CRIDA

वार्षिक प्रतिवेदन

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2004-2005

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Director
Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad 500 059
Phone : 040-24530177 (O) 24532262 (R)
Fax : 24531802, 24535336
Web : www.crida.ernet.in
E-mail : ramakrishna.ys@crida.ernet.in

Cover page

A two-year-old plantation of Pongamia, a biodiesel yielding tree, established in a watershed mode at institute farm.

Back cover

CRIDA in press and crop weather outlook homepage

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ANNUAL REPORT

2004-2005

केंद्रीय बारानी कृषि अनुसंधान संस्थान

संतोषनगर, हैदराबाद 500 059

Central Research Institute for Dryland Agriculture

Santoshnagar, Hyderabad 500 059

Preface

Kharif 2004 witnessed erratic rainfall distribution across the country. The initial perception of a favourable monsoon were scuttled with rains failing in the month of July. Drought was declared in states like U.P., Tamil Nadu, Jharkhand, Andhra Pradesh, Madhya Pradesh and parts of Bihar. The performance of monsoon during *kharif*-2004 has been unsatisfactory in terms of quantum and distribution of rainfall across the country. Rainfed crops were the most adversely affected. The area under coarse cereals during 2004-05 declined to 27.77 million ha as compared to 30.76 during 2003-04 year. The production estimate for 2004-05 was 31.88 million tonnes as compared to 37.77 during the previous year. Against a national target pegged at 225 m tonnes of food grains, the revised estimate was 206 million tonnes compared to the production of 212 million tonnes during 2003-04. Recurrent phenomenon of droughts thus poses the biggest challenge in dryland agriculture. CRIDA in close collaboration with the All India Coordinated Research Projects on Dryland Agriculture and Agrometeorology (AICRPDA & AICRPAM) continued to engage in basic, strategic and applied research for augmenting production and productivity from rainfed regions in the country.

Apart from such variability in rainfall on an year to year basis, the long-term impacts of climate change on agriculture could result in problems with food security and may threaten livelihood activities upon which much of the population depends. Further, changes in production of certain crops can affect imports and exports. To prepare for such long-term eventualities, a new multi-institutional and multi-disciplinary network initiative to study the vulnerability of Indian agriculture to climate change was launched at CRIDA during this year. Besides this, work on resource characterization led to the development of spatial maps for aridity, humidity and soil moisture indices for the southwest monsoon period for 300 stations spread across the country.

Soils in rainfed regions are not only thirsty but also hungry. Long-term studies on nutrient management indicated that integrated nutrient management practices could lead to overall improvement in soil quality in addition to sustaining productivity. Key indicators of soil quality in dryland Alfisols were identified and their relative contribution was estimated. A mid-term benchmarking of available nutrient status at all the experimental farms of AICRPDA centres was undertaken.

Watershed based natural resource management strategies hold the key for augmenting production from the dryland regions. This was demonstrated on field scale and sustainable region specific land use models were identified for several representative locations in the country. Regional scale watershed plans were developed with the aid of GIS and remote sensing tools.

As integrated farming systems play a vital role in dryland agriculture for meeting the food, fodder and livelihood requirements, a model farming system experiment was initiated during the year at the Hayatnagar Research Farm to study the multiple interactions among the various components and analyze outputs with relevance to diverse farming situations.

Pest management research at CRIDA is focused on developing and large scale on-farm testing of bio-intensive and ecological-based IPM modules. CRIDA is soon to embark on setting

up a bio-resource center at its research farm to promote wider use of bio-fertilizers and bio-pesticides. In addition, the best and cost effective practices for pest management in castor and pigeonpea-based cropping systems were identified and popularized. Forewarning models for major pests and diseases in castor, sorghum and groundnut are being developed. Abiotic stress tolerant putative transgenics in sorghum were confirmed and integration of desired heterologous mtlD gene into the sorghum genome was taken up successfully. Robust protocols for regeneration and rooting of transformants have been developed.

Work on alternate land use systems during the year provided a significant lead on the capacity of silvipasture systems to support small ruminants without external supplementation. Agro-forestry models for rainfed regions based on jatropha, pongamia, leucaena, *amla* and tamarind are yielding significant results.

New farm implements were added to the CRIDA portfolio. Notable are sunflower seed thresher and herbal dryer. A new mini oil extraction unit was designed and is being tested and improved upon to enhance oil recovery from Pongamia seed. Packages for mechanization in field crops were developed and demonstrated in large scale across several districts. As part of the on-going process of improving CRIDA-Industry linkages, tie-ups with four new industries were made for commercializing and popularizing CRIDA designed agricultural implements and machinery taking the total to seventeen.

Several technological and livelihood based interventions were tested and identified for enhancing the livelihood options for the rural poor. Socio-economic studies in the scarce rainfall regions led to the identification of suitable remunerative crops and cropping systems.

Technology transfer and capacity building of all stakeholders received due attention, with several training courses, on-farm skill transfer training programmes and front line demonstrations being undertaken. CRIDA also catered to the education needs of several students and researchers and ably supported the degree programme in Dryland Agriculture in collaboration with Osmania University. Infrastructure facilities such as open top chambers for studying effect of elevated CO_2 on identified crops, and a glass house for studying putative transgenics under containment have been established.

It is a matter of great pride that several colleagues received professional recognition and awards during the year under report. It is my fond hope that CRIDA with its national and international partners in research will continue to deliver its mandate and live up to the expectations of the rainfed farmers of the country.

Y.S. Ramakrishna
Director

20 September, 2005

Contents

Preface

Executive Summary

Hindi ---- i

English ---- vi

1. Introduction ---- 1

2. Research Achievements ---- 4

2.1 Resource Characterization ---- 4

2.2 Integrated Nutrient Management ---- 19

2.3 Rainwater Management ---- 27

2.4 Crops and Cropping Systems ---- 34

2.5 Alternate Land Use Systems ---- 45

2.6 Farm Machinery ---- 51

2.7 Socio-economic Studies ---- 58

2.8 Transfer of Technology ---- 63

3. Technologies Assessed and Transferred ---- 65

4. Education and Training ---- 68

5. Women in Agriculture ---- 71

6. Awards and Recognitions ---- 76

7. Linkages and Collaborations ---- 77

8. AICRP/Coordination Units/NATP ---- 78

9. Publications ---- 96

10. Ongoing Projects ---- 102

11. Consultancy, Patents and Commercialization ---- 109

12. QRT, RAC, Management Committee, SRC ---- 110

13. Participation of Scientists in Conferences, Meetings, Workshops and Symposia in India and Abroad ---- 112

14. Workshops, Seminars, Summer Institutes, Farmers' Day etc., organized by the Institute ---- 118

15. Distinguished Visitors ---- 121

16. Personnel ---- 123

17. Infrastructure Development ---- 126

Acronyms ---- 127

सारांश

यद्यपि केंद्रीय बारानी कृषि अनुसंधान संस्थान की स्थापना को केवल दो दशक ही हुए हैं परन्तु इसकी मान्यता सम्पन्न इतिहास वाले विविध संगठनों में पहले से ही अंतःस्थापित हैं। संस्थान अपनी देख-रेख में अखिल भारतीय समन्वित बारानी कृषि अनुसंधान तथा अखिल भारतीय समन्वित कृषि मौसम विज्ञान अनुसंधान परियोजनाओं से निकट संबंध बनाकर वर्षा आधारित कृषि में मूल एवं व्यूहात्मक अनुसंधान जारी रखकर स्थान विशेष की समस्याओं के समाधान में निरंतर प्रयासरत है।

यह संस्थान वर्षा आधारित क्षेत्रों की उत्पादकता में टिकाऊपन लाने हेतु समान अधिदेशों वाले राष्ट्रीय, अंतर्राष्ट्रीय एवं स्वैच्छिक/जन संगठनों से निकट संबंध स्थापित किए हुए है। संस्थान ने जैव-भौतिकीय अनुसंधान क्षेत्र में समेकित जलग्रहण प्रबंधन पद्धति तथा प्रभावी एवं कम लागत के कृषि उपकरणों के विकास द्वारा महत्वपूर्ण योगदान दिया है।

वर्ष के दौरान, संस्थान में संसाधन लक्षण, समेकित पोषक प्रबंधन, समेकित नाशीजीव प्रबंधन, वर्षाजल प्रबंधन, फसल एवं फसल प्रणालियाँ, वैकल्पिक भूमि उपयोग प्रणाली, कृषि उपकरणों का विकास, सामाजिक-आर्थिक मुद्दे एवं प्रौद्योगिकी हस्तांतरण पर अनुसंधान गतिविधियों को आगे बढ़ाने का प्रयास निरंतर जारी है। इस वर्ष कई संस्थानों और विश्वविद्यालयों के सहयोग से कृषि पर जलवायु परिवर्तनों के प्रभावों पर अनुसंधान की नई शुरूआत की गई।

संसाधन लक्षण

- जलवायु परिवर्तन से भारतीय कृषि की संवेदनशीलता पर अध्ययन के लिए एक बहु-संस्थानीय एवं बहु-विषयक परियोजना आरंभ हुई। जलवायु प्रभाव के अध्ययन के लिए देश में फैले वर्षा आधारित क्षेत्रों के 1504 केंद्र पहचानकर इनके जलवायु प्रचालों का डेटाबेस तैयार किया गया।
- कार्बन डाइ-आक्साइड की सांद्रता (600 पी.पी.एम.) के बढ़ाने से ज्वार, उड़द, सूरजमुखी एवं मूँगफली की जड़ एवं प्ररोह लंबाई, पर्ण क्षेत्र, जड़ एवं प्ररोह का शुष्क भार, कुल एवं पर्ण का शुष्क भार, जड़-प्ररोह अनुपात एवं विशिष्ट पर्ण भार पर महत्वपूर्ण रूप से सकारात्मक प्रभाव देखा गया। अन्य फसलों की तुलना में उड़द की फसल में बढ़ी हुई कार्बन डाइ-आक्साइड के प्रति बेहतर अनुक्रिया देखी गई।
- संस्थान में स्थित कृषि मौसम विज्ञान डेटा बैंक के पास अब देश में फैले 130 कृषि जलवायु क्षेत्रों के आँकड़े उपलब्ध हैं। इन आँकड़ों को कृषि सलाह सेवाओं एवं आकस्मिक योजना बनाने हेतु देश के विभिन्न अनुसंधानकर्ताओं को उपलब्ध कराया जा रहा है।
- दक्षिण-पश्चिम मानसून के दौरान (जून-सितंबर), देश में फैले 300 वर्षा मापक केंद्रों के मासिक आँकड़ों के आधार पर शुष्कता, आर्दता एवं मृदा-नमी सूचक संबंधी भूगौलिक मानचित्र तैयार किया गया। यह मानचित्र मानसून के दौरान जलवायु संसाधनों की क्षेत्रवार विविधता के बारे में महत्वपूर्ण सूचना प्रदान करता है।
- अकोला, अनंतपुर, अरजिया, बैंगलोर, बेल्लारी, बीजापुर, इंदौर, कोवलपट्टी, राजकोट, रीवा, सरदार कृषिनगर, सोलापुर एवं वाराणसी के लिए मृदाओं, जलवायु, भू-जल एवं सामाजिक-आर्थिक परिस्थितियों पर आधारित पर्यावरण हितैषी एवं टिकाऊ क्षेत्र विशेष भूमि उपयोग मॉडलों की पहचान की गई।

समेकित पोषक प्रबंधन

- समेकित पोषक प्रबंधन पर दीर्घावधि अध्ययनों से पता चला कि ज्वार में 4 टन कंपोस्ट + 20 कि.ग्रा. नाइट्रोजन या 2 टन ग्लैरीसीड़िया + 20 कि.ग्रा. नाइट्रोजन प्रति हेक्टेयर एवं मूंग की फसल में 2 टन कंपोस्ट + 10 कि.ग्रा. नाइट्रोजन या 1 टन ग्लैरीसीड़िया + 10 कि.ग्रा. नाइट्रोजन प्रति हेक्टेयर डालने से उर्वरकीय नाइट्रोजन की निर्भरता में 50 प्रतिशत तक की कमी की जा सकती है। इन उपचारों के फलस्वरूप जैविक कार्बन एवं उपलब्ध नाइट्रोजन जैसे मृदा गुणधर्मों में बेहतर सुधार हुआ।
- बारानी एल्फीसॉल मृदा में किए गए दस वर्ष के अध्ययनों से यह निष्कर्ष निकला कि खरीफ मौसम के बाद संचित मृदा नमी का उपयोग कर कुलथी की फसल को बॉयोमास के लिए सफलतापूर्वक उगाया जा सकता है। यह पद्धति हर वर्ष 3-4 टन प्रति हेक्टेयर बॉयोमास प्रदान कर सकती है जो 20 कि.ग्रा. नाइट्रोजन, 6 कि.ग्रा. फासफोरस, 17

कि.ग्रा. पोटाशियम एवं 17 कि.ग्रा. सल्फर प्रति हेक्टेयर की आपूर्ति कर सकती है। जिसके परिणामस्वरूप अगली खरीफ की ज्वार एवं सूरजमुखी फसलों की उत्पादकता में क्रमशः 28 और 18 प्रतिशत की वृद्धि होती है।

- पारंपरिक एवं न्यूनतम जुताई पद्धति में दीर्घावधि प्रयोगों के आधार पर फसलावशेष एवं अरंडी-ज्वार फसल चक्र में नाइट्रोजन का स्तर, सूक्ष्मजीव बॉयोमास नाइट्रोजन, उपलब्ध नाइट्रोजन, उपलब्ध पोटाशियम, जलीय चालकता एवं उपलब्ध सल्फर की पहचान बारानी अल्फीसोल मृदाओं के गुणवत्ता सूचको के रूप में की गई। इन सूचकों का मृदा गुणवत्ता में सापेक्ष योगदान औसतन इस प्रकार रहा हैः उपलब्ध नाइट्रोजन (32%) > सूक्ष्मजैविय बॉयोमास कार्बन (31%) > उपलब्ध पोटाशियम (17%) > जलीय चालकता (16%) > उपलब्ध सल्फर (4%)।
- वारंगल जिले के दामेरा एवं रेड्डी पालेम गांवों के खेतों में कपास की फसल में 25 बैलगाड़ी गोबर की खाद के साथ 150 कि.ग्रा. नाइट्रोजन, 100 कि.ग्रा. फासफोरस एवं 75 कि.ग्रा. पोटाशियम प्रति हेक्टेयर डालने की तुलना में 90 कि.ग्रा. नाइट्रोजन, 45 कि.ग्रा. फासफोरस, 45 कि.ग्रा. पोटाशियम, 2 टन गोबर की खाद, 30 कि.ग्रा. जिंक के साथ हरी खाद (अंतरा फसल मल्च) के प्रयोग के परिणामस्वरूप शुष्क पदार्थ उत्पादन में 15 से 17 प्रतिशत, कलियों की संख्या में 13 से 48 प्रतिशत एवं प्रति पौधा डोडे की संख्या में 14 से 31 प्रतिशत वृद्धि हुई।
- अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना के 19 केंद्रों, फूलबनी, राजकोट, बेल्लारी, बीजापुर, सोलापुर, आगरा, हिसार, एस.के.नगर, बैंगलोर, इंदौर, रीवा, अकोला, कोवलपट्टी, होशियारपुर एवं रख ध्यानसर आदि पर उपलब्ध पोषकों के वितरण पर किए गए अनुसंधान से स्पष्ट हुआ कि यहाँ कि मृदाओं में जैविक कार्बन, नाइट्रोजन, फासफोरस, कैलशियम, मैग्नीशियम एवं जिंक की कमी है, जबकि अन्य तत्व जैसे कि पोटाशियम, सल्फर, फेरस, कॉपर, एवं मैंग्नीज़ पर्याप्त मात्रा में उपलब्ध हैं।

वर्षाजल प्रबंधन

- आंध्र प्रदेश के प्रकाशम जिले में तंबाकू की खेली में फसल विविधता हेतु जलग्रहण आधारित प्राकृतिक संसाधन प्रबंधन पद्धतियों जैसे - लाइव बेड, भूमि संरक्षी सस्यन, कृषि-वन प्रणाली एवं जल संग्रहण एवं इसका पुनः उपयोग इत्यादि का सफलतापूर्वक प्रदर्शन किया गया। 40 हेक्टेयर सूक्ष्म जलग्रहण से 8340 घन मीटर वर्षाजल को एकत्र किया जोकि कृषि-वानिकी प्रणाली बनाए रखने के अलावा 16 हेक्टेयर तंबाकू की सिंचाई के लिए पर्याप्त पाया गया। इससे प्रति हेक्टेयर 7890 रुपये की अतिरिक्त आमदनी प्राप्त हुई।
- संस्थान में किए गए स्थानीय तकनीक पर आधारित एक अध्ययन में आम एवं टीक पेड़ की द्रोणी के चारों ओर 15-20 सें.मी. गहरे गड्ढों के निर्माण के साथ 5 सें.मी. मोटे घास की पलवार (मल्च) के द्वारा मृदा में नमी संरक्षण में 2 प्रतिशत की वृद्धि पाई गई। इसके परिणामस्वरूप, पौधों की ऊंचाई, चौड़ाई एवं वितान फैलाव में महत्वपूर्ण वृद्धि हुई।
- आंध्र प्रदेश के नलगोंड़ा जिले के एस.एस.पल्ली जलग्रहण में क्षेत्र स्तरीय जलग्रहण योजनाओं एवं प्रणाली के विकास के लिए भौगोलिक सूचना प्रणाली एवं सुदूर संवेदी की सहायता से प्राथमिकता आधारित भूमि उपचार के लिए संबंधित क्षेत्रों की पहचान की गई। मृदा एवं जल संरक्षण हेतु (ढलान के चारों ओर मेढ़ों का निर्माण, विचलन जलमार्गों, गेबियन संरचना, गली मुंहबंदी), वैकल्पिक भूमि उपयोग प्रणाली (मेढ़ों पर हरा आच्छादन, फल एवं अन्य पेड़ों का रोपण, वृक्षवीथी रोपण) एवं फसल प्रणालियों (अरंड, ज्वार) जैसे विभिन्न तकनीकी हस्तक्षेपों की शुरूआत की गई।
- तीन वर्षों तक फार्म पर किए गए अध्ययनों से पता चला कि अरंड एवं अरहर अंतरा सस्यन प्रणाली में 3 मीटर के अंतराल से संरक्षी गड्ढ़े बनाने से 11 से 14 प्रतिशत अधिक नमी संरक्षित की गई जिसके परिणामस्वरूप अरंड और अरहर के उत्पादन में क्रमशः 14 से 15 प्रतिशत की वृद्धि पाई गई।

फसल एवं फसल प्रणालियाँ

- सूरजमुखी की फसल में किए गए अनुसंधान ने दर्शाया कि सिफारिश की गई मृदा नमी संरक्षण पद्धतियों (गहरी जुताई एवं संरक्षण गड्ढों), उर्वरक प्रयोग (60 कि.ग्रा. नाइट्रोजन, 30 कि.ग्रा. फासफोरस पेंटाआक्साइड, 30 कि.ग्रा. पोटाशियम आक्साइड) को अपनाने से सूरजमुखी के.बी.एस.एच.-1 किस्म की उपज मार्डेन की तुलना में बेहतर थी। इससे प्रभावित होकर आंध्र प्रदेश के महबूबनगर

जिले के वनपर्ती मंडल के किसान पारंपरिक ज्वार एवं अरंड के बदले इस वाणिज्य एवं लाभकारी फसल को अपना रहे हैं।

- संस्थान के अनुसंधान फार्म में 0.53 हेक्टेयर भूमि में कृषि प्रणाली के एक माड्यूल को प्रदर्शन हेतु स्थापित किया गया। यह प्रणाली खाद्यान्न (ज्वार, बाजरा, अरहर, सूरजमुखी, कुलथी), बागवानी (ग्वार, टमाटर, भिंड़ी, बैंगन) एवं उपयोगी पौधों के बहुवर्षीय अवयवों (हीना, सहिजन, टीक) को समेकित करती है। यहाँ वार्षिक एवं बहुवर्षीय घासों एवं दलहनों को भी सुस्थापित किया गया और अब इस प्रणाली में पशु अवयवों को समाहित करने के लिए प्रयास किए जा रहे हैं।
- वर्षा, प्रकाश समय एवं न्यूनतम तथा अधिकतम तापमान के आधार पर अरंड अर्धकुंडलक (सेमीलूपर) अंड-निक्षेण (ऑविपॉजिशन) के अनुमान के लिए प्रतिक्रमण समीकरण (रीग्रेशन इक्वेशन) सहित दृष्टिगोचर सारणिक गुणांक (R^2) प्राप्त किया गया।
- महबूबनगर जिले में आयोजित फार्म परीक्षणों में अरंड अर्धकुंडलक के प्रबंधन में जैव-गहन समेकित नाशीजीव प्रबंधन माड्युल-2 (ट्राइकोग्रम्मा, बी.टी., ग्रनुलोवाइरस) के बाद माड्युल-1 (नीम, कीटनाशी, ग्रनुलोवाइरस) अत्यधिक प्रभावी पाया गया। किसानों द्वारा अपनाई जाने वाली कीटनाशी पद्धति (1.63) की तुलना में इस माड्युल ने बेहतर लाभ लागत अनुपात (1.77) दिया।
- फसल प्रणालियों पर आधारित अरंड एवं अरहर में समेकित नाशीजीव प्रबंधन के मुख्य अवयव के रूप में फसल विविधता का अध्ययन किया गया। इस अध्ययन से यह पता चला कि कीटों का आक्रमण फसल अवयवों से काफी प्रभावित होता है। अरंड+ग्वार, अरंड+लोबिया, अरंड+ज्वार एवं अरहर+ज्वार फसल अवयवों में नाशीजीव संख्या काफी कम पाई गई।
- बेसिलस थोरिनजेनसीस को पहचानकर अलग करने के लिए भारत के विभिन्न वर्षा आधारित भू-भागों की मृदा के नमूनों को जाँचा गया। पहचानकर अलग किए गए पाँच आशाजनक बी.टी. विलग अरंड की फसल में अर्धकुंडलक के प्रबंधन में दक्ष पाए गए।
- ज्वार की किस्म एस.पी.वी. 462 के प्ररोह शीर्षों से व्युत्पन्न कण कमुदाय का 'एम.टी.एल.डी. जीन' का प्रयोग कर 'जीनगन' द्वारा रूपांतरण किया गया। चयनित रूपांतरित कण समुदायों से पौध पुनर्जनन एवं जड़ विकसित करने की सफल विधि तैयार की गई। इन पौधों में रूपांतरण निर्धारित करने के लिए एच.पी.टी. प्राइमर्स का प्रयोग कर पी.सी.आर. विधि द्वारा मूल्यांकन किया गया। तत्पश्चात 'सदरन हाइब्रडाइजेशन' तकनीक द्वारा रूपांतरित पौधों में जीन की उपस्थिति की पुष्टि की गई।

