – ICRISAT for the scientists of Main centers and ORP centers under AICRPDA Network	March ,24- 29, 2008	CRIDA, Hyderabad

14.2 CRIDA Foundation Day

The 23st CRIDA Foundation day was celebrated on April 12, 2007 at CRIDA. Padmasree Dr. M.V. Rao Former Addl. Director General, ICAR and Member, A.P. State Legislative Council graced the occasion .The Foundation Day lecture was delivered by Shri D.A. Somayajulu Deputy Chairperson, A.P. State Agriculture Technology Mission & Advisor to Government of A. P. (Economic Affairs & Policy Implementation. Progressive farmers chintala Venkata Reddy,Draksha Ratna and Sri Ramakrishna Reddy who helped in the diffusion of CRIDA technologies at field level are felicitated by the dignitaries Dr. Y.S. Ramakrishna, Director, CRIDA explained the research activities and achievements made by CRIDA for the betterment of livelihoods of the poor in Dryland areas through field level implementation of rainfed technologies

Dignitories graced the Dial on CRIDA foundation Day

14.3 XXI Biennial Workshop of All India Coordinated Research Project for Dryland Agriculture

Twenty-first Biennial Workshop of All India Coordinated Research Project for Dryland Agriculture was organized during 2 - 5 May 2007 at Sher-E-Kashmir University of Agricultural Sciences & Technology, Jammu under the auspices of AICRPDA Center at Rakh Dhiansar, Jammu. About 150 scientists from CRIDA, AICRPDA Network Centers, ORPs, AICRPAM Network Centers, SKUAS&T and ICAR institutes actively participated during the deliberations of workshop.Dr.Y.S. Ramakrishna, Director, CRIDA presided over the function and Dr. Nagendra Sharma, Hon'ble Vice Chancellor of SKUAS&T was the Chief guest. Smt Bala, Director of Agriculture, Govt. of J&K was present. Dr. A.K. Bakhshi, Director of Research, SKUAS&T (Jammu) welcomed the delegates. Dr. G. Subba Reddy, Project Coordinator (Dryland) briefed about objectives of the workshop. Dr.Y.S. Ramakrishna, Director, CRIDA, in his Presidential address, appreciated the efforts of AICRPDA centers in generating improved technologies in rainfed farming under different production systems and emphasized the need for immediate up-scaling of successful technologies in the farmers' fields for increased productivity and income. On this occasion, AICRPDA Annual Report-2005-06; bulletins from AICRPDA centers Bangalore and Rajkot were released .Discussions on technologies for upscaling under

participatory technology development, action research gaps and future programmes for XI Five Year Plan priorities took place to finalize the technical programme for XI Five Year Plan .

21st Biennial Workshop of AICRPDA

14.4 Kisan Goshti

On the occasion of ICAR Foundation Day, CRIDA organized a 'kisan goshti' at HRF on 16.07.2007 under the Chairmanship of Dr.GGSN Rao, Project Coordinator (Agro Meterology). Dr.B.Venkateswarlu welcomed the gathering which was attended by large number of farmers from KVK adopted villages in Ranga Reddy Dist. Kisan gosti was coordinated by Dr. G. Subba Reddy, PC(Dryland) where in, CRIDA scientists gave answers to farmers questions on various aspects of dryland agriculture

14.5 Hindi Fortnight:

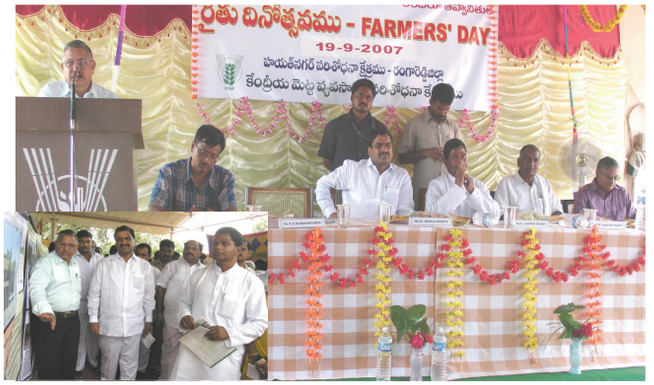
The Hindi fortnight was organized by the Institute from September 14-20, 2007 in which several competitions like Hindi-English technical terminology, Hindi noting and drafting, essay writing, were conducted to CRIDA staff and prizes were distributed by Dr. Y.S.Ramakrishna, Director, CRIDA and Chairman OLIC (Official Language Implementation committee) to the winners of the competitions held during the fortnight in the valedictory function held on September 20, 2007.