वैकल्पिक भूमि उपयोग प्रणाली

- बिना किसी बाहरी आपूर्ति के, 0.80 हेक्टेयर में 9 भेड़ो की कुल पोषणिक आवश्यकता को ल्यूकैना + स्टाइलों / सेरचोरस वनचारा प्रणाली द्वारा पूरा किया जा सकता है।
- कृषि-वानिकी मापांक विशेषकर ल्यूकैना एवं इमली के वृक्षों से मृदा में जैव कार्बन में 0.2 से 0.45 प्रतिशत वृद्धि हुई तथा नाइट्रोजन की मात्रा 122 से 182 कि.ग्रा. प्रति हेक्टेयर तक बढ़ी। यह लाभ पेड़ों से गिरने वाले पत्तों के गल-सड़ जाने से उत्पन्न खाद के कारण मिला।
- आम के पेड़ों के लिए सिफारिश की गई नाइट्रोजन, फासफोरस, पोटाशियम के साथ 75 कि.ग्रा. गोबर की खाद के संयुक्त उपयोग से अधिकतम उत्पदान 37.1 कि.ग्रा. प्रति पेड़ दर्ज किया गया। बिना सिंचाई (17 कि.ग्रा. प्रति पेड़) की तुलना में 0.75 ईपी. की ड्रिप सिंचाई से फल उत्पादन (27.8 कि.ग्रा. प्रति पेड़) में महत्वपूर्ण वृद्धि हुई।
- आंध्र प्रदेश के अदिलाबाद, अनंतपुर, चित्तूर, पूर्वी गोदावारी, कडपा, कर्नूल, श्रीकाकुलम, विशाखापट्टनम एवं विजयनगरम जिलों से जटरोफा के 60 एवं पोंगामिया के 66 जननद्रव्य एकत्रित किए गए। इनका संस्थान के अनुसंधान फार्म में मूल्यांकन किया जा रहा है।

कृषि यंत्र

- सूरजमुखी के बीज निकालने वाले एक सरल एवं सुविधाजनक यंत्र का निर्माण किया गया जो न केवल महिलाओं की कड़ी मजदूरी को कम करता है बल्कि 25 प्रतिशत समय की भी बचत करता है। दो महिलाओं द्वारा चलाये जाने पर इसकी क्षमता (आउटपुट) 12 से 15 कि.ग्रा. प्रति घंटा तक आंकी गई।
- द्रव्य पेट्रोलियम गैस द्वारा स्वनियंत्रित औषधीय बूटी सुखाने वाले यंत्र का विकास किया गया जिसे आमला, करी पत्ता, हीना, सहिजन के पत्तों एवं सनाय सुखाने के लिए उपयोग किया जा सकता है। इससे उत्पाद का अपना रंग एवं

गुणवत्ता बनी रहती है जिससे इन उत्पादों की स्वीकार्यता भी बढ़ी है।

- वर्तमान तेल निष्कासक (एक्सपैलर) पोंगामिया से केवल 24 प्रतिशत तेल निकाल पाते हैं जबकि 8 प्रतिशत तेल खली में ही छोड़ देते हैं। इसके समाधान हेतु एक नए तेल निकालने वाले छोटे यंत्र के डिज़ाइन की संकल्पना कर उसका निर्माण किया गया।
- मक्का, मूँगफली, सोयाबीन, ज्वार, अरंड, कपास, रागी, बाजरा एवं बारानी चावल की खेती में यांत्रिकीकरण के लिए पैकेजों को विकसित कर 9 जिलों के 27 गाँवों के 2416 हेक्टेयर क्षेत्र सम्मिलित करते हुए आन-फार्म परीक्षणों का प्रदर्शन आयोजित किया गया। बाजरा में 1222 रुपये प्रति हेक्टेयर से लेकर चावल में 7923 रुपये प्रति हेक्टेयर निवल लाभ दर्ज किया गया।
- संस्थान द्वारा डिज़ाइन किए गए कृषि उपकरणों एवं यंत्रों के निर्माण एवं विक्रय के लिए हैदराबाद, गुंटूर एवं बैंगलोर के चार नए औद्योगिक प्रतिष्ठानों के साथ सहमति-पत्र पर हस्ताक्षर किए गए।

सामाजिक-आर्थिक अध्ययन

- मृदा एवं जल संरक्षण विधियाँ अपनाने से, नई फसलों/किस्मों के समाविष्ट करने से, वैकल्पिक भूमि उपयोग प्रणालियों में पशु अवयव शामिल करने से, बेहतर फसल प्रबंधन पद्धतियों से, कृषि यंत्रों को किराए पर उपलब्ध कराने वाले केंद्र खोलने से, सलाह समितियाँ बनाने एवं उनकी क्षमता बढ़ाने इत्यादि तकनीकी हस्तक्षेपों द्वारा महबूबनगर, अनंतपुर एवं तुमकूर जिलों के ग्रामीण गरीबों की जीविका को बेहतर बनाया गया।
- आंध्र प्रदेश, कर्नाटक एवं तमिलनाडु के ग्रामीण क्षेत्रों में दुग्ध उत्पादन का अर्थव्यवस्था पर अध्ययन करने से पता चला कि यह व्यवसाय ग्रामीण गरीबों की मुख्य जीविका एवं उनके जीवनस्तर को उठाने का प्रभावी उपाय है। यह सुझाव दिया गया कि इस व्यवसाय को प्रोत्साहन प्रदान कर सुनिश्चित जीविका के रूप में प्रोत्साहित किया जा सकता है।
- आंध्र प्रदेश के दक्षिणी तेलंगाना एवं न्यूनतम वर्षा वाले क्षेत्रों में अध्ययन से पता चला कि पारंपरिक बारानी फसलों जैसे ज्वार, अरहर, अरंड, बाजरा एवं मूँगफली की खेती कम उत्पादकता एवं कम आमदनी के कारण अलाभकारी थी। सिंचाई उपलब्धता के अंतर्गत दक्षिणी तेलंगाना में चावल एवं आंध्र प्रदेश के दुर्लभ वर्षा वाले क्षेत्रों में टमाटर, खीरा एवं ज्वार की खेती अब किसानों का ध्यान आकर्षित कर रही है।

प्रौद्योगिकी हस्तांतरण/प्रशिक्षण

- प्रौद्रोगिकी हस्तांतरण इकाई में ''वर्षा आधारित कृषि में बेहतर तकनीकियां एवं बारानी कृषि के लिए नमी संरक्षण तकनीकियां'' विषय पर प्रायोजित प्रशिक्षण कार्यक्रमों का आयोजन किया गया। इन पाठ्यक्रमों से कृषि एवं बागवानी अधिकारियों, विषय विशेषज्ञों, विस्तार कर्मियों एवं तत्संबंधित अधिकारियों को लाभ हुआ।
- कृषि विज्ञान केंद्र ने 114 आवश्यकता आधारित कौशलोन्मुख प्रशिक्षण कार्यक्रमों का आयोजन किया। इनमें कुल मिलाकर 9887 किसानों, महिला किसानों, ग्रामीण युवा एवं क्षेत्रीय स्तर के विस्तार कर्मियों को लाभ हुआ। इन कार्यक्रमों में बारानी कृषि के सभी पहलुओं पर विस्तार से चर्चा हुई।
- कृषि विज्ञान केंद्र ने मुख्य बारानी फसलों जैसे- मक्का, अरंड, अरहर, बाजरा, ज्वार, चावल एवं सब्जियों पर 409 अग्रिम पंक्ति प्रदर्शनों का भी आयोजन किया। कृषि विज्ञान केंद्र द्वारा अपनाए गए गाँवों की लगभग 15 हेक्टेयर भूमि में अरंड की ज्योति किस्म को ग्राम-बीज उत्पादन कार्यक्रम में शामिल किया गया।

शिक्षा

- हैदराबाद, बैंगलोर, अनंतपुर, खड़गपुर एवं अकोला स्थित विश्वविद्यालयों से सोलह छात्र स्नातकोत्तर उपाधि के लिए अनुसंधान हेतु अध्ययनरत हैं जिनका मार्गदर्शन संस्थान के वैज्ञानिकों द्वारा किया जा रहा है। संस्थान के छः वैज्ञानिक आचार्य एन.जी.रंगा कृषि विश्वविद्यालय एवं जवाहरलाल नेहरू प्रौद्योगिकी विश्वविद्यालय, हैदराबाद में उच्च शिक्षा प्राप्त कर रहे हैं।
- संस्थान एवं पी.जी. कॉलेज ऑफ साइंस, उस्मानिया विश्वविद्यालय द्वारा संयुक्त रूप से चलाय जा रहे बारानी कृषि विषय पर तीन वर्षीय व्यावसायिक स्नातक कार्यक्रम ने सफलतापूर्वक चतुर्थ वर्ष पूरा किया। इस समय अंतिम बैच के रूप में तृतीय वर्ष के 18 विद्यार्थी अध्ययनरत हैं।

पुरस्कार एवं मान्यताएँ

- डॉ. वाई.एस. रामकृष्ण, निदेशक, कें.बा.कृ.अनु.सं. ने इक्रीसेट-भा.कृ.अनु.प. के सहयोगात्मक कार्यक्रम के अंतर्गत भागीदार के रूप में दोरिन मारगरेट माशलर पुरस्कार प्राप्त किया।
- डॉ. वी.एम. मायंदे को डॉ. पंजाबराव देशमुख कृषि विद्यापीठ, अकोला एवं मराठवाड़ा कृषि विश्वविद्यालय, परभणी की शैक्षिक परिषद का सदस्य चुना गया।
- डॉ. कौशल्या रामचंद्रन एवं डॉ. के.एल. शर्मा पाँच वर्ष की अवधि हेतु भारतीय कृषि अनुसंधान परिषद के राष्ट्रीय अध्येता के रूप में चुने गए।
- डॉ. एम. प्रभाकर को तीन वर्ष के लिए विज्ञान एवं प्रौद्योगिकी विभाग, भारत सरकार द्वारा युवा वैज्ञानिक अध्येता का पुरस्कार प्राप्त हुआ।
- डॉ. जे.वी.एन.एस. प्रसाद ने भारतीय सस्यविज्ञान सोसाइटी, नई दिल्ली द्वारा पी.एस. देशमुख युवा सस्यवैज्ञानिक पुरस्कार प्राप्त किया।

संपर्क

- संस्थान राष्ट्रीय एवं अंतर्राष्ट्रीय संगठनों जैसे ए.सी.आई.ए.आर., डी.एफ.आई.डी., इक्रीसेट, आई.पी.ई., विभिन्न राज्य कृषि विश्वविद्यालयों, भारतीय कृषि अनुसंधान परिषद के विभिन्न संस्थानों एवं गैर-सरकारी संगठनों से अपना निकट सहयोग जारी रखे हुए हैं।

Executive Summary

The Central Research Institute for Dryland Agriculture (CRIDA), though established only two decades back, has its roots embedded in diversified organizations having a rich history. The institute in close collaboration with All India Coordinated Research Project for Dryland Agriculture (AICRPDA) and All India Coordinated Research Project on Agrometeorology (AICRPAM) is engaged in basic and strategic research in rainfed agriculture and guiding work on location specific problems of the coordinating centers located across different rainfed agro-ecoregions.

CRIDA has developed close linkages with national, international and voluntary/public organizations sharing a similar mandate for augmenting the sustainable productivity of rainfed regions. The Institute has made valuable contributions in the field of biophysical research for integrated watershed management, and the development of efficient and low cost agricultural implements.

During the year, research activities were pursued on resource characterization, INM, IPM, rainwater management, crops and cropping systems, farm machinery and power, alternate land use systems, socio-economic issues and transfer of technology. A new initiative on the effect of climate change on agriculture has been initiated this year in collaboration with a number of institutes and universities.

Resource Characterization

- A multi-institutional and multidisciplinary project was launched to study vulnerability of Indian agriculture to climate change. For studying the climatic impact, 1504 centres of rainfed regions across the country were identified and a database of climatic parameters of these centers has been created.
- Under elevated CO_2 (600 ppm), sorghum, blackgram, sunflower and groundnut showed significant positive influence on root and shoot length, leaf area, root and shoot dry weight, total and leaf dry weight, root shoot ratio, and specific leaf weight. Blackgram was more responsive to elevated CO_2 than the other crops.
- The Agromet Data Bank located at CRIDA has now a database of 130 stations spread across the agro-ecoregions of the country. This data is made available to various researchers across the country for agro-advisory service and contingency planning.
- Spatial maps for aridity, humidity and soil moisture indices were prepared for southwest monsoon period (June-September) based on monthly data of 300 rain guage stations spread across the country. These maps provide information on region wise variability of climate resources during the monsoons.
- Based on soils, climate, groundwater, socio-economic conditions, ecofriendly and sustainable region-specific land use models were identified for Akola, Anantapur, Arjia, Bangalore, Bellary, Bijapur, Indore, Kovilpatti, Rajkot, Rewa, Sardar Krishinagar, Solapur and Varanasi.

INM

- A long-term study on INM revealed that 4t compost+ 20 kg N or 2t gliricidia loppings + 20 kg N ha^{-1} for sorghum, and 2t compost + 10 kg N or 1t gliricidia loppings + 10 kg N ha^{-1} for greengram reduced dependency on fertilizer requirement by 50%. These treatments led to improvement in soil properties like organic carbon and available nitrogen.
- A ten-year study conducted in dryland Alfisols led to the conclusion that a cover crop of

horsegram can be successfully raised during the post-*kharif* season utilizing the stored soil moisture. This would provide annually 3-4 t ha^{-1} of biomass which can supply 20, 6, 17 and 17 kg N, P, K, and S kg ha^{-1}, respectively. This led to an increase in the yield of subsequently raised *kharif* sorghum and sunflower by 28 and 18%, respectively.

- Based on long-term experiments comprising of conventional and minimum tillage, crop residues and N levels in castor-sorghum rotation, microbial biomass nitrogen, available nitrogen, available potassium, hydraulic conductivity, and available sulphur were identified as key indicators of soil quality in dryland Alfisols. On an average the relative contribution of these indicators towards soil quality index was: available N (32%)> microbial biomass carbon (31%) > available K (17%)> hydraulic conductivity (16%) > available sulphur (4%).
- Application of 90 kg N+45 kg P + 45 kg K + 2t FYM + 30 kg Zn ha^{-1} plus green manure (intercrop mulch) to cotton resulted in higher dry matter yield (15-17%), number of squares (13-48%) and number of bolls per plant (14-31%) as compared to farmers practice (25 cart loads of FYM+ 150-100-75 kg NPK/ha) in farmers' fields of Damera and Reddy palem villages of Warangal district.
- Studies carried out on the distribution of available nutrients in 19 AICRPDA centres viz Phulbani, Rajkot, Faizabad, Ranchi, Anantapur, Indore, Rewa, Akola, Kovilpatti, Bellary, Bijapur, Solapur, Agra, Hisar, S. K. Nagar, Bangalore, Arija, Hoshiarpur and Rakh Dhiansar under diverse production systems revealed that the majority were deficient in organic carbon, N, P, Ca, Mg and Zn. Availability of K, S, Fe, Cu and Mn was mostly adequate.

Rainwater Management

- Watershed-based NRM strategies for crop diversification in tobacco involving live-bed, cover cropping, agro-forestry systems and water harvesting/recycling were successfully demonstrated in Prakasam district, A.P. A 40-ha micro-watershed harvested 8340 m^3 of rainwater, which was sufficient to irrigate 16 ha tobacco besides maintaining an agroforestry system. This led to an additional income of Rs. 7890 ha^{-1}.
- In an on-station study, the ITK method of moisture conservation by making a couple of 15-20 cm deep depressions around mango and teak tree basins together with CRIDA's intervention of a 5 cm thick grass mulch proved superior in conserving and retaining nearly 2% more moisture, thereby significantly increasing plant height, diameter and canopy spread.
- Critical areas for prioritized land treatment were identified with the help of GIS and remote sensing for development of regional scale watershed plans and methodologies in S.S. Pally watershed of Nalgonda district, A.P. Several interventions for soil and water conservation (bund formation across the slope, diversion channels, gabion structure, gully plugging), alternate land use systems (green capping on bunds, planting of fruit and other trees, avenue plantation) and crops and cropping systems (castor, sorghum) were introduced.
- On-farm studies conducted over a period of 3 years revealed that conservation furrows at an interval of 3m in castor + pigeonpea intercropping system conserved 11-14% more moisture and increased the yield of castor and pigeonpea by 14 and 15%, respectively.

Crops and Cropping Systems

- Subsequent to the convincing demonstrations that sunflower cultivor KBSH1 sown by adopting recommended moisture conservation practices (deep tillage and conservation furrows) and fertilizer application (60 N+30P_2O_5+30K_2O) is superior than cv Morden, farmers in Wanaparty

mandal of Mahabubnagar district, A.P. are adopting this commercial and paying crop by replacing traditional sorghum and castor.

- A demonstrative farming system module in 0.53 ha was established at CRIDA's research farm. This system integrates food (sorghum, pearlmillet, pigeonpea, sunflower, horsegram), horticulture (clusterbean, tomato, bhindi, brinjal), and perennial (henna, drumstick, teak) components. Annual and perennial grasses and legumes were established and efforts are on way for inclusion of animal component in the system.
- Regression equation with significant co-efficient of determination was deduced for predicting castor semilooper oviposition based on rainfall, sunshine hours and minimum and maximum temperature.
- Bio-intensive IPM Module 2 (Trichogramma, Bt, granulovirus) followed by IPM Module 1 (neem, insecticide, granulovirus) was found most effective in management of castor semilooper in on-farm trials conducted in Mahabubnagar district. These modules resulted in higher benefit-cost ratio (1.77) as against farmers' practice of insecticide application (1.63).
- Crop diversity as a key component of IPM in castor and pigeonpea-based cropping systems was studied. These studies revealed variable influence on pest incidence, depending upon the component crops. Castor + clusterbean, castor + cowpea, castor + sorghum and pigeonpea + sorghum harboured least pest population.
- Soils from different rainfed tracts of India were screened for isolation of *Bacillus thuringiensis* (Bt). Five promising Bt isolates were isolated which were found efficient in the management of castor semilooper.
- Biolistic transformation of calli derived from shoot apices of sorghum cultivar SPV 462 was carried out using mtlD gene to generate putative transgenic plantlets. Regeneration and rooting of the selected transformed calli was successfully achieved. PCR verification of putative transgenic plantlets was carried out to confirm the transformation event using *hpt* primers. Southern hybridization analyses of putative transgenics confirmed the integration of trans gene in the genome of sorghum plants.

Alternate Land Use Systems

- Leucaena+stylo/cenchrus silvipasture system provided total nutritional requirement to 9 sheep in 0.80 ha without resorting to external supplementation.
- Agro-forestry module, particularly incorporating leucaena and tamarind, improved organic carbon from 0.2 to 0.45% and available N from 122 to 182 kg ha^{-1} of the soil indicating the beneficial effect of leaf litter of these trees.
- Conjunctive use of recommended NPK + 75 kg FYM to mango trees, recorded maximum yield of 37.1 kg $tree^{-1}$. Drip irrigation at 0.75 Ep produced significantly higher fruit yield (27.8 kg $tree^{-1}$) than no irrigation (17 kg $tree^{-1}$).
- Sixty germplasm accessions of Jatropha and 66 of Pongamia were collected from Adilabad, Anantapur, Chittoor, East Godavari, Kadapa, Kurnool, Srikakulam, Vishakhapatnam and Vizianagaram districts of Andhra Pradesh. These are under evaluation at CRIDA Research Farm.

Farm Machinery

- A simple and handy sunflower seed threshing device was fabricated which not only saved 25% of time but also reduced drudgery of women. The output was 12-15 kg h^{-1} when handled by two women.
- A herbal dryer with liquid petroleum gas fuelled auto control was developed which is useful for drying *amla*, curry leaf, *henna,* drum stick leaves

and senna. The product retains its original colour and quality thereby enhancing its acceptance.

- To overcome the inefficiency of the existing expeller machines, which extract only 24% oil from Pongamia and leave 8% in the cake, a new design of mini oil extraction machine was conceptualized and fabricated to extract 3% more oil from pretreated seeds at low energy input.
- Packages for mechanization in cultivation of maize, groundnut, soybean, sorghum, castor, cotton, fingermillet, pearlmillet and rainfed rice were developed and demonstrated in on-farm trials conducted in 27 villages of 9 districts covering an area of 2416 ha. A net gain ranging from Rs. 1222 for pearlmillet to Rs. 7923 ha^{-1} from rice was noted.
- Four new industries from Hyderbad, Guntur and Bangalore have signed MoUs for manufacture and sale of CRIDA designed agricultural implements and machinery.

Socio-economic Studies

- Interventions on soil and water conservation, introduction of new crops/cultivars, alternate land use systems with animal component, improved crop management practices, agricultural machinery custom hiring centers, capacity building and participatory formation of *Salah Samithis* helped in improving the livelihood of the rural poor of Mahabubnagar, Anantapur and Tumkur districts.
- A study on the economics of milk production in rural AP, Karnataka and TN revealed dairying to be a major livelihood factor with all intentions of becoming an effective wheel to uplift the rural poor. It was suggested that dairying as a measure of assured livelihood be encouraged by providing incentives.
- A study in Southern Telengana and Scarce Rainfall zones of AP revealed that cultivation of rainfed traditional crops like sorghum, pigeonpea, castor, pearlmillet and grountnut was non-remunerative because of poor yield and low returns. Rice in the former and tomato, cucumber and sorghum in the latter, all under irrigation, were catching the attention of the farmer.

Transfer of Technology/Training

- The transfer of technology unit organized sponsored training programmes on Improved Techniques in Rainfed Agriculture and Moisture Conservation Techniques for Dryland Agriculture. These courses benefited agricultural and horticultural officers, subject matter specialists, extension functionaries and the like.
- The Krishi Vigyan Kendra (KVK) conducted 114 need-based, skill oriented training programes benefiting 9887 farmers, women farmers, rural youth and field level extension functionaries. These programmes covered all aspects of dryland agriculture.
- The KVK also organized 409 Frontline Demonstrations on major rainfed crops like maize, castor, pigeonpea, pearlmillet, sorghum, paddy and vegetables. The concept of Village Seed Production Programme was introduced in KVK adopted villages covering 15 ha with castor cultivar Jyothi.

Education

- Sixteen students from universities located in Hyderabad, Bangalore, Anantapur, Kharagpur and Akola were engaged in research leading to post-graduate degrees, and are being guided by the institute scientists. Six scientists of the institute are pursuing higher studies at ANGRAU and JNTU, Hyderabad.
- The three year vocational bachelor's degree programme on dryland agriculture jointly offered in collaboration with the PG College of Science, Saifabad, Osmania University,

Hyderabad has successfully completed its fourth year. At present the final batch of 18 students of the third year is on rolls.

Awards & Recognitions

- Dr. Y.S. Ramakrishna, Director, CRIDA, as partner received Doreen Margaret Mashler Award for the year 2004 under the ICRISAT-ICAR collaborative programme.
- Dr.V.M. Mayande, Principal Scientist (FM&P) was appointed Member, Academic Councils of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and Marathwada Agricultural University, Parbhani.
- Drs. Kausalya Ramachandran, Sr. Scientist (Geography) and K. L. Sharma, Sr. Scientist (Soil Science) were selected as National Fellows of ICAR for a period of five years.
- Young Scientist Fellowship was awarded to Dr. M. Prabhakar, Scientist (Sr. Scale) (Entomology) for three years by the Department of Science and Technology, Govt. of India.
- Dr. J. V. N. S. Prasad, Scientist (Sr. Scale) (Agronomy) received P.S. Deshmukh Young Agronomist Award for the year 2002 conferred by the Indian Society of Agronomy, New Delhi.

Linkages

- The Institute continued its close collaboration with national and international organizations like ACIAR, DFID, ICRISAT, IPE and several SAUs, ICAR institutes and NGOs.

1 Introduction

Rainfed agriculture has an important place in Indian economy and rural prosperity. Over 64 per cent of net cultivated area is rainfed accounting for 40% of the total food production. The dryland areas support 40% of India's population of over a billion, and play a vital role in food security. Over 90% of coarse cereals and pulses, 55% of upland rice, 80% of oilseeds, and 65% of cotton are cultivated under rainfed situation. The small land holders and food insecure people largely live on these lands were bypassed earlier by Green Revolution technology, for obvious reasons.

1.1 Rainfed Farming – Historical

Rainfed farming is as old as agriculture itself. But scientific efforts started to improve the system in the first quarter of the 20th century. It was not until 1923 that the first systematic and scientific approach to the problem of dry farming was made. In that year, Dr. H.H. Mann, who was then the Director of Agriculture in Bombay province, in consultation with Sri C. V. Mehta, the then Minister of Agriculture initiated research on the subject of dry farming for the scarcity tracts of Bombay. The then Imperial Council of Agricultural Research (now ICAR) in India was convinced of the importance of dry farming problem and approved the Bombay Scheme of research and sanctioned necessary funds to carry it out. Subsequently, the Imperial Council offered to finance similar schemes for the then Madras, Hyderabad and Pubjab states. The Bombay Scheme was started in 1933 at Sholapur and Bijapur of erstwhile Hyderabad State, centers of famine tract. The work in Madras was started at Hagari near Bellary from 1934 and in Hyderabad state at Raichur in the same year. The Punjab Scheme was carried out at Rohtak from 1935. These centers came out with dry farming technologies popularly known as Manjri (Bombay), Hagari (Madras), Rohtak (Punjab), Sholapur (Bombay) and Bijapur dry farming practices and were in vogue for a long time till the seventies.

1.2 CRIDA's evolution

Realising the hardfelt need for a comprehensive and multi-disciplinary research in dryland agriculture, the ICAR launched the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) in 1970 with Project Directorate at Hyderabad and having 23 co-operating centers across the country. To further strengthen the activities in this field, the All India Coordinated Research Project on Agrometeorology (AICRPAM) was set up in 1983, also at Hyderabad, with 10 cooperating centers under different SAUs. The present strength of AICRPAM is now 25.

The performance and contributions of the AICRPDA prompted the establishment of a full-fledged research institute, Central Research Institute for Dryland Agriculture (CRIDA), on April 12, 1985 to take a lead in strategic research as related to dryland agriculture leaving location specific problems and their solutions to AICRPDA and SAUs. With the launching of the National Agricultural Technology Project by ICAR in 1998, CRIDA was further entrusted with the responsibility of planning and coordinating research on a production system mode for the rainfed agro-ecosystem.

1.3 Mandate

CRIDA conducts problem oriented inter-disciplinary research. Its mandate is:

- To undertake basic and applied research that will contribute to the development of strategies for sustainable farming systems in the rainfed areas.

- To act as a repository of information on rainfed agriculture in the country.
- To provide leadership and co-ordinate network research with state agricultural universities for generating location-specific technologies for rainfed areas.
- To act as a center for training in research methodologies in the fields basic to management of rainfed-farming systems.
- To collaborate with relevant national and international agencies in achieving the above objectives.
- To provide consultancy.

To fulfill the mandate, research and training activities are carried out in the thrust areas viz., resource characterization, rainwater management, crops and cropping systems, watershed management, soil and nutrient management, alternate land use systems, farm machinery, socio economics and transfer of technology. The institute aims to provide leadership in rainfed agricultural research both through networking with state agriculture universities, and through national and international organisations. CRIDA endeavors to foster values of team spirit and collaboration to achieve its major missions which are pervasive as well as location specific.

1.4 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.
- Evolved strategies for rainwater harvesting and recycling through cost-effective water conservation practices. Provided technical backstopping for watershed development activities of government and non-government organizations, and meeting their HRD requirement.
- Natural resource management by designing the strategies for sustainable and judicious use of resources to generate optimum output.
- Evolved strategies for agricultural drought management in dryland areas, contingency planning and mid-season corrections.
- Ensured sustainability through development of sequence cropping systems, management practices, and crop rotation specific to dryland areas.
- Designed alternate land use systems for provision of better land cover, employment opportunities and staggered income to farming community.
- Developed cost-effective, labour and energy saving implements for timely sowing, intercultural operations and harvesting. Also evolved a low cost and handy fruit and vegetable preservator.
- Conducted studies on the impact of improved and economically viable dryland technologies in terms of socio-economic issues to bridge the gap between technology development and technology transfer.
- Developed weather-based forewarning of crops pests and diseases and provided value added agromet advisory service through specific website (www.cropweatheroutlook.org)
- Developed co-learning strategies for farmers and scientists through action learning application of farm and watershed scale.

1.5 Infrastructure

CRIDA has the state-of-the-art facilities to fulfill its mandate and to support basic and strategic research and training activities being conducted at the institute. It has a spacious building complex with well-equipped laboratories, office, guesthouses, trainees hostels, seminar halls, museum, auditorium and well laid out research farms. An over-view of the facilities is provided below:

Laboratories – CRIDA has, in addition to a Central Laboratory, a number of well-equipped

laboratories in the fields of soil physics, soil chemistry, plant physiology, agronomy, microbiology, tissue culture, plant breeding, plant pathology, entomology, biochemistry, animal science, horticulture, agro-forestry, and biotechnology to facilitate research on natural resource management and crop and livestock production.

Research farms – Two well laid out research farms, one at Hayathnagar (280 ha) and the other at Gunegal (80 ha), cater the needs of generation and transfer of location specific technologies and demonstrations.

ARIS net – The network is being used effectively for e-mail, internet and file transfer protocol (FTP). During the year, the network was upgraded from the present Cat-5 cabling system to Cat-6 with Firewall. The present internet connectivity through NIC was replaced with ERNET with a higher band width. This year, the ARIS Cell trained all the administrative staff on efficient utilization of computer system and MS Office.

Library – Extensive information was collected and maintained on all aspects of dryland agriculture. The library presently has a collection of over 7130 books and 3445 back volumes, and subscribes to 121 Indian and 21 international journals. The library has also established an Agri-Information Centre for catering to information needs of scientists with AGRICOLA, AGRIS, CROP-CD and SOIL-CD. It is also connected with the ICRISAT e-library besides being able to extend online access to a host of foreign journals through the subscription of full text databases. This database is accessible in intranet to institute scientists only.

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 two air-conditioned conference halls with a seating capacity of 30 and 100, besides a large auditorium for 250 persons. CRIDA complex houses International Guest House with four suites, 16 air-conditioned and 16 non-air conditioned rooms for dignitaries and international visitors. Besides, there is also a 32 room trainees' hostel. The KVK is provided with a 20 room hostel facility at HRF. All these facilities are open to sister institutes as well as other organizations.

1.6 Financial outlay for 2004-05

Rupees in lakhs

	CRIDA		AICRPDA		AICRPAM	
	Sanctioned	Utilized	Sanctioned	Utilized	Sanctioned	Utilized
Non-Plan	830.00	825.32	21.50	17.02	11.50	8.09
Plan	215.00	202.78	860.00	860.00	150.00	150.00
Total	**1045.00**	**1028.10**	**881.50**	**877.02**	**161.50**	**158.09**

1.7 Staff Position

As on 31 March, 2005

Staff	Positions	
	Sanctioned	Filled
Scientific	68	61
Technical	82	82
Administrative	49	48
Supporting	67	63
TOTAL	**266**	**254**

2 Research Achievements

2.1 Resource Characterization

Natural resource characterization has a significant role to play in the management of agriculture, particularly in rainfed areas which are beset with plethora of natural and man made problems. It helps in analyzing the agricultural potential of a region and in developing strategies for increasing agricultural productivity. The Institute, together with its amalgamates AICRPDA and AICRPAM, has been characterizing since long climatic, edaphic and biotic factors and has developed data bases. This year lot of emphasis has gone into climate characterization and its practical utility. Recently an all-encompassing multi-institute and multi-disciplinary study on vulnerability of Indian agriculture to climate change has been launched of which the Institute is a major partner. These and other aspects are the subject matter of the following paragraphs.

2.1.1 Climate

2.1.1.1 Weather conditions at Research Farm

The southwest monsoon set in on June 4. The rainfall received at Hayathnagar Research Farm was 581 mm as compared to the normal of 742 mm.

Sowing of the crops commenced during 23 SMW (June 4-10) and was mostly completed by subsequent week end. Few crops were however sown up to 28 SMW (July 9-15). A rather well distributed rainfall of 205 mm (+57%) was received during July. However, the deficient (-66%) rainfall of 52 mm in August was received during first fortnight only. Thereafter a 20-day dry spell in conjunction with deficient (-66%) rain in September resulted in moderate/severe drought for most of the crops. Failure of post-monsoon rains further adversely affected the long duration pigeonpea and castor crops.

The southwest monsoon withdrew from the region on October 25. The weekly weather data are given in Table 1.

2.1.1.2 National Facility of Agromet Databank at CRIDA

The importance of agromet parameters need no more emphasis than to say that these play a crucial role in the formulation of agricultural

Table 1 Weekly meteorological parameters recorded at Hayathnagar Research Farm, Hyderabad

Standard meteorological week	Rainfall (mm)	Soil temperature (°C) at 10 cm		Air temperature (°C)		Relative humidity (%)		Sunshine (h)	Wind speed (km h^{-1})	Pan evaporation (mm)
		0716 h	1416 h	Max.	Min.	0716 h	1416 h			
1	0	20.4	29.2	27.0	13.2	93	45	8.2	3.6	3.4
2	0	19.7	29.1	26.9	11.6	89	32	9.7	3.3	3.9
3	0	21.2	31.1	30.0	13.8	87	28	10.0	3.9	4.9
4	12.0	22.1	29.9	28.1	19.0	91	53	5.7	6.7	4.3
5	7.7	22.1	29.1	27.2	18.5	94	56	5.0	6.2	4.6
6	0	20.6	31.6	28.1	14.1	82	32	9.2	4.4	4.7
7	0	22.2	32.4	29.5	15.2	85	34	10.0	5.2	5.2
8	0	24.4	34.7	32.6	16.9	76	31	10.0	4.3	6.6
9	10.1	25.7	37.3	33.5	20.4	61	25	9.5	7.1	7.3
10	0	27.0	37.2	34.4	18.5	72	26	10.0	6.5	8.0
11	0	27.3	38.5	36.1	20.4	48	18	9.5	5.3	9.3
12	0	29.0	39.8	38.6	21.4	62	21	8.9	5.0	8.1
13	29.2	29.0	38.5	35.7	21.8	80	34	8.1	7.1	8.1

Standard meteorological week	Rainfall (mm)	Soil temperature (°C) at 10 cm 0716 h	Soil temperature (°C) at 10 cm 1416 h	Air temperature (°C) Max.	Air temperature (°C) Min.	Relative humidity (%) 0716 h	Relative humidity (%) 1416 h	Sunshine (h)	Wind speed (km h^{-1})	Pan evaporation (mm)
14	3.1	28.1	39.7	35.1	23.8	66	33	5.0	6.9	6.8
15	0	31.5	42.4	38.6	24.5	62	21	8.3	5.5	9.1
16	10.2	31.0	42.4	39.5	25.7	44	21	9.5	6.4	9.6
17	7.4	29.9	41.8	35.5	24.2	73	35	9.1	7.8	8.7
18	0	31.8	38.9	35.2	24.9	73	41	5.2	9.5	8.2
19	22.7	30.8	40.5	35.7	24.4	75	37	9.0	10.3	8.2
20	27.6	27.7	35.9	33.5	24.3	79	46	3.9	10.0	5.9
21	0	31.1	41.1	36.9	26.2	63	27	7.6	9.7	12.1
22	0	32.7	34.3	37.2	26.3	61	30	8.0	7.3	9.7
23	37.2	28.8	37.2	33.9	23.8	79	48	5.1	8.2	7.2
24	13.0	28.2	33.7	31.8	23.9	75	50	2.9	14.7	7.2
25	4.4	28.0	36.2	33.3	24.0	72	38	6.8	14.6	9.9
26	17.6	30.6	35.6	33.8	24.3	67	46	4.1	9.6	9.5
27	14.7	27.6	35.4	32.6	23.9	79	48	5.3	8.6	7.6
28	100.6	26.6	30.7	30.6	22.6	82	64	1.8	6.9	3.5
29	3.5	28.1	34.6	31.4	24.1	77	53	6.2	7.4	6.2
30	62.0	25.1	27.9	27.5	21.6	88	75	0.5	8.1	5.5
31	36.9	23.7	29.8	27.3	22.1	89	67	3.0	12.3	4.0
32	0	26.3	34.5	30.3	22.6	79	57	5.4	12.9	5.7
33	39.0	25.9	34.2	30.0	22.3	83	55	7.0	11.8	5.2
34	5.3	27.7	35.5	30.7	22.6	81	53	5.1	9.3	6.1
35	0	28.9	37.3	31.5	23.0	71	46	7.9	5.8	6.7
36	19.8	26.8	31.6	29.7	22.5	86	62	3.0	4.2	5.1
37	5.5	26.1	34.9	30.8	22.4	83	53	6.5	5.9	4.7
38	20.5	27.0	34.3	31.5	22.9	83	58	5.5	4.8	3.9
39	0	27.5	37.4	31.1	21.9	87	52	8.4	4.9	4.6
40	51.8	25.9	32.7	30.5	22.0	89	65	4.6	4.8	4.7
41	10.3	26.5	34.1	31.0	21.8	90	62	5.7	3.0	3.8
42	9.4	23.7	35.5	29.7	16.7	82	44	9.7	2.6	4.4
43	13.3	25.6	34.1	29.8	20.0	90	54	7.7	3.7	3.9
44	2.0	24.1	32.6	28.9	18.2	83	46	5.2	4.7	3.5
45	0	24.4	32.7	29.5	18.4	85	43	5.9	4.0	4.1
46	0	25.0	33.6	30.7	18.1	91	41	7.9	3.9	4.5
47	0	22.5	31.9	29.9	13.6	79	29	10.0	3.7	5.0
48	0	21.8	30.7	28.7	13.0	73	26	9.8	4.0	4.8
49	0	20.1	29.7	28.1	12.0	73	32	9.7	3.3	4.0
50	0	22.4	29.8	28.2	13.2	78	34	9.1	2.9	3.7
51	0	20.9	30.1	29.5	13.8	77	27	9.5	3.1	4.2
52	0	21.6	29.7	28.0	15.5	90	39	8.3	3.6	3.7

Pan evaporation are estimated values; Rainfall is weekly total; Other parameters are weekly mean values

plans, be it contingency or pest and disease forewarning systems. It was found necessary to establish a national facility for a centralized data bank to maintain historical data for use of researchers and planners. This Data Bank was thus established in 2000 and since then is data basing and providing information to the clientele. Some of the continuous activities of the Bank are given below:

- Updation of agromet data for all 120 stations spread across the country.
- The daily observations on eight basic agromet parameters of all stations were scrutinized for missing and erroneous data using pivot table and charts and querying methodology.
- Crop data on phenology and growth parameters of 15 stations that were entered last year were updated. Additionally, data from 10 stations were added into the database.
- Provided need-based agrometeorological data to different organizations.

2.1.1.3 **Integrated National Agricultural Resources Information System (INARIS)**

On the lines of Agromet Data Bank, another information system was created for providing essential information on agromet parameters which will be of use in strengthening agromet advisory service provided by the Institute. This year's continued activities are mentioned below :

- Daily weather data collected from 45 centres were checked for its quality and kept in Oracle database.
- Probabilities of weekly rainfall and the maximum and minimum temperature during summer and winter months were computed.
- Spatial interpolation of thematic maps using monthly data of 300 IMD stations for temperature and rainfall were prepared using Arc Info GIS ver 8.3. These maps were prepared using spatial interpolation technique (inverse distance weightage).
- Based on monthly water balance parameters, computations of monthly values of Aridity Index, (WD/WN * 100) and Humidity Index (WS/WN * 100), moisture Adequacy Index (AE/PE *100) and Soil Moisture Index (Actual moisture/maximum water holding capacity of soil) were computed for 300 rain gauge stations spread across the country and spatial maps were prepared for the south west monsoon(June-September) period (Fig. 1). These maps provide an idea about the region-wise variability of climate resources over the country during the monsoon period.

2.1.1.4 **Impact, adaptation, vulnerability of Indian agriculture to climate change**

The effect of climate on agriculture is well known. But the effect of climate change, which has been documented to be happening actually, has not been studied properly in India. Considering the importance of this on Indian agriculture, a national network project was launched recently to quantify sensitiveness and consequent risks, associate with climate change and get prepared for any eventuality. The project is multi-institutional and multi-disciplinary, and the institute has taken up research on climate change impacts on rainfed agriculture. The main components of research are:

a) analysis of climate data for climate change;

b) impact of elevated CO_2;

c) carbon-sequestration potential of agroforestry systems; and

d) climate change and major dryland pests.

The project was launched in December 2004. Subsequently some preliminary studies were initiated and are described below:

- About 1504 stations situated in rainfed districts were identified for analysis.
- Temporal monthly rainfall data of 3000 raingauges in India were obtained.
- Frequencies of annual and seasonal rainfall and drought were computed. Rainfall trends along with moving averages at all the station were worked out.
- The output of the PRECIS model for the year 1961-1990, a Regional Climate Model for down scaling the GCM output at 50 sq.km. grid points for 9 scenarios (3 baseline adopted by

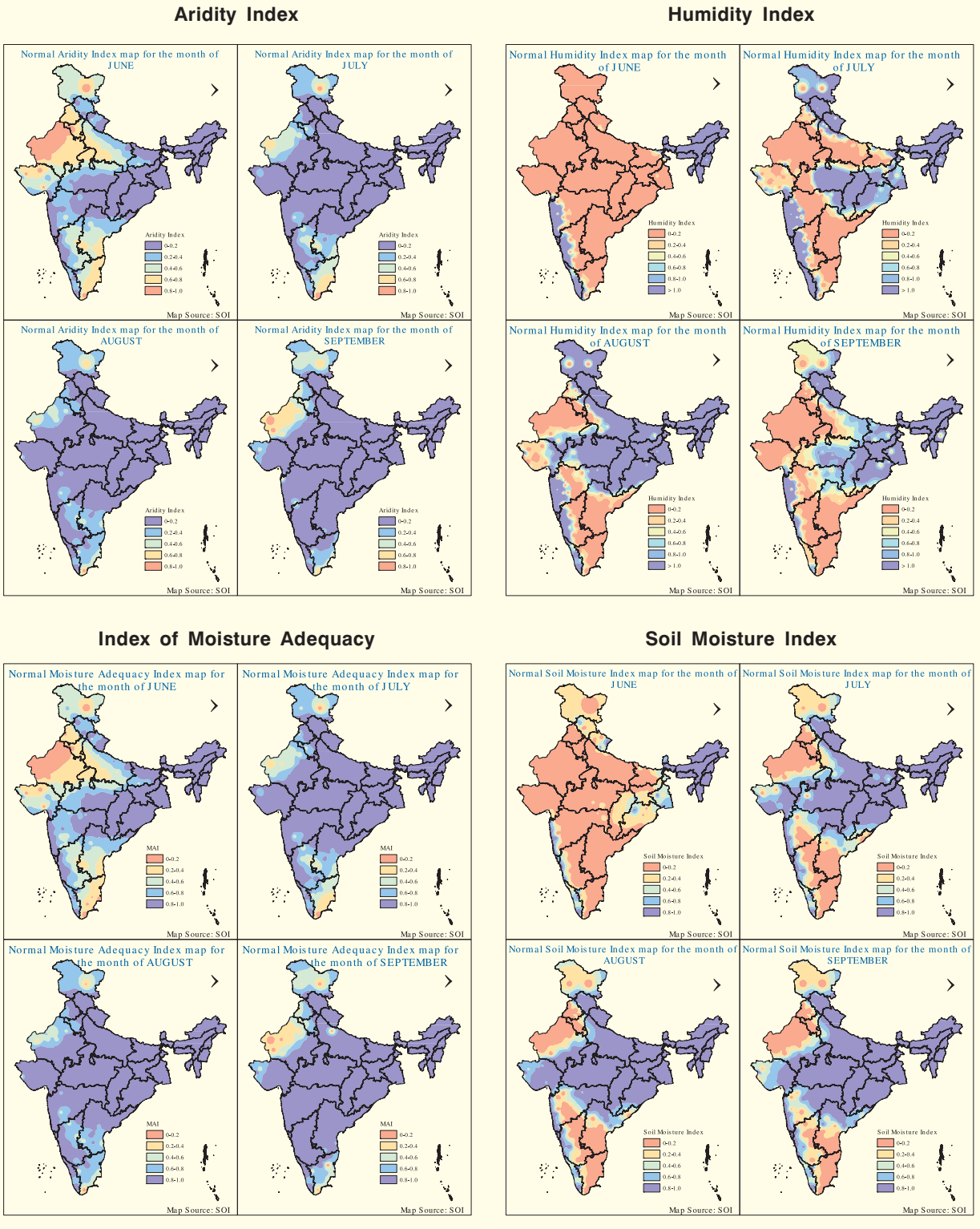


Fig.1. Spatial distribution of aridity, humidity, moisture adequacy and soil moisture indices

IPCC and two levels of emissions A_2 and B_2 with and without sulphur) was obtained from IITM along with version of PRECIS model. Efforts are on to validate the model output of daily maximum, minimum temperature and rainfall of the period 1961-90 with that of different locations of AICRPAM centers in the country. The output from this model shall form the input to crop simulation model (INFOCROP) to workout the impact of climate change on agricultural production.

2.1.2 Soil

2.1.2.1 Bio-physical characterization of HRF Phase III

In continuation of the results that were reported last year (CRIDA Annual report, 2003-04), the soil samples collected at different locations and depths were analyzed for bulk density, particle density and porosity. The results are presented in Table 2 and summarized below:

- The soils of different land categories varied in bulk density (BD) at 0-15 cm depth from 1.64 to 1.7 Mg m^{-3}. Cultivable soils had the lowest BD (1.64 Mg m^{-3}) while the soils of other three categories had 1.7 Mg m^{-3}. Similarly at sub surface (15-30 cm) the hills had maximum BD of 1.80 Mg m^{-3} while the cultivable soil had the lowest of 1.5 Mg m^{-3}. The BD of soil varied directly with the content of clay as evident from the soils of cultivable and hills.
- The soil porosity was worked out from the relation between particle density and bulk density. The porosity of surface soil among different land categories had a narrow range of 35 to 36% in surface soils. At 0-15 cm depth the porosity varied widely among different soils to an extent of 28 to 36%. At either depths higher porosity was observed in cultivable soils (36%) and lower under hills (35%). The porosity of cultivable soils was significant over rock out crops in surface soils, and hills and rock out crops in sub surface soils.