14.6 CJSC Meeting:

26th Annual Meeting of CJSC was held at NAARM during 13-15th September, 2007. CJSC Secretary of CRIDA attended the meeting and presented the Institute's views on employees' welfare.

14.7 Celebration of Farmers Day

Farmers Day was celebrated on 19.09.2007 at Hayathnagar Research Farm *Dr. G. Chinna Reddy Garu Hon'ble Minister for Rural Development, NREGP-AP & Self Help Groups, Govt. of A.P.* was the Chief Guest. Shri Malreddy Ranga Reddy MLA, Shri Balram Reddy, President, Andhra Pradesh Rythu Samakhya were other dignitaries who graced the dais on farmers Day. Visits of dignitaries and farmers to field experiments and exhibition stalls were organized. Nearly 1000 farmers from the surrounding villages participated in the Farmers Day. Welcome address was given Dr. Y.S. Ramakrishna, Director, CRIDA, emphasizing the role of rainfed technologies for improving the productivity and livelihoods of rainfed farmers. Hon'ble Minister assured the farmers of Government's help in addressing the problems faced by the dryland farmers. On this occasion a Pamphlet on " soil testing " in local language was released by dignitaries. Later scientists interacted with farmers and clarified their doubts regarding technologies implementation at field level.



Farmers day events

14.8 Brain Storming Workshop on Vision for Research and Development in Agro Meteorology

A two-day brain Storming Workshop on Vision for Research and Development in Agro Meteorology Sponsored by DST was held on October 23 & 24, 2007. The workshop was attended by 40 participants including retired eminent scientists. Recent trends in the field of Agricultural Meteorology were discussed in four Technical Sessions, viz., Resource Characterization of Various Production Systems, Database Management, Uniformity & Standardization Procedures, Crop-Weather Relationships & Weather Modification, and Operational Aspects of Meteorology for Sustainable Agriculture. A document with main focus on Vision for Research in Development of Agrometeorology was prepared by Prof. PSN Sastry, Retired Agrometeorologist, IARI.

Experts discussing various issues of Vision for Research and Development in Agro Meteorology

Shri N. Raghuveera Reddy, Minister for Agriculture, Govt. of A.P. addressing the gathering of farmers, researchers and other dignitaries

14.9 Vigilance Week:

Vigilance week was observed at CRIDA from November 12-16, 2007. CRIDA staff attended a meeting on 12th November, 2007 to take the oath of vigilance and maintaining transparency in the organization.

14.10 KISAN 2007 Exhibition

CRIDA participated in KISAN 2007 Exhibition held at Moshi, Pune during December 12-16, 2007 for creating awareness and popularizing dryland technologies particularly the farm implements and machinery developed by the Institute

14.11 Seminar-cum-Brainstorming session on 'Strategies for enhancing Agriculture Production, Profitability and Livelihood opportunities of dryland farming communities.

A one day Seminar-cum-Brainstorming session on 'Strategies for enhancing Agriculture Production, Profitability and Livelihood opportunities of dryland farming communities – A.P. was held on 27-12-2007.Farmers and officials from various departments viz., Dept. of Agri., BASIX, AWARE, REEDS, M.V.Foundation, Crop Insurance, WASSAN, SERP / APRLP, ZC Unit, CSA, ITC, NABARD, ANGRAU, Forestry, Animal Husbandry, ICICI, ICRISAT, KVIC, NCDEX, IKISAN, NCMSL etc., participated in the seminar. The discussion was chaired by Dr M.V.Rao the eminent Agricultural Scientist and Ex. Vice Chancellor, ANGRAU. At the out set Dr. Y.S. Ramakrishna, Director, CRIDA extended a warm welcome to all the participants and emphasized the need for enhancing productivity in rainfed areas.