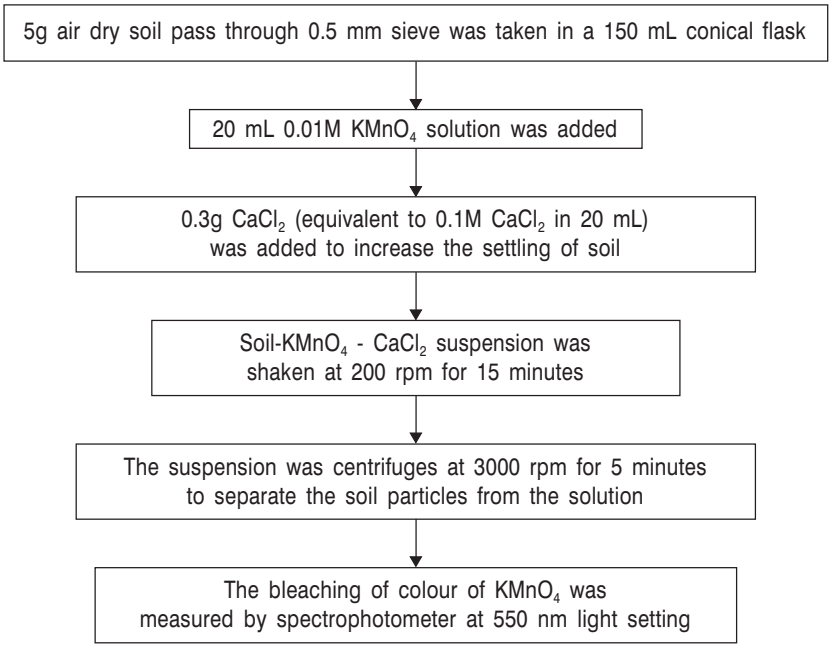
2.1.2.2 Assessment of soil quality by estimating labile carbon

Soil organic matter (SOM) and related soil properties are probably the most widely acknowledged indicators of soil quality. Since SOM has no definite chemical composition, soil organic carbon (SOC), the dominant elemental constituent of SOM is more commonly measured and reported. Scientists, extensionists and farmers are increasingly interested in making simple assessments of soil quality in the field to guide management decisions. The soil quality kits developed by USDA-NRCS contain tests for nine soil parameters, but do not include any test for active soil carbon. Determination of such active C fractions as particulate organic matter, extractable carbohydrates or rapidly mineralizable C are time consuming and require complex laboratory manipulations that limit their use. Under this background, the experiment was planned to develop a rapid, reproducible method for measuring the active fraction of soil carbon using $KMnO_4$. The procedure followed for estimating labile carbon is mentioned below :

Table 2 Soil physical properties of phase III, HRF

Soil	0-15 cm			15-30 cm		
	PD	BD	Porosity	PD	BD	Porosity
Cultivable	2.82 (0.92)	1.64 (0.11)	36 (4.95)	2.43 (0.10)	1.56 (0.09)	36 (4.83)
Foot hills	2.60 (0.22)	1.70 (0.17)	35 (9.70)	2.50 (0.15)	1.70 (0.14)	32 (7.52)
Hills	2.60 (0.14)	1.70 (0.09)	35 (6.62)	2.50 (0.02)	1.80 (0.09)	28 (3.85)
Rock out crops	2.60 (0.08)	1.70 (0.10)	35 (4.27)	2.50 (0.12)	1.70 (0.09)	32 (5.07)

Values in parentheses denote ±1 S.D of the mean; PD = particle density; BD = Bulk density



The investigations led to the following conclusions :

- Active carbon content was 2.1, 3.0, 3.1 and 3.4% of organic carbon content for forest soil, grass land, undisturbed bare soil and cultivated land, respectively.
- The active soil C measured by this procedure was closely related to other soil quality indicators, such as infiltration (r=0.84), MWD (r=0.77), bulk density (r=0.87), dehydrogenase activity (r=0.79), microbial biomass carbon (r=0.81), and organic carbon (r=0.73).
- This procedure will be improved upon and used for developing a user friendly field kit to measure active soil carbon.

2.1.3 Practical utility

2.1.3.1 Radiation and water use efficiency of sorghum

Radiation use efficiency (RUE) and water use efficiency (WUE) are two very important inputs to crop weather modeling and evaluation of productivity. Studies were undertaken to study these parameters on sorghum (cv CSV-15) and pigeonpea (cv PRG-100) as intercrop (2:1) under rainfed conditions at HRF. Recommended agronomic practices were adopted. Periodic observations on leaf area, dry matter, transmitted PAR, and daily insolation were recorded. Ritchie's water balance methodology was adopted for working out actual evapo-transpiration and in turn the WUE of these crops/cultivars. The following observations were made:

- The maximum leaf area index was 2.37 for sorghum grown as intercrop with pigeonpea, and 3.45 for sole pigeonpea. The leaf area index of pigeonpea inter cropped with sorghum was 1.50. The extinction coefficient 'k' for sorghum and pigeonpea were 0.425 and 0.523, respectively.
- The RUE (Fig. 2 & 3) were 2.13 (r^2=0.838) and 1.305(r^2=0.892) g MJ^{-2} for sorghum and pigeonpea, respectively. These values appear to be low, particularly for pigeonpea, mainly due to stress conditions.
- A linear curve with an intercept on X-axis fits well for water use vs dry matter production in sorghum. While an exponential curve better represents the relationship for pigeonpea. It is

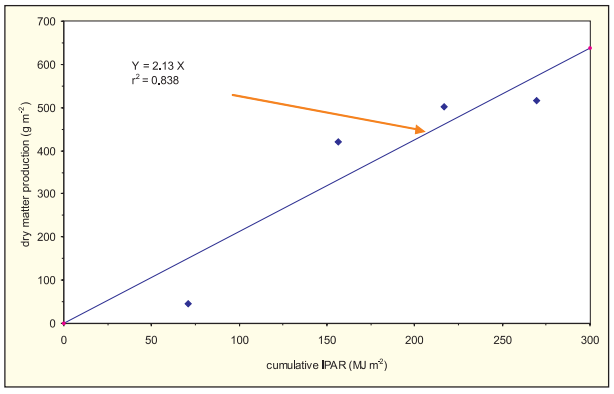


Fig.2. Relationship between cumulative IPAR and dry matter production for sorghum (cv CSV 15)

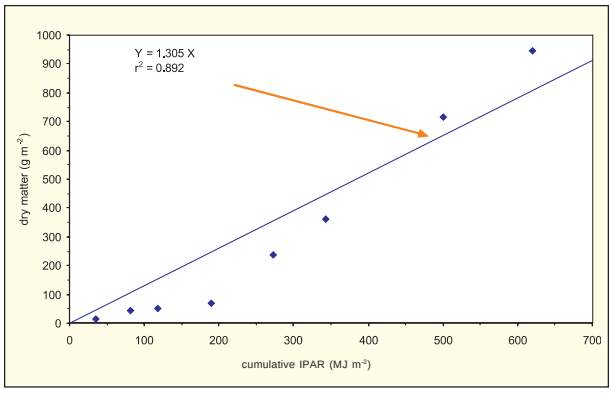


Fig.3. Relationship between cumulative IPAR and dry matter production for pigeonpea (cv PRG 100)

seen that WUE increases with advancement in growth stage for pigeon pea. It was also observed that about 125 mm of water evapo-transpired before significant accumulation of dry matter started in either of the crop.

- Considering the cumulative evapo-transpiration and total dry matter produced, the average WUE worked out to be 1.75 and 2.23 g kg^{-1} for sorghum and pigeonpea, respectively. The values for last year's WUE for sorghum and pigeonpea were 1.87 and 0.64 g kg^{-1}.

2.1.3.2 Spectral characteristic of rainfed *kharif* sorghum

In recent years advances have been made in remote sensing as a proven technology in assessing crop condition, growth behaviour and in evaluating crop productivity. The vegetation indices computed from different spectral wave bands have been related to vegetation canopy properties including green leaf area index, biomass and yield. The information on temporal distribution of soil water in the root zone and its continuous evaluation are important for efficient soil and water management particularly in dryland region where rainfall is the main constraint for crop production. Efforts were made for predicting yield of sorghum within a toposequence by combining information on temporal distribution of root zone soil moisture along with normalized difference vegetation index (NDVI). A root zone soil moisture model was used to evaluate the seasonal soil moisture fluctuation and actual evapotranspiration. Daily rainfall was used as model inputs. Instantaneous uniform redistribution of soil moisture in the effective root zone and negligible contribution of soil water through the upward flux were assumed. Runoff was estimated from rainfall data using the curve number techniques of the Soil Conservation Services adapted for conditions in India and combined with a soil moisture-accounting procedure. The Penman-Monteith method was used to calculate the reference evapotranspiration. Six different types of soils within a toposequence were used to calculate the actual evapotranspiration. The magniture or crop water-deficit was assessed in terms of the extent by which the actual evapotranspiration (AET) fell short of its potential value (PET). The specific indices used to quantify stress were relative evapotranspiration (AET/PET), relative evapotranspiration deficit (1-AET/PET) or soil moisture deficit. Additive and multiplicative forms of water-production functions were used to predict crop yield.

The Additive model: $$Y/Y_m = 1 - \sum_{i=1}^{N} K_i (1 - AET/PET)_i$$

The Multiplicative model:

$$Y/Y_m = \prod_{i=1}^{N} [1 - Ki (1 - AET/PET)_I]$$

Y = actual harvested yield; Ym = maximum harvested yield; Ki = yield response factor in each phonological stages.

The Ki for sorghum was 0.2, 0.55, 0.45 and 0.2 for vegetative, flowering, yield formation and ripening period. The soil characteristics of different block within a toposequence and water production function calculated using water balance model are presented in Table 3.

A multiple regression was run with yield as dependent variable and NDVI and water production function (both additive and multiplicative) as independent variables. The high coefficient of determination (>0.87) indicates that spectral indices along with temporal distribution of soil moisture as water production function is effective in predicting yield (Table 4).

2.1.3.3. **Refining regional level prediction of yield**

Infocrop model was used to estimate cotton crop yield in Nagpur district for 2003-04. Rainfall from different rainfall stations was collected and theissen polygons were generated. Similarly, information on soil depth and soil type (particle size distribution) was collected from soil resource maps. Crop acreage and its distribution was derived from satellite imagery. Cotton crop model was run for homogenous polygons obtained through superimposition of theissen polygons, soil attribute polygons and crop coverage imagery. Estimations were obtained for each soil type and soil depth (Tables 5 & 6) and aggregated after accounting for the cotton cropped area under each category of soil type and depth. This integrated approach resulted in estimating the yield variability under different soil types and depths and an estimate of yield and productivity for the district.

The exercise led to the following estimations :

Estimated cotton growing area: 72515 ha

Total Production: 45.57 million kg of seed cotton or 93830 bales of 170 kg of lint

Productivity: 629 kg ha^{-1} seed cotton or 220.15 kg ha^{-1} of lint

Table 3 Soil characteristics of different blocks and water production functions

Blocks	Soil moisture at field capacity (% v/v)	Soil moisture at permanent wilting point (% v/v)	Soil depth (cm)	Water production function	
				Additive	Multiplicative
Block 1*	13.93	6.93	40	0.433	0.520
Block 2	19.77	8.72	50	0.597	0.646
Block 3	19.38	10.82	47	0.511	0.579
Block 4	26.99	14.41	80	0.819	0.829
Block 5	24.14	13.15	80	0.762	0.779
Block 6	19.44	10.13	65	0.623	0.667

* Blocks indicated in descending order of elevation within a toposequence, Block 1 being highest.

Table 4 Multiple regression using yield, NDVI and water production function variables

Dependent variable	Independent variables	R^2	Adjusted R^2	Level of significance
Yield (kg/ha)	NDVI and additive water production function	0.872	0.786	0.046
	NDVI and multiplicative water production function	0.875	0.791	0.044

Table 5 Distribution of cotton crop under different soil types of Nagpur district

Particle size distribution class	Proportion of the cotton crop (%)
Fine clayey	45.40
Coarse loam	29.30
Clay	12.40
Fine loam	3.00
Loam	9.70
Loamy skeletal	0.20

Table 6 Distribution of cotton crop under different soil depths of Nagpur district

Soil depth class	Proportion of the cotton crop (%)
Deep	74.20
Extremely shallow	2.90
Moderately shallow	0.30
Moderately deep	2.40
Shallow	1.40
Very shallow	18.80

2.1.3.4 **Land use planning for management of agricultural resources**

This multidisciplinary study was initiated with a primary objective of identifying eco region specific, ecofriendly and sustainable land use models. Traditionally in rainfed agriculture the farmer has taken to wide crop diversification to manage the aberrant weather and frequent droughts. In this venture to overcome the constraints created by climate, many a time unsuitable but economy driven land use is practiced. On these land uses various agricultural interventions are demonstrated showing superiority of improved technology without taking into consideration soil health and conservation aspects. A time series analysis showed that crop diversification as revealed by Simpson Index was much higher at any part of the time in rainfed agriculture over irrigated agriculture.

An evaluation of the present day land use in various agro-ecoregions cutting across rainfed crop based production systems in various states was undertaken. Since any rainfed agriculture within an agro-ecoregion is based on hydrology, a micro watershed was identified as a unit. Thus, 16 watersheds were selected varying in climate from dry semi-arid to sub-humid with five soil orders and rainfed rice, oilseeds, cotton and coarse cereals-based production systems. These watersheds covered 5258 ha and involved 1763 farmers. All the farmers perceived that yield as well as rainfall had declining trend and that soil erosion was uncontrolled.

The following paragraphs summarise outcome of this massive exercise conducted at 16 centres spread across 16 agro-ecoregions of 10 states.

- The study showed that on an average about 50% land use by the farmers matched scientifically selected land use. However, the productivity could be improved considerably with the available technology. In the remaining 50% where land use was improper, the crops might be under or over exploiting the soil resources. This was noticed mostly in black cotton soil. In this connection, matching cropping systems (sole, inter-and sequence) and alternate land use systems were identified to use the natural resources optimally based on soil suitability criteria. These improved land use practices were carried out on 603 ha out of the operational area on almost contiguous toposequence on a slope length (1-8%) involving 400 farmers. This technological intervention improved the crop yield on an average by about 50%. These interventions were also supported by improved dryland technology generated by NARS.
- The farmers were sensitized through 17 field days, 7 farmers' days, 16 group meetings, and 14 training programmes covering 3214 farmers of all categories. This capacity building helped the multidisciplinary scientific community in moving from type experimentation to a

system mode on a watershed basis. Despite the general tendency of low rainfall, the scientific land use planning delivered a higher output than expected in the rainfed agriculture.

- The dryland horticulture-based systems were initiated but it would take few more years to quantify its impact. *Mucuna utilis,* a medicinal plant on Alfisols of Bangalore, pigeonpea + greengram, system for rice intensification (SRI) and seed priming of chickpea in *rabi* in Alfisols of Hyderabad, coriander and chickpea + senna inter /relay crops in late *kharif* Vertisols of Kovilpatti; sesame + castor in Vertisols of Akola, rainfed rice-pigeonpea in Inceptisols of Varanasi, groundnut-vamu sequence in Vertisols of Bellary, safflower with compartment bunding in deep Vertisols of Solapur, cotton varieties for range of soils in Vertisols of Nagpur, cost of production reduction with saving of P fertilizer in groundnut in Alfisols of Anantapur, groundnut + blackgram, cotton + sesame in Vertisols of Rajkot, citrus+soybean-wheat in Vertisols of Indore, pearlmillet+greengram (3:1) in SK Nagar, maize+blackgram (2:2) in Arjia and the like are a few of the impacting rainfed technologies for better land use delivered to the farmers (Fig. 5). The suitability of various land utilization types on a soil-land scape continuum were developed for all the 16 watersheds. An example of Vadugad watershed, Rajkot representing rainfed groundnut-based production system is shown in Fig 4.

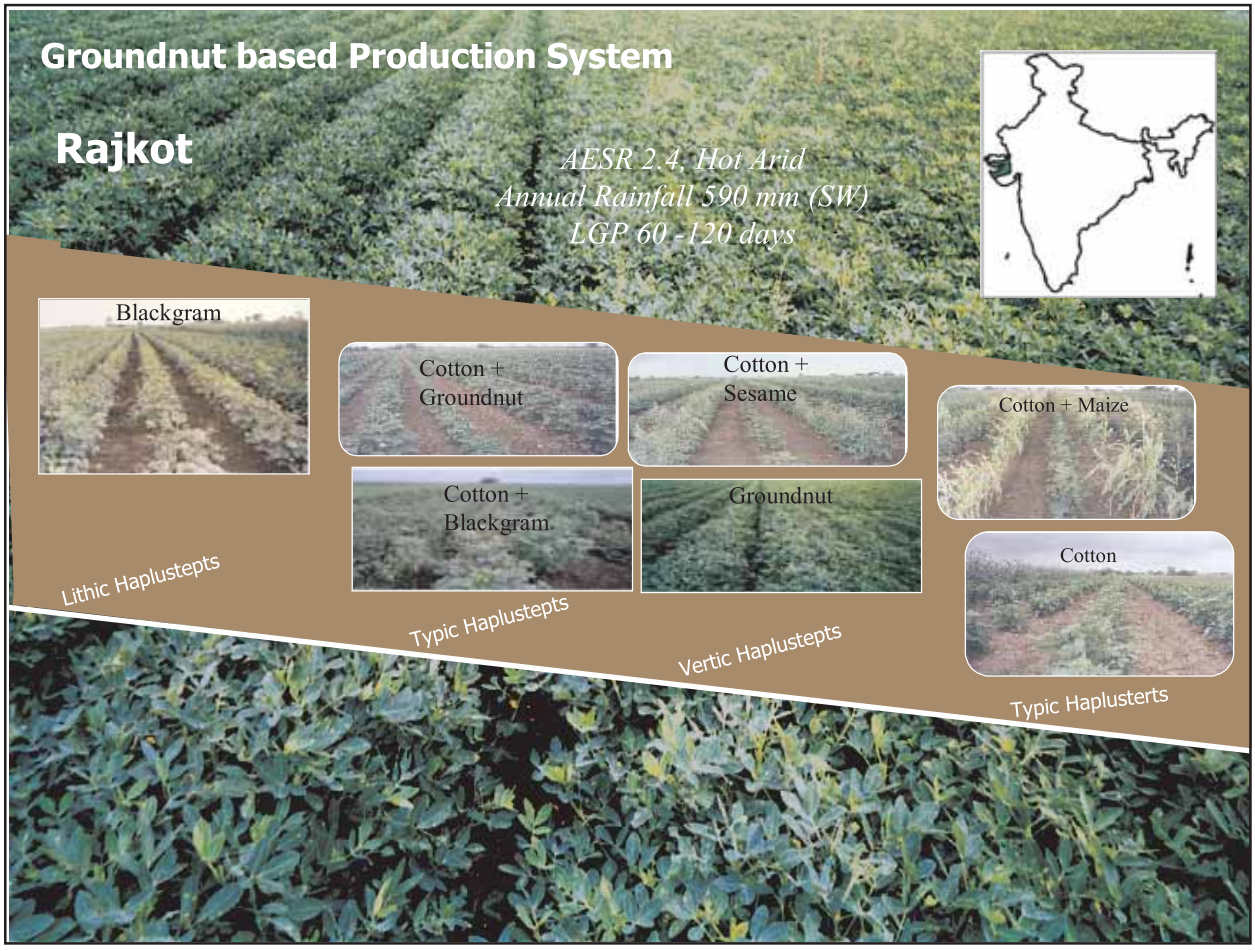


Fig.4. The suitabillity of various land utilization types on a soil-land scape continuum at Vadugad watershed, Rajkot

Agrohortisystem (mango+ amla+ sapota+ tamarind+ horsegram) in Typic Haplustepts at Nallvelli watershed, Hyderabad.

Chickpea in rice fallows in Typic Haplustepts at Nallvelli watershed, Hyderabad.

System for Rice Intensification (SRI) in Typic Haplustepts at Nallvelli watershed, Hyderabad

Cotton + groundnut (1: 1) in Typic Haplustepts at Vadugad watershed, Rajkot

Coriander + chickpea+ senna Inter relay cropping in Typic Haplusterts at Chidambarapuram watershed, Kovilpatti

Mucuna utilis, a medicinal crop in Typic Dystrusteps at Amanishivpurkere watershed,Bangalore

Soybean in Typic Haplusterts at Jaitpura watershed, Indore

Vamu (*Ammi visinaga*) in Aridic Haplusterts at Gadehothur watershed, Bellary

Rabi sorghum – cv. M.35- in Typic Haplusterts at Sarole watershed, Solapur

Peralmillet+cowpea in Typic Ustorthents at Saleempura watershed, Sardarkrishinagar

Agrohortisystem (cowpea +mango) in Kanhaplic Rhodustalfs at Doddaganganawadi watershed, Bangalore

Pigeonpea in Udic Eutrudepts at Balipur watershed, Varanasi

Groundnut+sesame(6:2) intercropping and Maize+ blackgram (2:2) intercropping in Typic Haplustepts in Suwana watershed, Arjia

Cotton cv. LRK – 516 in Lithic Ustorthents, Panubali watershed, Nagpur

Soybean +Pigeonpea (1:1) in Typic Haplusterts at Khuj watershed, Rewa

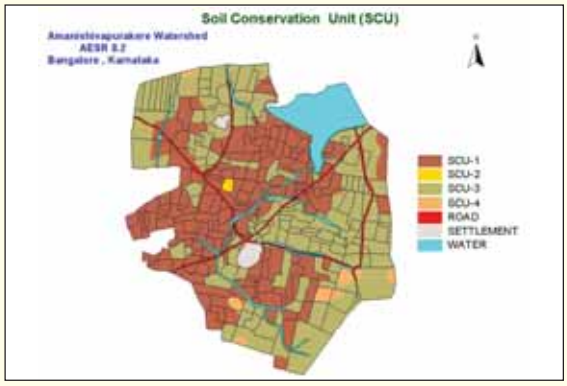
Hybrid Cotton in Typic Haplusterts at Varkhed watershed, Akola

Fig.5. Rainfed technologies as better land use options

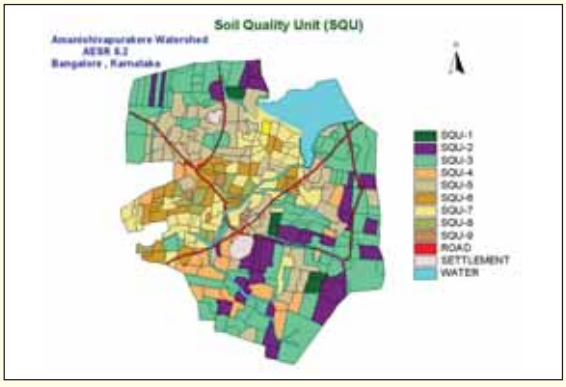
- Soil Conservation Units (SCUs) and Soil Quality Units(SQUs) were delineated using the site-specific soil characteristics from Soil Mapping Units in Arc View GIS environment and SCUs and SQUs were superimposed for identification of Land Management Units (LMUs) and a utilitarian maps and done for all the 16 watersheds under rainfed agro-ecosystem. As the SCUs, SQUs and LMUs were identified at cadastral level(farmers' field boundary), these homogeneous units that are delineated individual farmers' fields are expected to address for bettering soil fertility and *in situ* moisture conservation and land evaluation for optimizing Alternate Land Utilization Types (Fig.6).

2.1.3.5 Effect of elevated CO_2 on crops and soil microorganisms

Of late, lot of concern is being generated on the effect of climate change to the biosphere, particularly that of increasing levels of CO_2 in the atmosphere on plants. This study involving sorghum



SCU	Details	(%)
1	Very deep + slight erosion	45.13
2	Moderate-deep + slight erosion	0.26
3	Very deep + moderate erosion	52.49
4	Very deep + severe erosion	2.13



SQU	Details	(%)
1	Neutral (pH) + high (OC)	1.55
2	Neutral (pH) + medium (OC)	12.39
3	Neutral (pH) + low (OC)	35.43
4	Acidic (pH) + medium (OC)	7.40
5	Acidic (pH) + low (OC)	19.40
6	Alkali (pH) + medium (OC)	6.75
7	Alkali (pH) + low (OC)	13.84
8	Alkali (pH) + high (OC)	2.68
9	Alkali (pH) + high (OC)	0.57

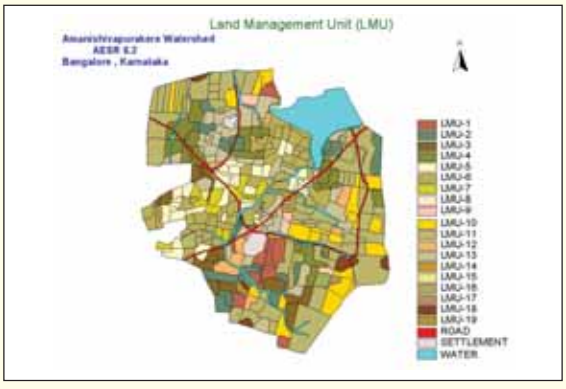


Fig.6. Delineation of Soil Conservation, Soil Quality and Land Management Units for Amanishivpurkere watershed, Bangalore Rural District

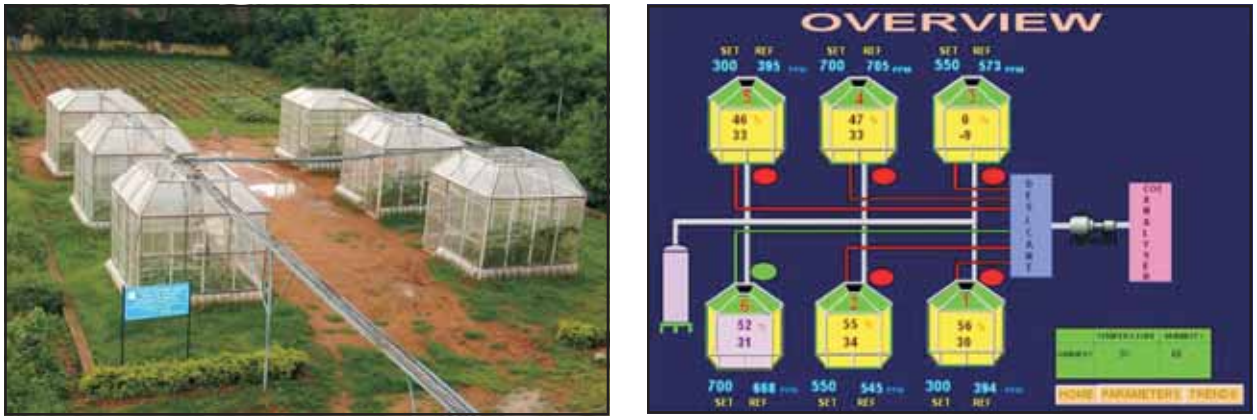


Fig.7. Overview of OTCs and their functioning

(cv CSV-15), blackgram (cv T-9), sunflower (cv MSFH-8) and groundnut (cv JL-24) was initiated last year to study the effect of CO_2 on initial plant establishment, identify suitable genotypes responsive to elevated CO_2, and to conduct basic studies on metabolic pathways. The study was undertaken in four open top chambers (OTCs) with fully automatically controlled CO_2 monitoring and control system. In these chambers, first of its kind in India and established at CRIDA, desired CO_2 level can be maintained throughout the experimental period and the temperature, RH and CO_2 concentration of each chamber is displayed continuously on a computer (Fig.7). Some important findings are given below and depicted in Fig.8.

- The plant growth studies carried out in the OTCs revealed that the shoot length under elevated CO_2 (600 ppm) was higher when compared with chamber control and open control in all the crops studied. The response was more prominent in blackgram with a significant increase of 85% under elevated CO_2 when compared with open control. Next in line were groundnut (69%), sorghum (23%) and sunflower (9%).
- The length of the roots at 30 DAS under elevated CO_2 (600 ppm) showed a significant increase in sorghum (21%) and blackgram (11%) when compared with open control, whereas it was not significant in sunflower and groundnut.
- The leaf area in all the crops showed positive and significant response under elevated CO_2 condition when compared with chamber control and open control. Blackgram, among the four crops evaluated, showed higher and significant response under elevated CO_2 over chamber control (53%) and open control (356%). Groundnut, sorghum and sunflower were next in order with 130, 79 and 46% under elevated CO_2 when compared with open control.
- The response of total dry weight in all the four crops tested was positive and significant. Blackgram showed significantly more response under elevated CO_2 when compared with other three crops. The increment in total dry weight at 30 DAS under elevated CO_2 was 208% more in black gram over open control and 80% over chamber control. In groundnut it was 78 and 14%, sunflower 73 and 32%, and in sorghum 44 and 9% over open and chamber controls, respectively.
- The response of shoot dry weight was similar to total dry weight. The increment in shoot dry weight of blackgram was significantly higher over open control (190%) and chamber control (101%) when compared with other three crops. The increment in shoot dry weight in groundnut was 92 and 13%, sunflower 83 and 49%, and in sorghum 43 and 13% over open and chamber controls.
- Under elevated CO_2 all the crops showed a

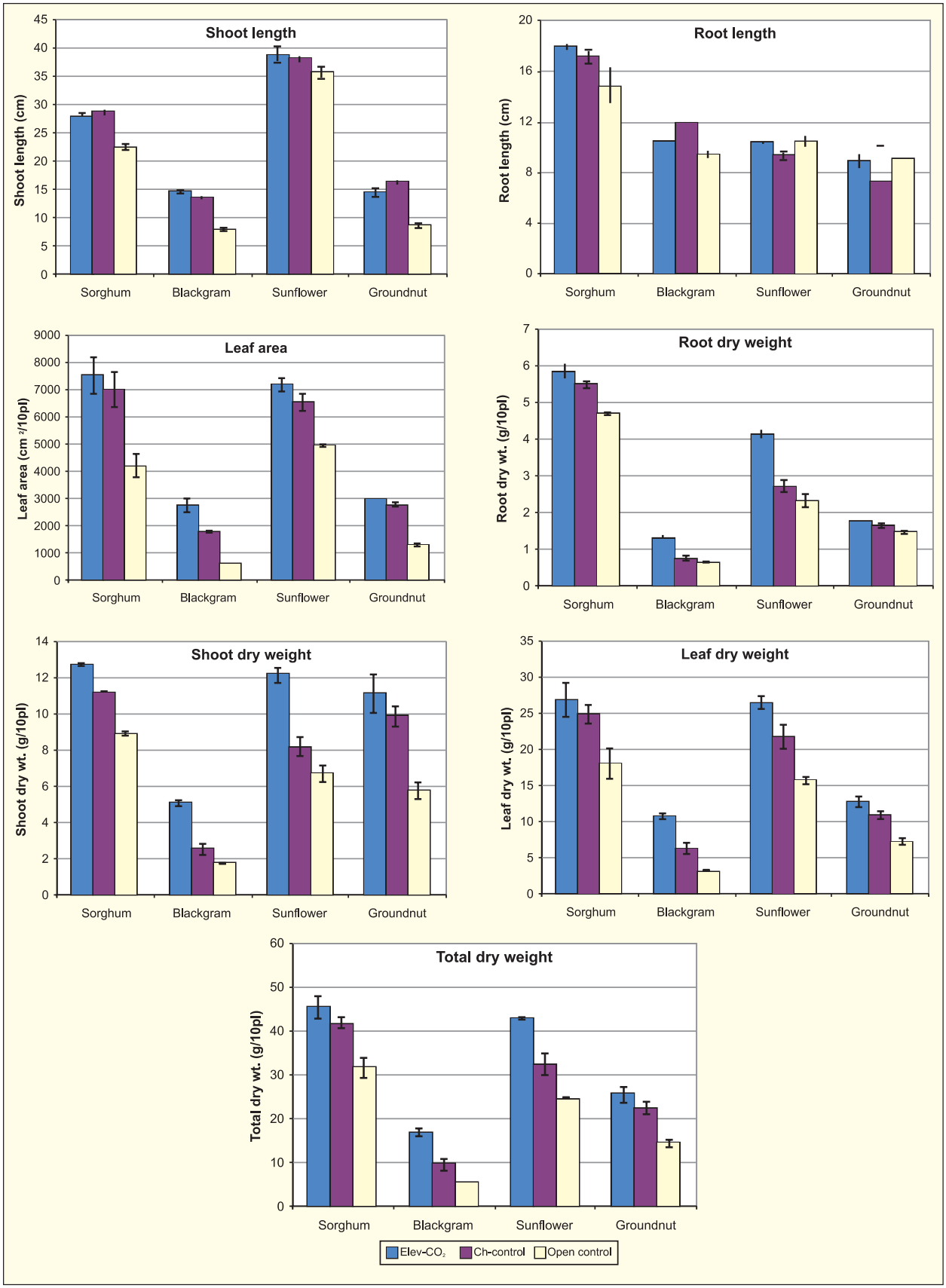


Fig.8. Effect of elevated CO_2 on plant growth parameters at 30 DAS

significant and positive response for root dry weight. The response ranged from 112 to 21% increments over open control and 78 to 6% over chamber control. Blackgram showed the highest response (112 and 78%) under elevated CO_2 condition, followed by sunflower (83 and 49%), sorghum (24 and 6%) and groundnut (21 and 7%) over open and chamber controls, respectively.

- With increase in CO_2 concentration leaf dry weight increased in all the crops and it was the most responsive parameter. Here too, blackgram showed the highest response. The increment under elevated CO_2 in leaf dry weight was 236% over open control and 71% over chamber control. The next more responsive crop was groundnut (79 and 17%) followed by sunflower (69 and 22%) and sorghum (50 and 8%).
- The response of root and shoot dry weight in all the crops was significantly higher under elevated CO_2. In sorghum the increment in root weight was significantly higher (21%) than increment in shoot weight under elevated CO_2. This was followed by blackgram where the increment in root dry weight was 11% more than increment in shoot dry weight. In sunflower and groundnut increment in root and shoot weight was almost similar and hence the change in root:shoot dry weight ratio was not significant.
- In OTCs, after 120 days of maintaining 600 ppm CO_2, the population of all the important groups of microorganisms increased significantly (Table 7). The increase was most striking in fungi followed by bacteria and actinomycetes. There was also a significant increase in microbial biomass carbon (MBC). The results indicate that elevated CO_2 enhanced microbial activity in the soil which resulted in higher biomass carbon and also more total organic carbon in the soils. The mechanism of enhancement in microbial population and MBC needs further investigation.

2.1.3.6 Drought indices for detection and monitoring of agricultural drought

While the effects of drought are well documented, a proper working definition of drought is less clear because its definition is both spatially variant and context dependent. Therefore, a number of drought indices have been developed and are in use, each having a variety of data input requirements and each providing a somewhat different measures of drought. Given the range in derivations and different responses of these indices, not all are suitable for detecting and monitoring agricultural drought. With this in view, this study was initiated to compare performance of four indices, viz., PDSI, SDI, SPI and AI in agricultural drought detection and monitoring in Andhra Pradesh.

Droughts in Andhra Pradesh:

Incidence of droughts in all the 23 districts of Andhra Pradesh was studied using Palmer Drought Severity Index (PDSI) and Soil Moisture Deficit Index (SDI) by taking into account monthly data on rainfall, maximum and minimum temperature (1963-1999) and available water holding capacity of soils across all the districts. This year's preliminary

Table 7 Effect of elevated CO_2 on soil microorganisms

Parameter	Control	Elevated CO_2
Organic carbon (%)	0.58	0.72
Microbial Biomass Carbon (µg g^{-1}) soil	60.40	89.00
Fungi ($x10^3$)	8.00	25.00
Bacteria ($x10^5$)	42.00	110.00
Actinomycetes ($x10^5$)	26.00	37.00

observations are reported here and conclusions would be done only after end of the study.

A) Palmer Drought Severity Index (PDSI):

i) Drought frequency:

In coastal A.P., mild drought months constituted 11 to 23 %. In Telangana, it varied from 13 to 28 % and in Rayalaseema, 14 to 23 %. Moderate drought months occurred 10 to 18 % in coastal A.P., 10 to 20 % in Telangana and 10 to 16 % in Rayalaseema. Severe drought months were 3 to 13 % in all the 23 districts whereas extreme drought occurred in 1 to 2 % of the time.

ii) Droughts of the *kharif* season:

Taking broadly the *kharif* season as June to November, occurrences of droughts of moderate and above intensity in each of the months are 11 to 38 % in coastal A.P., 16 to 38 % in Telangana and 11 to 30 % in Rayalaseema. These droughts are likely to affect crop production adversely. The extent of damage due to drought will depend on the type of crop and stage of growth.

iii) Drought spells:

Here drought periods when the value of the index fell below –1.00 continuously was taken into account. The study showed that drought spells of 1 to 4 months were more frequent in all the districts, frequency of which ranging from 2 to 20. Drought spells lasting for 11 to 12 months varied from 5 to 12.

B) Soil Moisture Deficit Index (SDI):

i) Drought frequency:

The occurrence of mild droughts was more common in all the 23 districts, ranging from 11 to 32 %. Severe droughts occurred one per cent of the time in Vizianagarm, Medak and Adilabad districts only.

ii) Droughts in *kharif* season:

Only East Godavari district in coastal Andhra Pradesh experienced drought 5 % of the time in the month of July. In Telangana it was 3 to 11%. Occurrence of drought ranged from 5 to 27% from August to November in all the districts except Hyderabad where drought of moderate and above intensity did not occur during *kharif* season.

iii) Drought spell:

Here too, continuous drought periods when the value of the index fell below –1.00 were considered. Occurrence of 1 to 4 month drought spells was common like in Palmer Drought Severity Index. Frequency of these spells ranged from 3 to 18 in all the districts. Only Mahabubnagar, Nalgonda and Anantapur experienced 11 to 12 month drought spell four times whereas Kurnool experienced it thrice. Visakhapatnam, Guntur, Khammam, Nizamabad and Chittoor experienced only once.

2.2 Integrated Nutrient Management (INM)

Low rainfall, high temperature, eroded and degraded soils with low water holding capacity and multi-nutrient deficiencies besides declining ground water are major factors contributing to low crop yield in rainfed agriculture. Alfisols and Vertisols are the predominant soil orders occurring in the rainfed regions of India. In these regions, soil health as indicated by physical, chemical and biological properties is very poor resulting in decreased productivity and profitability. One way of addressing to soil related problems is through integrated nutrient management. CRIDA during the past has been carrying out short and long-term INM trials which led to quite a few recommendations. This year, two long-term trials have led to some good conclusions. During the later part of the year, two significant studies were initiated on restoration of soil quality through conservation agricultural management practices and on organic carbon assessment and its maintenance. Some of these aspects are discussed below.

2.2.1 Nutrient status of soils

2.2.1.1 Distribution of available nutrients in various soil types

Despite the fact that soils of rainfed regions are poor in quality and have multi nutrient deficiencies, these have not been characterized systematically for their nutrient availability and distribution. In order to overcome this lacuna, nineteen representative profiles of different soil types under eight diverse rainfed production systems at different AICRPDA centers spread across India were examined for their available nutrient status. Delineation of emerging nutrient deficiencies will be extended to the farmers fields in subsequent years, and based on nutrient status and crop response nutrient recommendations will be computed. Some of the significant findings are given below and in Table 8.

Table 8 Macronutrient status of soil profiles under diverse rainfed production systems

Production system/ location	N	P	K	S	Ca	Mg
	(kg/ha)				(me/100g)	
Rice- based production system						
Faizabad	102.2 – 115.5* (125.7)**	5.3 – 17.7 (8.4)	140.2 – 183.7 (160.3)	22.4 – 41.4 (32.5)	3.10 – 4.70 (3.71)	1.00 – 1.14 (1.09)
Phulbani	93.5 – 117.8 (104.8)	11.8 – 22.8 (14.5)	152.3 – 237.4 (195.1)	12.7 – 23.5 (19.0)	0.31 – 3.93 (2.02)	0.15 – 0.77 (0.40)
Ranchi	161.8 – 264.7 (215.5)	11.7 – 24.5 (17.4)	125.4 – 156.8 (138.8)	16.5 – 22.8 (19.3)	1.54 – 3.22 (2.77)	0.24 – 0.80 (0.65)
Groundnut- based production system						
Rajkot	30.2 – 161.2 (93.5)	7.7 – 8.4 (8.0)	49.3 – 367.4 (188.8)	7.6 – 12.9 (9.6)	5.17 – 6.12 (5.69)	2.31 – 2.99 (2.83)
Anantapur	73.1 – 125.9 (103.6)	15.6 – 29.8 (19.6)	120.8 – 143.3 (129.2)	5.3 – 47.9 (23.1)	4.43 – 5.94 (5.33)	0.66 – 0.84 (0.74)
Soybean- based production system						
Indore	193.2 – 188.4 (243.9)	7.8 – 12.4 (9.0)	248.2 – 362.8 (322.3)	16.5 – 34.2 (22.7)	6.59 – 6.98 (6.72)	1.14 – 1.19 (1.17)
Rewa	60.1 – 166.6 (113.9)	7.7 – 10.5 (9.0)	336.0 – 506.2 (407.5)	28.0 – 50.4 (40.2)	5.44 – 5.86 (5.70)	2.22 – 2.75 (2.60)
Cotton- based production system						
Akola	96.6– 125.8 (116.2)	5.3 – 7.4 (6.3)	35.8 – 161.3 (76.7)	16.1 – 19.0 (17.5)	6.60 – 6.84 (6.76)	1.14 – 1.19 (1.17)
Kovilpatti	58.9 – 144.2 (86.3)	4.9 – 7.4 (6.7)	210.5 – 474.8 (272.3)	77.2 – 92.2 (87.4)	6.28 – 7.05 (6.72)	1.11 – 1.19 (1.16)
Rabi sorghum- based production system						
Bellary	32.5 – 60.9 (44.0)	8.1 – 8.7 (8.3)	304.6 – 483.8 (365.4)	16.8 – 32.4 (24.3)	5.47 – 5.90 (5.78)	2.56 – 2.82 (2.76)
Bijapur	52.8 – 66.4 (58.2)	8.2 – 11.8 (9.4)	318.1 – 488.3 (378.2)	52.6 – 88.4 (70.6)	5.66 – 6.09 (5.80)	2.94 – 3.03 (2.99)
Solapur	59.2 – 102.9 (73.7)	7.6 – 9.6 (8.0)	456.9 – 595.8 (500.4)	31.3 – 82.6 (41.2)	5.37 – 6.02 (5.73)	2.90 – 3.03 (2.94)
Pearlmillet-based production system						
Agra	102.9 – 144.2 (123.6)	7.1 – 18.7 (10.4)	94.1 – 116.8 (103.1)	103.0 – 137.0 (127.7)	2.32 – 4.51 (3.46)	0.91 – 1.10 (1.02)
Hisar	68.9 – 191.9 (150.3)	8.5 – 32.4 (10.9)	143.3 – 206.1 (163.1)	57.5 – 172.0 (124.1)	1.62 – 7.40 (4.81)	0.33 – 0.64 (0.36)
S.K.Nagar	86.6 – 114.2 (98.4)	7.8 – 18.4 (11.6)	58.2 – 107.5 (85.1)	18.14 – 21.2 (19.6)	1.45 – 2.16 (1.85)	0.15 – 0.42 (0.32)

Production system/ location	N	P	K	S	Ca	Mg
	(kg/ha)				(me/100g)	
Fingermillet-based production system						
Bangalore	82.8 – 120.5 (102.0)	48.6 – 145.2 (65.2)	40.3 – 98.1 (53.0)	40.5 – 66.7 (56.0)	0.97 – 1.53 (1.36)	0.07 – 0.46 (0.26)
Maize-based production system						
Arjia	96.5 – 288.5 (182.6)	6.1 – 14.5 (8.5)	62.7 – 201.6 (109.4)	9.4 – 22.8 (16.0)	4.29 – 6.22 (5.41)	0.16 – 0.81 (0.44)
Hoshiarpur	65.2 – 215.7 (124.1)	9.6 – 18.1 (12.6)	35.8 – 134.4 (81.24)	2.3– 9.1 (4.7)	4.32 – 5.42 (4.99)	0.18 – 0.28 (0.22)
Rakh Dhiansar	94.1 – 154.3 (114.9)	10.3 – 15.9 (12.4)	44.8 – 71.6 (55.6)	17.9 – 23.5 (20.8)	0.93 – 1.44 (1.06)	0.13 – 0.24 (0.18)

* Range in the profile; ** Profile mean

- The soils of dryland regions were low in organic carbon having a profile mean of less than 5.0 mg kg^{-1}. However, higher content was observed in surface layers (0-15 cm) of Indore (6.8 mg kg^{-1}), Ranchi (6.2 mg kg^{-1}), Rakh Dhiansar (5.6 mg kg^{-1}), and Faizabad and Hoshiarpur (5.2 mg kg^{-1}).
- Mean and range of available N status in all the profiles was low. Profiles of Rajkot, Kovilpatti, Bellary, Bijapur, Solapur belonging to Vertisols and S.K. Nagar (Aridisol) showed available N below 100 kg ha^{-1} indicating severe deficiency. Available N status of surface layers (0-15 cm) showed that all profiles were low except Indore. In most of the profiles, surface soils showed higher available N which decreased with depth.
- Phosphorus deficiency was also widespread. Surface soils of Rajkot, Akola, Solapur and Bellary were deficient in available P. While soils of Faizabad, Phulbani, Ranchi, Indore, Rewa, Kovilpatti, Bijapur, Agra, S.K.Nagar, Arjia, Hoshiarpur and Rakh Dhiansar had medium available P, the remaining had higher content. Soils of Bangalore showed exceptionally high build-up of available P.
- Available K varied from low to high. Surface soils of Agra, S.K.Nagar, Bangalore, Hoshiarpur and Rakh Dhiansar were low, Faizabad, Phulbani, Ranchi, Anantapur, Akola, Hisar and Arjia medium, and Rajkot, Indore, Rewa, Kovilpatti, Bellary, Bijapur and Solapur were high in content.
- Whereas surface soils of Faizabad, Rajkot, Akola, S.K.Nagar and Hoshiarpur were low in available sulphur, those of Phulbani, Ranchi, Indore, Bellary, Arjia and Rakh Dhiansar were medium. Remaining soils had higher content.
- Available exchangeable Ca status varied widely. Surface layers of Phulbani, Ranchi, Anantapur, Agra, Hisar, S.K.Nagar, Bangalore, Arjia, Hoshiarpur and Rakh Dhiansar were deficient indicating that most of Alfisols and light textured Inceptisols and Entisols were Ca deficient.
- Surface soils of Phulbani, Ranchi, Anantapur, Agra, Hisar, S.K.Nagar, Bangalore, Arjia, Hoshiarpur and Rakh Dhiansar were deficient in Mg. Soils of Bangalore showed severe Mg stress (0.07 me 100 g^{-1}).
- Among micro nutrients, Zn was a major yield limiting factor in surface soils of Phulbani, Rajkot, Anantapur, Rewa, Akola, Bellary, Bijapur, Solapur, Agra, S.K.Nagar, Arjia, Hoshiarpur and Rakh Dhiansar. Surface soils of Bellary and Bijapur were Fe deficient whereas as Cu and Mn were sufficient in all the soils.