Dr. M.V. Rao, stressed the need to produce extra food grains to feed the growing population and discussed the issues concerned like problems faced by the small and marginal land holders, degradation of natural resources, timely availability of credit, support prices and farm mechanization. Representatives of Rytu Samakhya viz., Shri. M.Balaram Reddy, Shri. V.Nagireddy and Shri. Nagaratnam Naidu shared their views. Later two concurrent sessions were held to discuss the issues viz; productivity & profitability and market issues including credit and infrastructure. In the afternoon, Shri N. Raghuveera Reddy, Minister for Agriculture, Govt. of A.P. attended the concluding session of the seminar as chief guest. Hon'ble Minister congratulated CRIDA for choosing an important topic for the seminar and emphasized the need to increase the food production. Later, Dr.Y.S. Ramakrishna, Director, CRIDA, presented the recommendations emerged out of the seminar deliberations.

15 Distinguished visitors

Dr. Chinna reddy, hon'ble minister for Rural Development(NREGP), Govt. of Andhra Pradesh and Self Help Groups(SHGs) visited CRIDA on June 16, 2007. He visited CRIDA research farm at Hayatnagar, and other scientific laboratories on rainfed technologies to improve the productivity in drylands. He was impressed with the work carried out at CRIDA and congratulated the staff and scientists for carrying out research and extension work which is very practical and field oriented.

Dr. D.P. Garrity, Director General, ICRAF visited CRIDA on 22.11.2007 to discuss possible collaboration.

Drs. Henning Baur and Ramni Jamnadass from ICRAF visited CRIDA on 26.11.2007

Three Ethiopian Bench Marking Mission delegates visited CRIDA on 22.12.2007 for understanding about the research issues on rainfed agriculture in India.

Eight Afghanistan Nationals from Indian Agricultural Statistics Research Institutes, New Delhi visited CRIDA on 25-27 December 2007.

Dr. Channa Reddy, Minister of Agricultural, Govt. of AP vistis Crida

16 Personnel

(As on March 31, 2008)

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)
Dr. C.R.Thyagaraj	Principal Scientist (FM&P)
Dr. K.L.Sharma	Principal Scientist (Soil Science) & ICAR National Fellow
Dr. M. Osman	Principal Scientist (Agronomy)
Dr. G. Rajeshwara Rao	Principal Scientist (Forestry)
Dr. Ch. Srinivasa Rao*	Principal 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)
Dr. K. Srinivas Reddy	Senior Scientist (S&WCE)
Dr. B.Sanjeeva Reddy	Senior Scientist (FM&P)
Dr. U.K.Mandal	Senior Scientist (Soil Physics)
Er. I.Srinivas	Scientist (Selection Grade) (FM&P)
Er. Ravikanth V. Adake	Scientist (Senior Scale)(FM&P)
Sri I. Ramamohan	Technical Officer (T-7/8)
Sri V. Sree Ramulu	Technical Officer (T-7/8)
Sri B. Narsimlu	Technical Officer (T-7/8)
Sri J. B. Ramappa	Technical Officer (T-6)
Sri Ram Kumar	Technical Officer (T-6)
Smt. K. Usha Rani	Technical Officer (T-6)
Sri K Venkanna	Technical Officer (T-6)
Sri S.S. Sishodia	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 (retired on 29.02.2008)
Dr. V.S.Rao	Principal Scientist (Horticulture)
Dr. P.Raghuram Reddy	Principal Scientist (Plant Breeding)
Dr. M. Maheshwari	Principal Scientist (Plant Physiology)
Dr. S. Desai	Principal Scientist (Plant Pathology)
Dr. N.N.Reddy	Principal Scientist (Horticulture)
Dr. Y.G.Prasad	Principal Scientist (Entomology)
Dr. S.K.Yadav	Principal Scientist (Biochemistry)
Dr. S.Venkateswarlu	Senior Scientist (Agronomy)
Dr. M.Vanaja	Senior Scientist (Plant Physiology)
Dr. B.M.K.Reddy	Senior Scientist (Agronomy)
Dr. M.Srinivasa Rao	Senior Scientist (Entomology)
Dr. V.Maruthi	Senior Scientist (Agronomy)