2.2.2 Response of different crops to INM

2.2.2.1 Low tillage and INM strategies

The prime objective of this long-term study (initiated in 1998) was to identify effective INM treatments for sorghum cv CSH 9 and greengram

cv ML 267, and to enhance organic matter in dryland Alfisoils. The experiment was conducted in a strip-plot design with two tillages, conventional (CT) and reduced (RT), and five INM treatments viz., 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, 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 greengram. Recommended level of phosphorus was applied equally to both crops uniformly. This year results, alongwith conclusion drawn from not yet concluded long term trial, are mentioned below:

- In reduced tillage plots, higher sorghum grain yield (1938 kg ha^{-1}) was recorded in 4 t compost + 20 kg N, and that by 2 t gliricidia loppings + 20 kg N (1931 kg ha^{-1}). These figures were significantly higher than those of control (704 kg ha^{-1}) (Fig.9).
- In conventionally tilled plots also, higher yield (2027 kg ha^{-1}) was observed in 4 t compost + 20 kg N, followed by 2006 kg ha^{-1} in plots receiving 40 kg N through urea.
- In case of greengram, under reduced tillage, application of 2 t compost + 10 kg N proved quite effective in recording grain yield as high as 1392 kg ha^{-1}, followed by 1372 kg ha^{-1} in 1 t Gliricidia loppings + 10 kg N plots. Similar trend was observed under conventionally tilled plots.
- On an average, conventionally tilled plots recorded relatively higher yield when compared to the plots under reduced tillage.
- The agronomic efficiency of the treatments varied from 25.01 to 30.83 kg grain kg N^{-1} in case of sorghum, and 20.86 to 36.34 kg grain kg N^{-1} in case of greengram, irrespective of the tillage treatments. However, higher agronomic efficiency (30.83 kg grain kg N^{-1}) in case of sorghum was detected with 4 t compost + 20 kg N treatment, whereas in case of greengram, agronomic efficiency was higher (36.34 kg grain kg N^{-1}) in 2 t compost + 10 kg N treated plots.
- On an average, soil organic carbon was higher in reduced tillage plots (0.75) than under conventionally tilled ones (0.72 %). Under reduced tillage, application of 4 t compost + 2 t Gliricidia loppings maintained higher organic carbon content (0.86) followed by 0.81% in 4 t compost + 20 kg N treated plots (Fig.10).

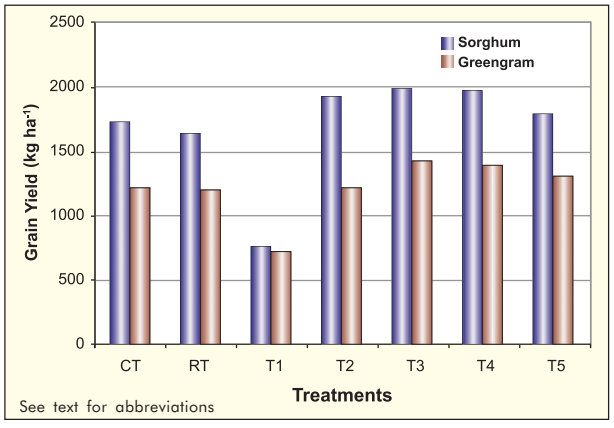


Fig.9. Sorghum and greengram grain yield as influenced by tillage and INM

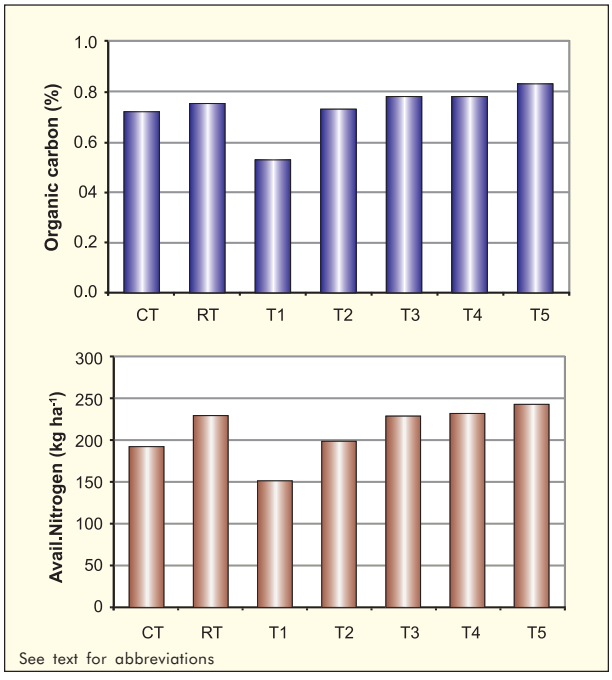


Fig.10. Effect of INM and tillage on organic carbon and available nitrogen

- Soil available nitrogen (easily oxidizable nitrogen) content also exhibited the same trend as organic carbon, being higher in reduced tillage plots than under conventionally tilled ones. 4 t compost + 2 t Gliricidia loppings treated plots had higher available nitrogen content of 262 and 222 kg ha^{-1} under reduced and conventional tillage plots, respectively.
- Analysis of long-term studies has clearly revealed that the treatments such as 4 t compost + 20 kg N and 2 t Gliricidia loppings + 20 kg N (in case of sorghum) and 2 t compost + 10 kg N and 1 t gliricidia loppings + 10 kg N (in case of greengram) have great scope in reducing the demand for fertilizer requirement. The system is quite sustainable since organic materials such as compost and Gliricidia biomass can be easily generated on the farm boundaries/bunds itself.

2.2.2.2 Improvement and assessment of soil quality

Soil quality is the integrated effect of management of most of the soil properties that determine crop productivity and sustainability. Good soil quality not only produces good crop yield, but also maintains environmental quality and consequently plant, animal and human health. Unfortunately, with the advancement of agriculture, soils are being degraded at an alarming rate by wind and water erosion, desertification, and salinization because of misuse and improper farming practices. Soil quality assessment has been suggested as a tool for evaluating sustainability of soil and crop management practices. Hence, there is a need to develop criteria to evaluate soil quality and to take corrective actions to improve it.

A long-term experiment was conducted with the objective of selecting appropriate land management treatments and to identify key indicators of soil quality for dryland semi-arid tropical Alfisols under sorghum-castor rotation. The experiment was laid out in a strip split-split plot design with 3 replications and was maintained since 1995 with sorghum and castor in a two-year rotation. The strip constituted two tillage treatments: zero tillage (ZT) and conventional tillage (CT). The main plot treatments constituted three residue treatments; dry sorghum stover (SS), fresh Gliricidia loppings (GL) and no residue (NR). Sub plot treatments consisted of four N rates 0 (N_0), 30 (N_{30}), 60 (N_{60}) and 90 (N_{90}) kg N ha^{-1}. In all, 24 treatment combinations were evaluated. P was applied to each crop @ 13 kg ha^{-1}. Key soil indicators were identified for semiarid tropical Alfisol under castor-sorghum rotation and scores were assigned to the selected indicators using linear scoring procedure on the principle of 'more is better' and 'less is better' approach. Finally weighted additive soil quality index was computed. The salient features of the study and the conclusions drawn after a 10 year period are presented below:

- Tillage, residue and nitrogen levels played a significant role in influencing the yield of sorghum and castor when studied as individual factors. Conventional tillage proved superior to minimum tillage for maintaining yield of both crops.
- Application of Gliricidia loppings resulted in significantly higher yield of crops compared to sorghum stover residue and no residue. Increasing nitrogen supply, increased yield of castor and sorghum. The interactive effect of tillage and nitrogen on crop yield was significant.
- The average yield of sorghum was higher under $CTGLN_{90}$ (1589 kg ha^{-1}) followed by $CTSSN_{90}$ (1476 kg ha^{-1}) and $CTGLN_{60}$ (1459 kg ha^{-1}). Higher castor yield was recorded under $CTGLN_{90}$ (1090 kg ha^{-1}) followed by $CTGLN_{60}$ (1039 kg ha^{-1}) and $CTNRN_{90}$ (1037 kg ha^{-1}).
- The Sustainable Yield Index (SYI) was significantly higher under CT than under MT. Application of Gliricidia residue to sorghum and castor resulted in higher SYI compared with other residues. SYI was higher in $CTSSN_{90}$ (0.60) followed by $CTGLN_{60}$ (0.59) and $CTGLN_{90}$ (0.58).

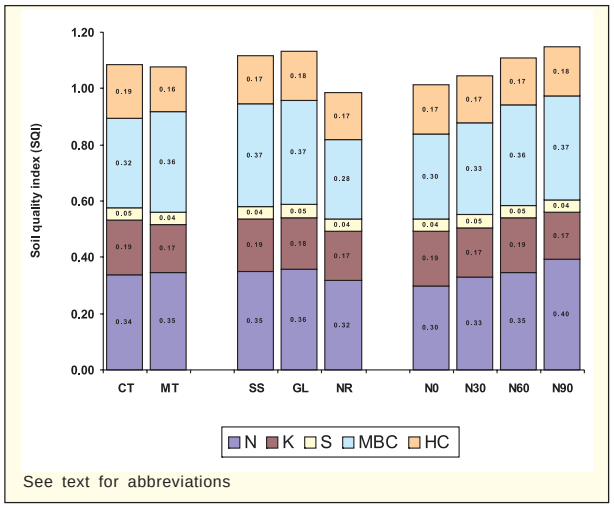


Fig.11. Proportional contribution of key indicators towards soil quality index

- Considering the ease of sampling, cost of estimation and logic and interpretability, the final set of indicators chosen were microbial biomass nitrogen (MBC), available nitrogen, available potassium, hydraulic conductivity (HC), and available sulphur (Fig.11).
- Tillage did not influence soil quality index (SQI) significantly. Main individual effects of residue and nitrogen levels on SQI were significant. Main interactions between the management factors were also significant. Application of Gliricidia was superior to that of sorghum stover. Gliricidia at all levels of nitrogen proved quite effective in maintaining soil quality under CT than under MT.
- Among the 24 treatments, the final SQI ranged from 0.90 to 1.27. Highest SQI was obtained in $CTGLN_{90}$ (1.27) followed by $CTGLN_{60}$ (1.19) and $MTSSN_{90}$ (1.18). Lowest SQI value was obtained under $MTNRN_{30}$ (0.90) followed by $MTNRN_0$ (0.94), which indicates relatively less aggradative effect of these treatments.
- SQI increased with the increasing levels of nitrogen. The contribution of individual indicators towards SQI was 32 % for N, 31% for MBC, 17% for K, 16% for HC and 4% for S.
- Castor oil yield as computed by yield x percent oil content was significantly influenced by tillage, residues, and N. The interactive effects of tillage x N also significantly influenced oil yield. As such, oil yield across the treatments varied from 183 ($MTNRN_0$) to 475 kg/ ha^{-1}($CTSSN_{90}$).

2.2.2.3 Optimizing nutrient supply for enhanced productivity and stability

On-farm trials were conducted during 2004 at Reddypalem and Damera villages of Warangal district. Ten farmers from Damera and eleven farmers from Reddypalem villages were selected. INM treatment (INM with flat bed (N90 P45 K45 + 2 t FYM ha^{-1} + Zinc 30 kg ha^{-1} + green manure (inter crop mulch) + PSB + 2% DAP spray) was applied to half an acre in all the 21 selected fields and was compared with farmers practice (25 cartloads of FYM + 150-100-75 kg NPK ha^{-1}). The following results were obtained:

- Plants in the INM treatment were taller and robust when compared to those from the farmers practice. This was reflected in production of higher dry matter. At 80 and 110 DAS the dry matter with INM treatment was 16.8 and 14.5% higher, respectively over farmers practice.
- At all the stages of sampling, number of squares with INM treatment was higher compared to farmers method. There was 48, 13 and 18 % increase in number of squares with INM treatment compared to that from farmers practice at 55, 75 and 110 DAS, respectively.
- INM treatment produced 31, 14 and 12% higher bolls per plant at 75, 95 and 110 DAS, respectively over farmers practice.

2.2.3 Soil health improvement

2.2.3.1 Effect of long-term incorporation of horsegram biomass

Soils of rainfed regions are characterized by low organic carbon and poor fertility. Build-up of soil organic carbon (SOC) is difficult due to low biomass production and rapid oxidation under high

temperature and moisture that prevail. Although FYM use and green manuring proved effective in improving SOC and meeting N requirements partially, FYM availability is a problem and generating biomass in a non-competitive manner is difficult. However, scope exists to generate leguminous biomass non-competitively by utilizing 20 to 30% of annual rainfall received during post-rainy season in SAT Alfisol regions, which goes unutilized. This biomass can be incorporated *in situ* to improve SOC and meet nutrient requirements of subsequent *kharif* crops. A long-term field experiment was initiated in *kharif* 1994 at GRF at two sites with sorghum-sunflower rotation at site I and sunflower-sorghum rotation at site II. At both sites, in the main plots, horsegram was grown up to flowering and incorporated in one plot, other being fallow. Different fertilizer treatments were used as subplots. The trial was continued for 10 years and concluded in 2004. The cumulative impact of biomass incorporation was studied on soil quality parameters and crop yield. The main findings were :

- Horsegram biomass could be generated and incorporated ranging from 3.03 to 4.28 t ha^{-1} with different fertilizer treatments by using off season rainfall (70-100 mm) during 7 out of 10 years. Through this, on an average, 21 kg N, 6 kg P, 17 kg K and 7 kg S ha^{-1} could be added to soil annually.
- Soil organic carbon after 10 years ranged from 0.28 (N_0P_0) to 0.46% ($N_{50}P_{30}$) in fallow, and 0.37 (N_0P_0) to 0.53%($N_{50}P_{30}$) in incorporated plot at site I (initial OC 0.3%). At site II (initial OC 0.24%), SOC ranged from 0.27 (N_0P_0) to 0.41% ($N_{50}P_{30}$) in fallow, and 0.30(N_0P_0) to 0.52 % ($N_{50}P_{30}$). Microbial biomass carbon ranged from 114(N_0P_0) to 217mg g^{-1} ($N_{50}P_{30}$) in fallow and 128(N_0P_0) to 290 m g^{-1} ($N_{50}P_{30}$) in incorporated plots (Fig.12).

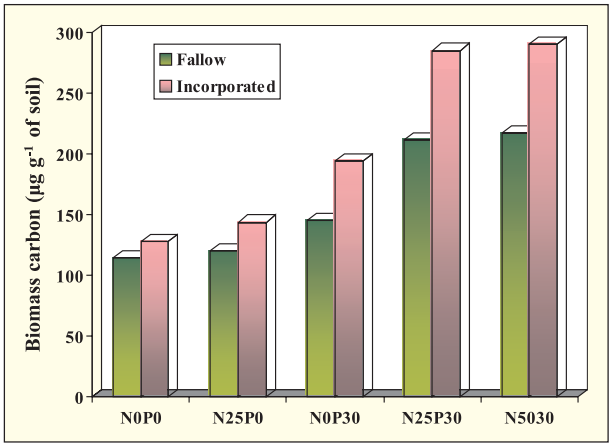


Fig.12. Effect of long-term horsegram incorporation on soil microbial biomass carbon

- Incorporation of horsegram biomass improved available nutrient status at all depths. Continuous application of N and P led to substantial build up of available P, whereas improvement in available N was not significant. Available K increased with incorporation but decreased with the application of $N_{50}P_{30}$.

To quantify the residual effects of biomass incorporation and nutrient application, sorghum and sunflower crops were raised during *kharif* 2004 without any fertilizer treatments. Both fertilizer and incorporation treatments significantly improved the grain yield (Table 9).

Table 9 Residual effect of horsegram incorporation and nutrient application on grain yield of sorghum and sunflower

Residual fertilizer	Sorghum (grain yield (kg ha^{-1})		Sunflower (seed yield (kg ha^{-1})	
treatments	Incorporated	Fallow	Incorporated	Fallow
N_0P_0	397	307	343	258
N_1P_0	758	570	525	436
N_0P_1	769	581	536	462
N_1P_1	1040	816	718	637
N_2P_1	1216	990	840	715

2.2.4 Evaluation of regenerative agricultural technology with low external inputs

Resource conserving and efficient farm technologies need to be designed and evaluated to improve the livelihood of resource poor farmers. The research priorities for the development of technologies for resource poor farmers (low-input) are to find practical farming methods that could not only be in tune with regenerative impulses of nature, but also enhance them. Such improvements prove more durable and sustainable but also appear to be more capable of revitalization and regeneration across time. The food production systems cause some degradation of the natural base, and restoration is not being done by the farmers. Seeking ways to restore or regenerate them toward their original state through making maximum use of the renewable internal resources is the need of the hour.

Keeping this in view, on-farm trials were initiated two years back focusing on groundnut shell as a manure to reduce the cost of fertilizer and maintain sustainable yield of groundnut. In the second year of the trials, efficiency of groundnut shell manure (prepared by spreading groundnut shells as cattle bedding material) was compared with other fertilizer treatments and farmers own methodology. The following results were obtained:

- Even with two dry spells occurring at flowering and pod filling stages, the yield was 10-12% higher in the groundnut shell manure applied fields over the farmers' practice which contained less organics. Compost-applied fields remained on par (Fig.13).

Bedding material

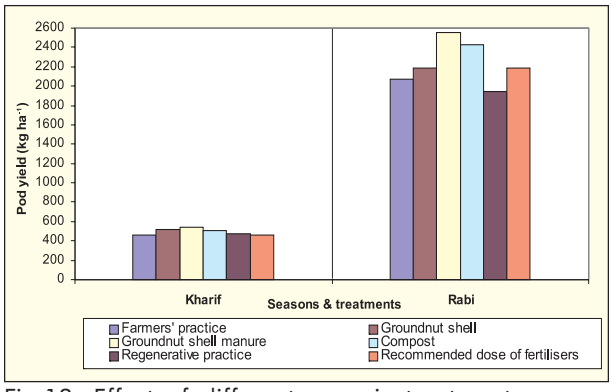


Fig.13. Effect of different organic treatments on pod yield of groundnut

- More number of pegs per groundnut plant were recorded due to increased flower number.
- Application of groundnut shell manure could be able to improve soil resilience over time to face intermittent droughts which are unpredictable and quite frequent.

2.2.5 Identifying systems for carbon sequestration and increased productivity

The study was undertaken to understand the impact of various agricultural practices and management levels as adopted by experimental stations and farmers on soil nutrient dynamics such as total N and P content, their relationship with soil organic carbon (SOC) in various land uses of semi arid tropical India with the aim of identifying potential carbon sequestering crop production systems. Some of the significant findings are summarized here.

- Significant positive correlation between total N and organic carbon, clay and fine clay were noticed at lower depths.
- In black soils, organic carbon was positively and significantly related to clay ($r=0.42$) and fine clay ($r=0.38$). Similarly, total P was positively and significantly correlated with SOC at 0-30 and 0-50 cm depth.

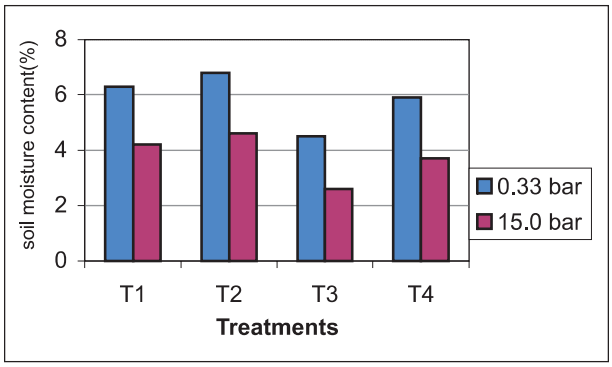


Fig.14. Soil water content at various tensions under teak

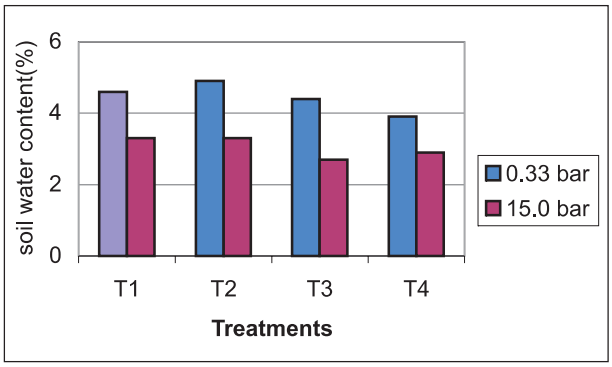


Fig.15. Soil water content at various tensions under subabul

T_1 = S:TS:C (1:1:1); T_2 = FA:C (2:1); T_3 = S:FA+TS:C (1:1:1); T_4 = S:FA:C (1:1:1); S= soil; TS = tank silt; C = Compost; FA = fly ash

- High levels of management improved the soil fertility in black and red soils through increase in SOC and major nutrient contents. Horti-cultural, forest, permanent grasslands and few agricultural-based systems like cereals, soybean and cotton were identified suitable for SAT India.

2.2.6 Alternate uses of fly ash

The effect of fly ash on soil physical and chemical properties, and subsequently on teak and sababul, was being investigated at CRIDA research farm in a three-year-old agrisilviculture system for the past three years. In the concluding year, the following results were obtained:

- The higher dose of fly ash (2 parts fly ash:1 part compost) could maintain higher soil water content at 0.33 and 15.0 bar tension (Fig.14&15).