Dr. Arun Kumar Shankar	Senior Scientist (Plant Physiology)
Dr. M.Prabhakar	Senior Scientist (Entomology)
Dr. G.Jayaram Reddy	Scientist (Senior Scale) (Agronomy)
Dr. N.Jyothi Lakshmi	Scientist (Senior Scale) (Plant Physiology)
Smt. P. Anantha Kumari	Technical Officer (T-7/8)
Sri T. Madhusudhan Swamy	Technical Officer (T-7/8)
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-6)
Sri P. Yadagiri	Technical Officer (T-5)

Section of Design and Analysis**

Dr. Y.V.R. Reddy	Principal Scientist & Head (retired on 31.05.2007)
Dr. Sreenath Dixit	Principal Scientist (Ag. Extension) & Head (since June 2007)
Dr. K. Kareemulla	Senior Scientist (Joined CRIDA on transfer from IGFRI, Jhansi on 02.07.2007)
Dr. C.A.Rama Rao	Senior Scientist (Agril. Economics)

Section of Transfer of Technology

Dr. M.V. Padmanabhan	Principal Scientist (S&WCE) & Head
Dr. A.K. Mishra	Senior Scientist (LP&M) (Left CRIDA on 25.05.07 to join NRC on Women in Agri., Bhubaneswar as Principal Scientist)
Dr. D.B.V.Ramana	Senior Scientist LP& M)
Sri K.Ravi Shankar	Scientist (Senior Scale) (Agril. Extn.)
Dr. K.Nagasree	Scientist (Senior Scale)(Agril. Extn.)
Sri K. Surender Rao	Technical Officer (T-6)
Sri K.V.G.K. Murthy	Technical Officer (T-6)
Sri B. Dhanunjaya	Technical Officer (T-5)
Sri S. Yadagiri	Technical Officer (T-5)
Sri V.L. Savithri	Technical Officer (T-5)

KVK

Dr. C.R.Thyagaraj	Principal Scientist (FM&P) & OIC (since June 2007)
Dr. M.S.Prasad	Principal Scientist (Agril. Extension)
Dr. G.Nirmala	Senior Scientist (Agril. 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-9)
Sri Pukh Raj Singh	Technical Officer (T-9)
Sri R. Dasaratha Rami Reddy	Technical Officer (T-7/8)
Sri S.M. Vidyasekhar	Technical Officer (T-7/8)
Smt. A. Vidyadhari	Technical Officer (T-6)

All India Coordinated Research Project for Dryland Agriculture

Dr. G.Subba Reddy	Project Coordinator
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
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. V.U.M. Rao	Principal Scientist (Ag. Meteorology)
Dr. Kausalya Ramachandran	Principal 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	Principal Scientist (Agronomy) & Head
Dr. S.S.Balloli	Senior Scientist (Soil Science)
Dr. Shaik Haffis	Technical Officer (T-7/8)

AIRS CELL

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

Library

M. Maheswari	Senior Scientist (Plant Physiology) & OIC
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) & OIC
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 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)
Sri B. Balakrishna	Technical Officer (T-5)
Sri S. Narsimha	Technical Officer (T-5)
Sri M. Srinivasulu	Technical Officer (T-5)

Gunegal Research Farm

Dr. K. Srinivas Reddy	Senior Scientist (S&WCE) & OIC

Administration

Sri Charles Ekka	Senior Administrative Officer (Joined CRIDA on transfer from SBI, Coimbatore on 01.09.2007)
Sri P.Balabrahmaiah	Finance & Accounts Officer (transferred to CPCRI, Kasargod, on 7.3.2008)
Shri B.D. Sati	Finance & Accounts Officer (joined CRIDA on transfer from IVRI, Bangalore on 07.03.2008)
Sri R.K.Shukla	Asst. Administrative Officer (Retired on 30.11.2007)
Sri V.Govardhan	Asst. Administrative Officer
Sri G. Lakshminarayana	Asst. Administrative Officer
Shri P. Pushpakar	Asst. Administrative Officer
Sri K. Ramakrishnaiah	Technical Officer T-5
Sri Ch. Srinivas	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)
Sri Syed Sarwar Ali	Technical Officer (T-5) (Driver)