2.3 Rainwater management

In rainfed areas, water is life. The main source of water here is rainfall which is meager and not well distributed. Every drop counts and thus proper and effective rainwater management is the main issue. Farmers have been practicing rainwater conservation for quite some time by making suitable amendments in the field. The extension, amalgamation and improvement in these practices, in recent times, led to the development of watershed which is a unified and all encompassing concept and takes into consideration not only water and soil conservation and cropping systems but also the community as a whole. CRIDA has been a pioneer in this field and led to development of watershed models. Continuing these efforts and expanding the areas of operation, this year too, age old practices like conservation furrows and depressions were critically evaluated and suitably modified, watershed-based strategies were designed, regional scale models for watersheds were prepared, and assessment of impact of land management practices was carried out. Later in the year, a major comprehensive activity on rainfall-runoff - ground water dynamics in a watershed mode was initiated, results of which are likely to be very useful. Some of the findings of research and developmental activities are summarized here.

2.3.1 Evaluation of management practices

2.3.1.1 Evaluation and improvement of indigenous methods of moisture conservation and run-off management

Effect of conservation furrows in castor and pigeonpea intercropping system (5:1) was evaluated in five villages of Nalgonda district of Andhra Pradesh over a period of three years. The results are as under :

- Conservation furrows at 3.6 m interval proved significantly superior in increasing the yield of castor (14%) and pigeonpea (15%) as compared to control which yielded 350 kg of castor and 67 kg ha^{-1} pigeonpea (Table 10).

Table 10 Yield of castor+pigeonpea intercropping system as influenced by conservation furrows

Village	Farmer(F)	Castor mean yield (kg ha^{-1})		Pigeonpea mean yield (kg ha^{-1})	
		Control	Conservation furrow	Control	Conservation furrow
Chintapalli	F1	387	437	74	83
	F2	373	423	66	75
Gollapalli	F3	333	386	67	76
	F4	340	361	67	77
Kurmedu	F5	322	399	63	72
	F6	334	397	59	68
Nasarlapalli	F7	372	415	74	85
	F8	377	425	72	81
Vinjamuru	F9	331	380	64	72
	F10	326	370	65	73
Average		350	399	67	76

- The increase in the yield of components crops in the system was due to higher moisture conservation in the soil profile which ranged from 11-14% in different years (Fig.16).

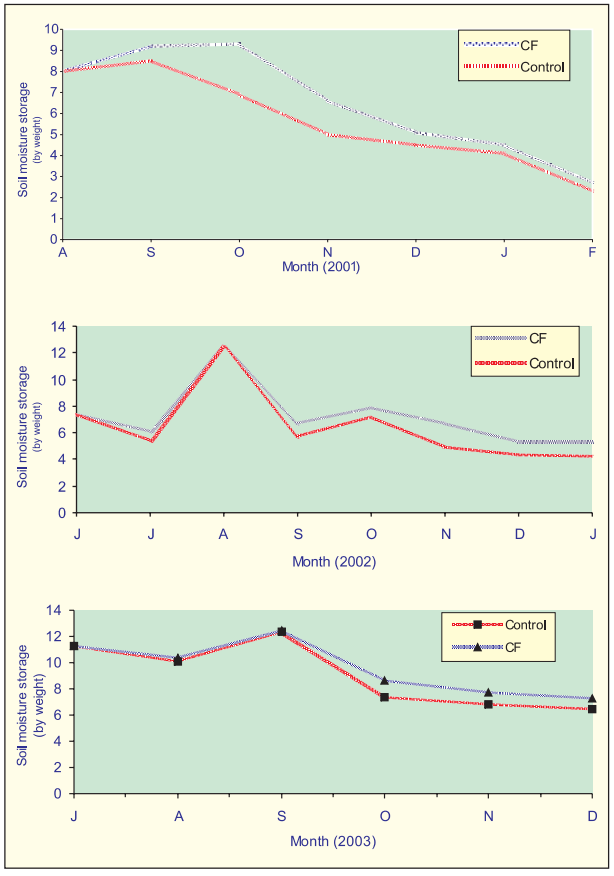


Fig.16. Soil moisture as affected by conservation furrow during 2001-2003

2.3.1.2 Rain water management for teak and mango

With increasing demand for agricultural products, pressure on dryland is increasing rapidly. Growing teak, neem or mango is a good option in rainfed areas to get higher productivity and profitability. With limited water resources, dryland areas can be improved with micro water harvesting or rainwater management. In this context an experiment was conducted at CRIDA research farm (Alfisol) to study the effect of making a few 15-30 cm deep depressions in the basins of three-year old teak and mango trees. This was compared with the conventional basin method of rainwater conservation. These treatments were superimposed with and without mulch (grass mulch of 5 cm thickness applied during June), a CRIDA intervention, to increase retention of moisture. The salient findings of the study were:

- The studies on growth parameters on mango showed that use of grass mulch on an average increased the height, collar diameter, canopy spread (N-S) and canopy spread (W-E) by 1.18, 0.29, 0.67 and 1.55 % as compared to no mulch. Among the treatments the ITK with depressions enhanced the height and canopy spread (N-S) by 1.07 and 1.34 % as compared

Mango-basin with depressions

Teak-basins

to the traditional practice of conventional basin without depressions.

- The growth parameters in teak on an average resulted in gaining higher height, collar diameter and canopy spread (W-E) by 0.98, 1.2 and 1.85 % by using grass mulch respectively over no grass mulch. Use of ITK (depressions) enhanced the height, collar diameter, canopy spread (N-S) and canopy spread (W-E) by 2.37, 1.02, 2.0 and 3.3 % over the conventional basin without depressions.
- Moisture distribution in mango and teak followed similar pattern. Places lying on the circle of depressions retained more water. Water retention was reduced in both directions (inward and outward) from the circle. With increased depth of the soil, more water was retained. Among the treatments tested, traditional basins along with depressions and mulch conserved and retained more water by 1.7, 2.0, 0.7 and 1.8% respectively over control at 0.15 cm, 15-30 cm, 30-45 cm and 45-60 cm soil profile depth in teak while in mango higher moisture was retained (2.7, 3.2, 3.3 and 2% more moisture) by conservation basin with depression and grass mulch as compared to conservation basin only. But these depressions had no clear advantage over traditional basins in terms of water retention, and further studies are needed for obtaining detailed information.

2.3.1.3 **Evaluation of conservation furrows in Alfisol**

Conservation furrows are being recommended for better retention of rain water in Alfisols with a view to capture the occasional runoff and make it available to the crop grown. Although numerous citings show benefits of such practices, 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 and the high antecedent moisture content generally associated with runoff producing storms, which in itself are few in a crop growing period. Hence a study was planned to study critically the effect of conservation furrows on moisture conservation and its effect on castor yield. Significant results were:

- Although the treatment differences were not statistically significant, conservation furrow at 0.9 m spacing recorded 17, 22, 10 and 19% higher yield over conservation furrow at 1.8, 2.7, 3.6 and no furrow, respectively.

Treatments	Yield (kg ha^{-1})
Conservation furrow at 0.9 m spacing	967
Conservation furrow at 1.8 m spacing	828
Conservation furrow at 2.7 m spacing	795
Conservation furrow at 3.6 m spacing	883
Control	813

- Soil moisture retention was generally higher in treated than the control plots. However, no clear trend of moisture content vis-à-vis furrow spacings could be observed. The moisture near the furrows was higher by 0.26 to 5.30% compared to the plot mean.

2.3.2 Watershed and rainfall management

2.3.2.1 Development of regional scale watershed plans and methodologies for prioritized land treatment

The watershed concept provides a holistic approach for the overall development of an area and represents the principal vehicle for transfer of agricultural technology. The approach aims to optimize moisture restoration, reduce soil erosion and maximize productivity of the land. In the light of easy availability of remote sensing technologies, this short-term study of nearly four years, was conceptualized for developing regional level watershed plans, prioritizing critical areas and identifying action plans, all in a participatory mode. During the period, a comprehensive methodology was developed for prioritizing critical areas for taking up developmental activities in S.S. pally micro watershed of Nalgonda district, A.P. The local farmers/villagers took keen interest in the project activities even though drought prevailed all through the project period. A number of interventions in soil and water conservation and crops and cropping systems were introduced. Their impact and key learnings from the study are detailed below:

- Field bunds across the slopes, diversion channels, waterways, gully plugging by gabion structure, recharging pits, percolation ponds and sand bag checks were constructed/installed at appropriate places for preserving rainwater and soil loss. A participatory ground water monitoring exercise showed a one metre increase in water level, despite 2004 being a dry year (Fig.17). Similarly, a 50% reduction in run off was measured. It was also found that four tons of soil was conserved by gabion and check dams, and that 15 ha area saved from soil and gully erosion.

Green capping of bunds with stylo

- Introduction of sorghum cv SPV-462 led to improvement in productivity of sorghum by 25 to 30%. Farmers also developed a liking for cultivating castor cv Kranti being a drought tolerant, hardy, remunerative and less risky crop.

- For proper utilization of resources, a number of alternate land use measures were initiated like green capping of bunds/waterways by *Urochloa, Panicum, Cenchrus* and *Stylosanthes,* introduction of sweet orange, sapota, mango and curry leaf, and avenue plantation by *jamun*, tulip tree, cassia and sissoo. For protection of trees, a low cost bamboo tree guard, costing Rs. 300 was recommended. Local artisans were encouraged to make these guards for increasing their income. These measures led to make the village more greener which was otherwise a scrub jungle.

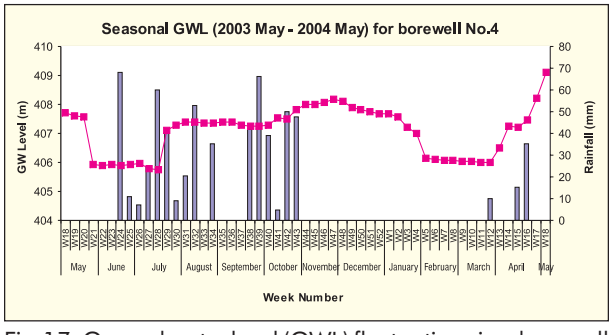


Fig.17. Ground water level (GWL) fluctuations in a borewell

Discussion with local artisans for manufacture of bamboo guards

Key learning

1. Socio-economic criteria may be integrated with biophysical parameters for prioritization of critical areas for development.
2. The demonstration of action learning tools like portable twin plot rainfall simulator helped in creating better understanding of resource conservation by land management amongst the villagers.
3. Topographic survey is a must before initiation of the programme at a micro level and gives sound footing for integrating technical plan with PRA exercise for developing joint action plan. During the survey, minor details like survey number, soil, vegetation and land uses may be collected for making the action plan more useful to the beneficiaries. Survey is needed as the Survey of India map does not give all the details and the contours are drawn at wider intervals (20 m).
4. Interventions like application of gypsum in farmers' fields with alkaline soil reaction could amend the soil and lead to increased yield. This type of problem-oriented intervention builds the confidence and satisfaction of the farmers.
5. Considering the high level of spatial variation in rainfall at micro level, a rain gauge should be invariably fixed in the watershed area to record the actual rainfall.
6. The runoff producing rainfall was 53% of total rainfall (471 mm), which was reduced to 21% in case of treated area.
7. For design of overflow structures in the cultivated field the rainfall intensity of 50 mm h^{-1} may be sufficient. For designing water harvesting structures 100m^3 storage from one hectare of catchment can be considered.
8. To make the plantation programme successful, low cost tree guards made of bamboo may be introduced besides supplemental irrigation during dry period in the first year.
9. From the land use survey it was clear that the palmyra plants are drought resistant and more useful to this area and the village community. Traditionally neem is grown in this area and is liked by the farmers for its medicinal and timber values. Pongamia is grown along the waterways and potential exists to produce lubricant and bio-diesel from seed and to use its leaves and cake as green manure.
10. The villagers should be involved from the beginning for participatory monitoring of watershed activities. Participatory hydrological monitoring of ground water increases the awareness of the farming community on resource depletion or improvement.
11. The gauging device for measuring runoff and soil loss may be invariably installed at some hot spots for creating awareness on resource losses and the effectiveness of conservation measures in arresting them as a part of monitoring and evaluation programme.
12. Farmers are in need of good quality seed and planting material, even without subsidy, to increase the present yield level.

2.3.2.2 Watershed-based NRM Strategies

Experiments conducted at Prakasam district, AP and involving live-bed, cover cropping, tree-

crop interaction and harvesting-recycling of water through networking of farm ponds were initiated in 2002 for developing strategies for resource conservation, effective utilization of rainwater for improving the yield of tobacco, and introducing agro-forestry for land use diversification. Results obtained during the past three years are described here.

- Live-beds occupied an area of 4.4% in the first year and 6.6% in the second due to luxuriant growth of Gliricidia. The biomass production was low in the first year but improved subsequently. In the first year the dry matter production was 0.67 kg m^{-2} (only stylo) compared to 1.85 kg m^{-2} (stylo plus Gliricidia). The yield of stylo declined in the second year due to shading of Gliricidia.
- Sunnhemp, greengram and cowpea as cover crops were raised during the monsoon. Dry matter production from greengram, cowpea and sunnhemp was 690, 901 and 1693 kg ha^{-1}, respectively in the first year, and 2620, 3820, 4670 kg ha^{-1}, respectively in the second. The production of biomass was less in the initial year due to prolonged dry spells. Incorporation of sunhemp biomass resulted in a saving of 12.5 kg N ha^{-1}.
- Agroforestry trials involved three fast growing tree species namely casuarina, *subabul* and eucalyptus. All the tree species recorded very good survival (>90%) but eucalyptus attained higher plant height(6m) and dbh (11 cm) than *subabul* (4m, 10 cm) and casuarina (2m, 6cm). But for guinea grass, yield of blackgram, *kalmegh* and tobacco as intercrops did not vary significantly with tree species. The yield of intercrops showed a declining trend in the second year, more so under eucalyptus. Guinea grass yield declined from 95 to 84%, *Kalmegh* 93 to 90%, blackgram 88 to 75%, and tobacco (cured leaf) from 96 to 76%. Trees reduced the yield of the adjacent crop rows more than the middle ones.
- Waterways were designed for safe disposal and harvest of rainwater based on catchment area, rainfall intensity and peak flow rate. A total length of 3926 m of waterways was dug out for networking of different storage structures. A handsome 8340m^3 amount of water was harvested in different storage structures from 40 ha micro-watershed. This water was found sufficient to irrigate 16 ha tabacco area once, and resulted in saving of the crop and an additional net return of Rs.7890 ha^{-1}.

2.3.2.3 Assessment of impact of sustainable land management practices

In this recently initiated study, watersheds developed by various government and non-government organizations after 1995 in consonance with the revised NWDPRA guidelines, and located in AESR 7.2 encompassing Ranga Reddy and Medak districts of Andhra Pradesh are being evaluated for sustainable land management practices. These watersheds are being compared with neighboring untreated watersheds using a wide variety of robust bio-physical and socio-economic indicators of sustainability.

Reconnaissance survey of five watersheds was undertaken during October-November 2004. Cadastral maps of villages from Map Sales Office of State Government and drainage chanels and contour lines digitized from Survey of India. Topographical maps were utilized to delineate micro-watersheds and classify them in an hierarchy according to the procedure implemented at CRIDA earlier under IVLP Program at Nallavelli Village in 1996. Under this scheme, the hierarchy put forth by All India Soil & Land Use Survey in 1988 in the National Watershed Atlas has been extended to first-order streams. While in the National Watershed Atlas, stream order have been classified from the fourth (Watershed level) through eighth order (Water Resources Region), in CRIDA this hierarchy scheme was extended to include first, second and third order streams also as they were found crucial for

water resources planning in rainfed regions. The donor area of first order stream is thus identified as a micro-watershed and all programs pertaining to watershed development and management are focused in this area. The micro-watersheds identified for this study were located, delineated and nested within the regional watershed to understand the flow process of water, soil, nutrient and energy.

Core issues which would impact sustainability of agricultural production in the selected watersheds were identified. These are status of water resource, soil and vegetative cover, importance of agriculture in village economy, alternative source of livelihood, social and economic structure in the village and institutional support in the form of government initiatives and support, economic policy, macro-economics, socio-political conditions, and the like. Suitable indicators addressing the core issues in the watersheds were selected for evaluation. The impact of land management practices introduced in these treated watersheds is under study using satellite imageries of IRS-1B LISS-II of November 1997, IRS-1D LISS-III of March 2001 and IRS-P6 LISS-III of October 2004. Interpretation of satellite data and assessment of sustainable indicators, viz., vegetative vigour as indicated by NDVI, net ground vegetative cover, environmental integrity

Interaction with farmers at Chintapatla village

of vegetative cover, soil erosion levels, water harvesting, water utilization indicated as extent of cultivation, safe disposal of surplus water and water quality as indicated by NDWI are being estimated for the watersheds.

- Preliminary analysis reveals that the watershed programs have benefited the villagers to a certain extent but the farming community desires a more holistic program for the development of villages. Program implementation varied from one agency to another leading to differential response which was often not comparable. While water harvesting was at the core of watershed development program, soil conservation measures were not highlighted. The farmers

A failed water harvesting structure due to lack of support mechanism at village level- Chintapatla, near Ibrahimpatnam

Farm woman, a beneficiary of SHG 'Sangam', explaining efficiency of check-dam constructed by DDS at Metlakunta village, near Zahirabad

who were interviewed during this period, stressed the need for government sponsored integrated development programs that would ensure income throughout the year.

2.3.3 Monitoring and evaluation of micro irrigation systems

This sponsored project was undertaken to evaluate the micro irrigation systems installed in farmer' fields for system's design, installation, quality of agronomic and extension services. The monitoring and evaluation was carried out for a sample of 10% of installations in drought prone Anantapur, Kurnool, Kadapa and Chittoor districts of A.P. About 400 installations were evaluated so far. Some of the findings are as under :

- On the whole farmers were satisfied about the overall functioning of the micro irrigation systems, but feel that there is still a scope for improvement in design, installation, agronomic services and water management.
- In most cases quality of the product was as per standard and the design optimum.
- Quite a few firms were not providing adequate field demonstrations on after-care and maintenance, utility of fertigation and the like.
- In some cases it was observed that due to unreliable electricity supply, there is more water consumption because the farmers kept the system permanently open.

2.4 Crops and Cropping Systems

Prevalence of crops and cropping systems in a region is dictated by the climatic and edaphic factors particular to it. During the past, as a result of a number of on-station and on-farm research on crops and cropping systems, a number of useful recommendations were made on usage of cultivars, package of practices for various crops, cropping systems and the like. Continuing these efforts, this year too a number of basic and applied experiments were conducted on identification of cultivars, abiotic and biotic stresses, genetic transformation of dryland crops, physiological mechanisms for drought tolerance, IPM in dryland crops, and farming system modules, to name a few. These concerted efforts have led to break throughs in developing transgenic drought tolerant sorghum, identification of Bt isolates for management of dryland pests, and development of IPM modules for dryland crops. These alongwith some other research highlights are described below:

2.4.1 Crops

2.4.1.1 Evaluation of maize for sustainable grain, fodder and silage production

The study was taken up to quantify the growth and productivity of maize under different levels of fertilizer application along with harvesting techniques for enhanced production of grain and fodder. The maize cultivars (viz., Harsha, DHM-105, African Tall, and Teosinte) were grown with varied fertilizer treatments consisting of inorganic(100%), inorganic(50%)+ FYM(50%) and FYM(100%). The inorganic treatment was through the recommended dose of 40N:30P_2O_5 as basal and 20 N through urea as top dressing. In the other two treatments, the nutrients were supplemented through 50% FYM and 100% FYM, respectively. The salient findings were (Table 11):

- The productivity under triple harvesting technique under various fertilizer treatments revealed that the fresh fodder weight and grain yield were higher with FYM followed by inorganic +FYM treatment and the inorganic one.
- In the varietal response to triple harvesting technique for fresh fodder above the cobs, the hybrid DHM-105 performed better followed by cvs Harsha and African Tall. Grain yield in the triple harvesting technique followed similar trend.
- In the full plant harvest for fresh fodder weight at tasselling, higher yield was recorded in the

Table 11 Seed and fodder yield of maize cultivars

Cultivar	Seed wt. FP (F)	Seed wt. (c) HP(F)	Fresh fodder wt. FP(T)	Fresh fodder wt. (a)HP(T)	Dry fodder wt. FP(T)	Dry fodder wt. (b) HP(F)
Inorganic						
Harsha	41.73	38.93	234.66	47.33	57.26	26.93
DHM-105	46.00	44.00	262.00	48.33	59.80	22.33
African Tall	35.60	32.40	293.00	39.66	66.73	29.06
Teosinte	19.60	-	263.66	-	75.33	-
Average	**35.73**	**38.44**	**263.33**	**45.11**	**64.78**	**26.10**
Harsha	44.06	41.80	287.00	54.33	72.06	32.26
DHM-105	48.80	43.20	342.00	59.66	76.93	29.40
African Tall	36.40	33.13	394.66	41.00	81.73	38.26
Teosinte	21.66	-	349.66	-	85.33	-
Average	**37.73**	**39.37**	**343.33**	**51.66**	**79.01**	**33.31**
FYM						
Harsha	47.00	42.40	295.00	51.33	63.53	30.46
DHM-105	48.53	44.06	321.00	58.33	66.00	21.13
African Tall	37.93	34.46	379.33	49.00	71.13	36.93
Teosinte	22.46	-	376.66	-	76.73	-
	38.98	**40.31**	**343.00**	**52.88**	**69.34**	**29.51**

Wt.= weight g plant^{-1}; FP = Full plant; HP= Half plant; T=Tasseling (100% completed) stage; F= Final harvest stage; a = Harvest above cob; b = Remaining part of plant after (a); c = Seed weight from (b)

cv African Tall followed by cvs Teosinte,DHM-105 and Harsha. However in the full plant harvest for dry weight at final harvest, Teosinte yielded the highest followed by cvs African Tall, DHM-105 and Harsha. The grain yield at full plant final harvest showed that the highest yielder was by DHM-105 following by cvs Harsha and African Tall.

- Cv Harsha was the earliest to flower with lowest Anthesis-Silking Interval(ASI), an index for tolerance to moisture stress, followed by DHM-105, African Tall and Teosinte.

2.4.1.2 **Evaluation of sunflower cultivars**

In order to validate the results obtained during the past four years on evaluation of three sunflower cultivars (Morden, KBSH1 and MSFH17), a number of on-farm demonstrations were conducted in Wanaparthy mandal of Mahabubnagar district, A.P. to display to the farmers the superiority of recommended practices over farmers method. Significant outcome and impact made are described below :

- Sunflower cultivated in deep soil recorded 24% higher yield over that planted in shallow soil.
- Hybrid KBSH1(1202 kg ha^{-1}) was distinctly superior to the next best check cv Morden (1059) in both seed and oil yield. The hybrid performed well under resource constraint conditions of moisture and nutrition also.
- Sunflower, particularly cultivar KBSH-1, has caught the fancy of the farmers who are preferring it over traditional crops like castor and sorghum. The area under this crop has increased by 20% this year due to delay in the onset of the monsoon.
- Recommended moisture conservation practice (deep tillage, conservation furrow) and fertilizer application (60 N: 30 P_2O_5 : 30 K_20) increased yield by 17 and 16% over farmers methods (no conservation practice; 9N+23 P_20_5) and recorded

an additional return of Rs 1979 and Rs 2194 ha^{-1}, respectively over farmers' method.