Hindi Cell

Dr. G.G.S.N. Rao	Project coordinator (Ag. Met.) & OIC (Official Language)
Sri S.R.Yadav	Asst. Director (OL) and Public Relations Officer
Sri G. Prabhakar	Technical Officer (T-5)

Works

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

* on deputation to ICRISAT for 3 years from 1 January 2006
@ on deputation to NIH, Roorkee
** Renamed as Socioeconomic and Policy Research Cell in June 2007

17 Infrastructure Development

17.1 At CRIDA Campus

1 Renovation of auditorium

2 Renovation of auditorium verandah, staircase and main building entrance steps

3 Roof water drainage system at CRIDA complex - under progress

4 Renovation of Hydrology lab - under progress

5 Renovation and up gradation of auditorium comprising of boral plaster- false ceiling, echo proof wall paneling, improved audio system and providing LCD projector with motorized screen for projection and PAR stage lights.

6 Re-wiring of TTC hostel

7 Construction of Community hall in Residential Complex area

17.2 HRF

1. Installation of 30 KVA transformer for Phase-III at HRF – under progress

2 Establishment of Integrated Bio-Resource Centre at HRF for production of biofertilizers, biopesticides, biofungicides and planning material.

3. Rain water drainage provision for IBRC at HRF - under progress

4 Establishment of field and farmer' lab

5 Installation and commissioning of 100 KVA transformer

6 100 KV H.T. line from main gate to farm office

7 Installation of 63 KVA transformer and providing street lights in Phase-II and Phase –III

8 Construction of permanent bullock shed.

9 Construction of HDPE-lined farm pond, percolation pond and land development work in KVK watershed

17.3 GRF

1 Renovation of store room

2 Bore well and pumpset

Establishment of Micro Irrigation & Rainwater Harvesting Structures at KVK Farm :

The micro irrigation system sanctioned by Zonal Coordinator, Zone-V was established in KVK farm, Hayatnagar to serve the irrigation requirements of perennial horticulture crops like Mango, Guava, amla Annona sps, Fig etc in Agrihorticulture system of KVK

Inauguration of Field and Farmers Service Laboratory at HRF

Shri S. Sudhakar Reddy, Hon'ble Member of Parliament inaugurated the Field and Farmers Services Laboratory at HRF on 27th August 2007. This lab will cater to the soil test and analysis of samples from farming community.

Shri S. Sudhakar Reddy, Hon'ble Member of Parliament inaugurating the Field and Farmers Services Laboratory

Integrated Bio Resource Center Inaugurated at HRF,CRIDA

CRIDA has set up an Integrated Bio Resource Center (IBRC) with financial grant from Andhra Pradesh Netherland Biotechnology Programme. The main objectives of the center are production of quality planting material of agro-forestry species and bio inputs like bio-fertilizers and bio-pesticides for supply to rainfed farmers. The other activities of this center include providing training to farmers, rural youth and small entrepreneurs on production and field use of quality bio inputs in order to

reduce the overall cost of production of rainfed crops. The center was inaugurated by Padmasri Dr.M.V.Rao, Former Additional Director General of ICAR and Hon'ble Member of the A.P.Legislative Council on 16 October, 2007. The center has facilities to produce biofertilizers like *Bradyrhizobium*, PSB, *mycorrhiza* and bio pesticides like Bt, *Beavueria* and *Metarhizium* and bio fungicides like *Trichoderma* and *Pseudomonas*. This center will work in close collaboration with KVK, CRIDA. Progressive farmers, entrepreneurs and staff of the KVKs all over India may avail the hands on training opportunities at the center. For further information on products and training modules offered by the center, please contact Director, CRIDA at ramakrishna.ys@crida.ernet.in.

Inauguration of the IBRC by Padmasri Dr.M.V.Rao (inset: view of the IBRC building)

Subscription to Science Direct by CRIDA Library

CRIDA library has subscribed for 'Science Direct (On line only)' published by Elsevier for the year 2007 which is one of the most reputed full text database in the field of sciences. Many of the important peer reviewed professional journals in the field of agriculture and biological sciences are covered in the Science Direct. 'Science Direct' on Internet can be accessed till December 31, 2007.

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

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