2.4.1.3 Decision support system for major rainfed crops

An effort was made to develop a decision support system based on long term agro-climatic data (maximum and minimum temperature, RH_1, RH_2, wind speed, sunshine hours, evaporation, rainfall) for rice, wheat, sorghum, groundnut, maize, pearlmillet, soybean, mustard, chickpea and potato. This system would serve as a practical tool for improving the existing weather-based agro-advisory services and facilitate issuing advice for day-to-day agricultural operations.

A programme in Micro Soft Visual Basic (VB) was developed to calculate daily normal values of various weather parameters, day length of any day at selected stations based on latitudes, Potential Evapotranspiration (PET) based on temperature using Campbell and Diaz method, a crop specific water balance model for calculating phenological stage wise actual evapotranspiration (AET), water requirement (PE), water surplus (WS), water deficit (WD), moisture adequacy index (MAI), and the like.

As a case study, the model was run for rice crop, taking into account the crop specific inputs like degree-days requirement for each stage of some varieties, and crop coefficient values. In the model, based on total degree-days requirement, phenological stages were identified taking the temperature as input. The user has to select the station name, crop, and its sowing date in order to compute the water balance. A screen has been developed to perform calculations of water balance parameters for a specific year and also for all the years in the database. The output file displays average MAI and cumulative values of PET and AET, for each crop growth stage and also for the total crop growing period. Based on this information, Agromet-advisory Units can advice the farmers for scheduling irrigation to different crops.

A program was also developed to work out the deviation of actual weather parameters from normal during the crop-growing period starting from sowing date. The output displays the deviations of various weather parameters and length of abnormal weather conditions during various phenological stages of any crop. A program to identify the frequency and duration of dry and wet spells during the crop-growing season from sowing date has also been developed. A home page containing this software was created to incorporate all these programs into the main program of Decision Support System which will be later linked to appropriate website/s.

2.4.2 Cropping systems

2.4.2.1 Farming systems modules for rainfed environment

The productivity of rainfed crops in Southern Telangana Zone, Andhra Pradesh often fluctuate due to vagaries of rainfall. In order to get stable profitability, there is a need to integrate livestock with arable crops. In this context, farming systems modules were documented in marginal (< one hectare) and small farmers (1.0-2.0 ha) in Vertisols of Manmarri and Alfisols of Antharam of Shabad Mandal, Ranga Reddy District.

Vertisols

The studies indicated that, among the cropping systems of 0.8 ha area, maize- coriander-

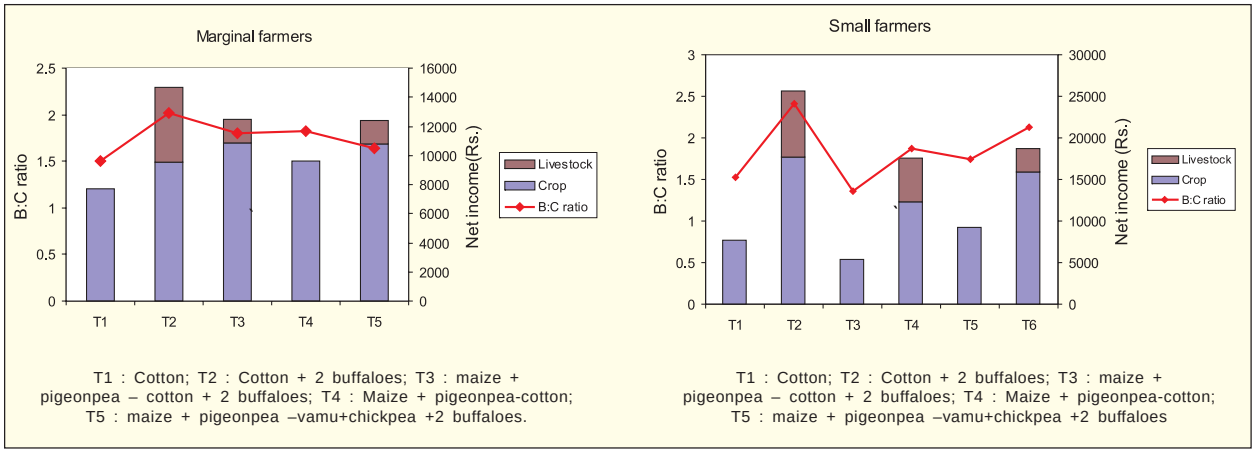


Fig.18. Influence of farming system modules on productivity and profitability (Vertisols)

chickpea system recorded highest net income of Rs.18,925 followed by cotton (Rs.13,880) while maize + pigeonpea system gave net returns of Rs.11,467. Maize- coriander-chickpea gave higher BC ratio of 3.18 followed by maize + pigeonpea (2.37) and coriander-chickpea (2.29). Integration of two buffaloes with cotton crop recorded a net income Rs.14,647 with a BC ratio of 1.60. But two buffaloes with a part of cotton system contributed Rs.5,100 to the net income along with by-product of 1000 kg FYM. Maize + pigeonpea-cotton along with two buffaloes was equally profitable and yielded a net income of Rs.17175 (Fig.18).

Small farmers growing cotton-maize + pigeonpea-coriander + chickpea registered highest net returns of Rs.14,400 followed by maize + pigeonpea-cotton-castor system. Integration of two buffaloes in maize + pigeonpea-cotton recorded higher gross income of Rs.47,090 followed by cotton Rs.42,700. Cotton with two buffaloes recorded the highest net income (Rs.25,050) followed by maize with one animal (Rs.18680) and maize + pigeonpea-cotton system (Rs.17,523).

Alfisols

At Antharam where Alfisols are predominant maize+pigeonpea and maize+pigeonpea recorded the highest net income (Rs.12,325) followed by maize+pigeonpea-cotton system (Rs.9780) in 0.8 hectares area. Maize + pigeonpea and maize+pigeonpea systems recorded the higher BC ratio (2.52) followed by maize+ pigeonpea (1.97) and maize+pigeonpea-cotton system (1.89) of castor–sorghum+pigeonpea-carrot+chickpea system gave higher net income of Rs.15,225 followed

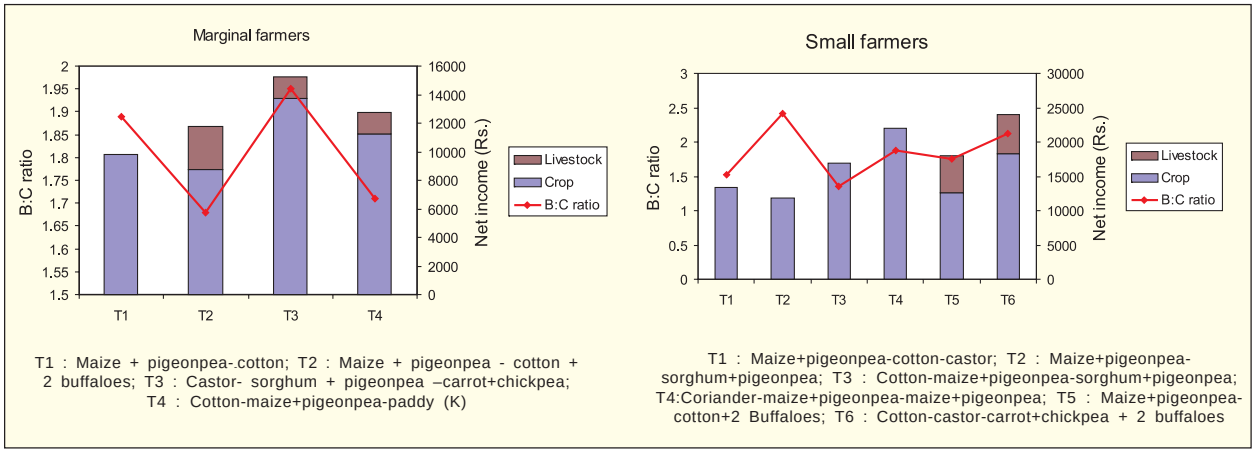


Fig.19. Influence of farming system modules on productivity and profitability (Alfisols)

by cotton–maize+pigeonpea-paddy along with two buffaloes (Rs.12,740). The animal component in the system contributed Rs.1500 to the net income with 1000kg FYM as a bonus by-product. (Fig.19).

Among the cropping systems without buffaloes coriander–maize+pigeonpea system gave the highest net returns followed by cotton–maize+pigeonpea-sorghum+pigeonpea system (Rs.16,980) in 1.24 ha. Coriander–maize+pigeonpea and maize+pigeonpea–sorghum and pigeonpea system gave similar BC ratio (2.28-2.35) followed by cotton–maize+pigeonpea-Sorghum+pigeonpea system.

Demonstrative Farming System Module at CRIDA

A farming system module covering 0.53 ha was initiated on a watershed basis at CRIDA farm during this year. The arable cropping systems comprising castor + cluster bean (1:1), pearlmillet+pigeonpea (3:1), sorghum+pigeonpea (3:1) and sunflower- horsegram were grown in 0.3 ha. As a part of horticulture component tomato, brinjal (525 m^2), and custard apple, *amla* (.08 and 0.1 ha) were also grown. Drumstick, perennial pigeonpea, and *henna* were grown along the bunds. Preliminary results indicated that the arable crops in different systems under limited irrigation realized a net income of Rs.4188 and a BC ratio of 2.27 inspite of severe drought experienced during different physiological growth stages of the crops. Tomato, *bhindi*, brinjal and curry leaf recorded a gross income of Rs.402, 588, 750 and 27, respectively. Due to severe drought, teak and *henna* were given life saving irrigation. Stylo, cenchrus and lemon grass were established in the month of July and had 50-70% survival.

2.4.3 Abiotic stress

2.4.3.1 Enhancing tolerance of sorghum to abiotic stresses through genetic manipulation

Sorghum is an important staple food crop of the drylands, Erratic rainfall and frequent and intermittent and terminal dry spells seriously affect its yield with losses 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. Present research project deals with the transformation of sorghum cv SPV-462 by introduction of mtlD gene (mannitol-1 phosphate dehydrogenase which catalyses the conversion of mannitol-1-phosphate o mannitol) for biosynthesis of mannitol. A highly efficient, robust, rapid and season independent protocol for plant regeneration from shoot apices has been developed. Suitable binary vectors were constructed with constitutive promoter. Conditions for microprojectile bombardment were optimized with Gene Pro 2000 He for achieving higher frequency of transformation, which was confirmed by frequency of GUS expression. Regeneration and rooting of plantlets from transformed calli selected on hygromycin was achieved. Molecular characterization using PCR and Southern analysis confirmed the integration of trans-gene into the genome of the transgenic plant. The details are:

- For transformation of sorghum calli derived from shoot apices two gene constructs namely, *pCB mtlD CRIDA1 (mtlD* gene cloned in *pCAMBIA 1305.1*) *and pCB mtlD CRIDA2 (mtlD* gene cloned in *pCAMBIA 1300)* were used. Transient gene expression was monitored using histo-chemical staining of cells for GUS activity with 5-bromo-4-chloro-3-indolyl glucuronide (XGLUC) in case of the construct *pCB mtlD CRIDA1*. Calli were incubated in dark 24h after bombardment and GUS assays were carried out according to standard procedures (Tables 12&13).
- Shoot tip derived calli were bombarded with *pCB mtlD CRIDA1 & 2* binary vectors containing npt II for bacterial selectable marker and hptII for plant selectable marker genes. Approximately 400 calli were bombarded per week and the putative transformants were selected on media containing hygromycin @6mgL^{-1} (Fig.20).

Table 12 Frequency of GUS expression in sorghum calli after bombardment

Number of calli tested	Number of calli GUS +ve	Frequency of GUS expression(%)	Number of spots per calli (range)
30	26	86.7	1- 15
30	26	86.7	1- 11
30	18	60.0	1- 13

Table 13 Regeneration frequency subsequent to bombardment

Number of calli bombarded	Number of calli transferred for regeneration	Number of putative transgenic plantlets selected
400	69	18
400	96	28
400	83	22

Fig.20. Putative transgenic sorghum plantlets

- The regeneration frequency after transformation was around 41% and about 23 shoots differentiated per callus (Table 13). Plantlets surviving on media containing hygromycin were used for rooting, hardening (Fig.20) and for subsequent molecular characterization by PCR and southern analyses.
- Genomic DNA isolated from mtlD putative transgenics was digested with EcoRI, KpnI and EcoRV and separated on 0.8% agarose gel and blotted onto nylon (Hybond) membrane by capillary method. The membrane was UV cross-linked and hybridized using *mtlD* probe. Non-radioactive protocols (Alkaphos direct labeling and detection system, Amersham Biosciences) were used for Southern hybridization of DNA. Southern analyses established integration of the transgene sequence into the genome of the transgenic plantlets (Fig.22). The DNA from the non-transformed plants did not show any signal. All the four plants tested with EcoRI, KpnI and EcoRV sites, revealed integration of the transgene.

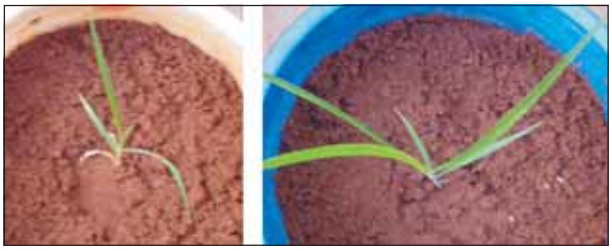


Fig.21. Putative transgenic plantlets being hardened

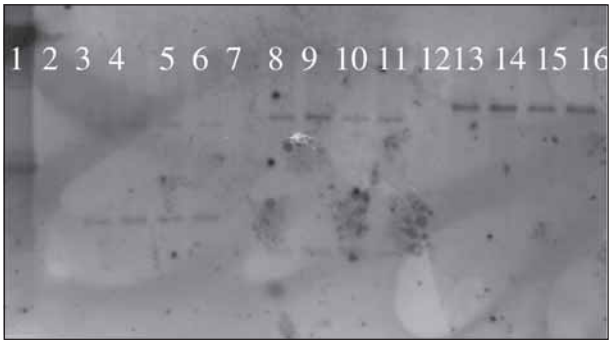


Fig.22. Southern confirmation of putative transgenics

2.4.3.2 Genetic transformation of greengram for enhancing abiotic stress tolerance

The yield levels of present day greengram varieties are quite low and unstable. This can be attributed to large number of biotic and abiotic stresses faced by the crop during different phenological stages. Since the crop is grown mainly under rainfed situations and since sufficient and satisfactory level of genetic variability for abiotic stress tolerance, mainly drought, is lacking it is imperative to introduce alien genes of recognized relevance into elite germplasm for enhancing crop productivity. Low regeneration and genetic transformation frequency reported in greengram appear to be a major impediment for developing stress tolerant transgenics.

Present study is aimed at introduction of annexin bj (Source: *Brassica juncea*) gene into a popular greengram cultivar. The gene is known to impart tolerance to moisture stress by relieving oxidative stress. The success of transformation in crop plants of interest basically depend upon the availability of an efficient regeneration system. To standardize conditions for an efficient regeneration system, attempts have been made to induce embryogenic calli from various explants (cotyledon, cotyledonary node, leaf, epicotyl and hypocotyl) on media supplemented with different combination of plant growth regulators. Subsequently these calli were tested for shoot regeneration on a variety of media and a combination of plant growth regulators. Preliminary results indicate a very high frequency of calli using somatic embryogenesis from cotyledonary node explants cultured on MS medium containing Benzyl Adenine (2mg L^{-1}) and Thiodiazuron (0.4 mg L^{-1}). However, only a moderate level of regeneration was achieved on 1/2 MS, 1/3 MS and MS containing IBA (0.8 mg L^{-1}). Efforts are continuing to improve the efficiency of shoot regeneration from embroyogenic calli. In order to optimize various conditions for biolistic as well as Agrobacterium mediated transformation, 14-day old cotyledonary node calli and young leaves were transformed with pCAMBIA vectors 1305.1 and 2301 having GUS as reporter gene function. GUS frequency was measured to verify the transformation event and for assessing the transformation frequency. A reasonably good GUS expression was observed by using both the approaches of transformation.

2.4.3.3 Mechanisms of drought tolerance in rainfed short duration pulses

Under rainfed tropical conditions, short duration pulses such as greengram, blackgram and cowpea are usually grown in conditions of frequent water deficit. The resistance of plants to drought stress mainly depends on two types of adaptations-drought avoidance and tolerance. It includes whole plant mechanisms that provide the plant to respond and survive drought. Therefore an attempt was made to understand the physiological responses of short term water deficits and its relief on water relations, accumulation of metabolites and yield in greengram. Significant results are given below.

- Increasing water deficit stress imposed at flowering by withholding water in greengram cvs ML-267 and WGG-37 decreased relative water content, leaf water potential and osmotic potential gradually from zero day to 16 days after imposing moisture stress. Both the varieties recovered from stress 48 h after re-watering.
- Levels of total soluble sugars, free amino acids and proline were assessed during stress and 48 h after re-watering. Total soluble sugars and proline accumulation was 2-2.5 fold in both the varieties during stress and their levels recovered to that of control, 48 h after re-watering indicating their role in osmotic adjustment.
- Total dry matter, grain yield, pod and seed number/ plant decreased significantly with water stress in both the varieties. The decrease in hundred seed weight and harvest index was not significant.

2.4.4 Biotic stress

Plant protection assumes greater importance in dryland crops which are grown in resource poor environments. Strategies that aim at reducing the

share of protection costs in the cost of cultivation such as forewarning of pest occurrences, conserving and augmenting the natural control processes in crop environments, maintaining crop diversity, capacity building through participatory approaches in IPM and reducing dependency on external inputs are in focus at CRIDA without affecting stability in crop yield and enhancing profitability of dryland crops. The following are the significant findings:

2.4.4.1 **Forewarning castor semilooper**

Semilooper is a key pest of castor in Andhra Pradesh and the severity of different broods on castor is usually dependent on prevalence of favorable weather. An attempt was made to assess the influence of weather factors on castor semilooper oviposition. Analysis of four year data (2001-2004) on weekly pest count and corresponding weather revealed that evening relative humidity of 6 days lag had significant positive influence, while maximum temperature and vapour pressure deficit at 6 days lag had significant negative correlation with semilooper egg count. Rainfall at 7 days lag had a positive and significant correlation with egg count. Further, step-wise regression analysis of the four-year data resulted in the following equation for prediction of semilooper egg levels:

$$Y = 4.6 + 0.121X_1 + 0.443\ X_2 + 0.71\ X_3 - 0.69X_4 - 0.09X_5\ (R^2 = 0.52^*)$$

Y= Semilooper egg level 3 days after; X_1 : Rainfall (mm) 4 days back; X_2 : Sunshine hours of the previous day; X_3: Minimum temperature 3 days back; X_4 : Maximum temperature of the previous day; X_5 :Rainfall (mm) 2 days back

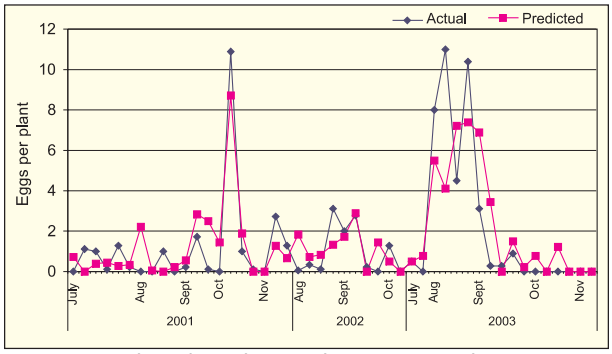


Fig.23. Predicted and actual castor semilooper infestation during 2001-2003

The prediction equation could capture the trends in peak infestations during September-October (2001), September (2002) and August-September (2003). The prediction equation is to be validated with *kharif* 2005 data. (Fig.23).

2.4.4.2 **Production of bio-agents**

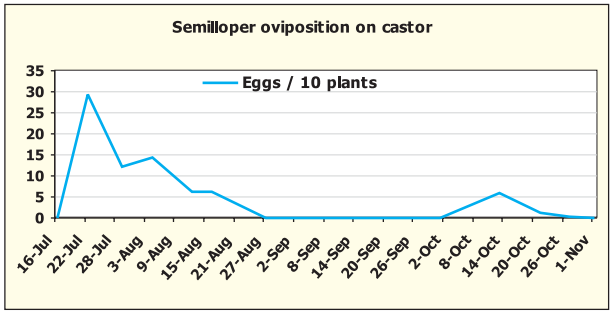
Three baculoviruses and one egg parasitoid were produced during 2004-05 for use in on-farm evaluation trials in management of castor and pigeonpea pests. The three baculoviruses produced were *Achaea janata* granulosis virus (AjGV, 20000 diseased larvae), *Helicoverpa armigera* nuclear polyhedrosis virus (HaNPV, 15000 diseased larvae), and *Spodoptera litura* NPV (SlNPV, 6500 LE). About 100 cards of *Trichogramma* egg parasitoid were also produced.

Field collection of *Helicoverpa* larvae on castor for virus production

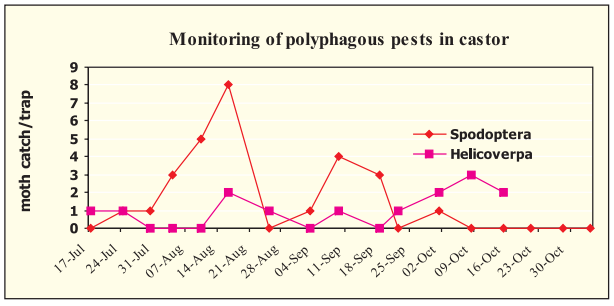
2.4.4.3 **On-farm evaluation of bio-intensive IPM modules in castor**

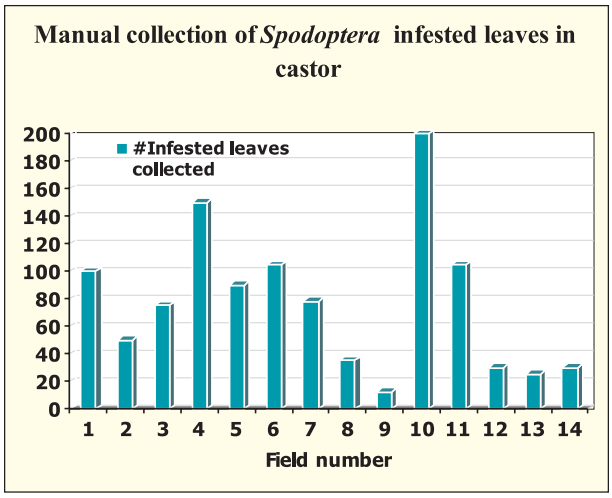
On-farm evaluation of bio-intensive IPM modules was undertaken involving 75 farmers to cover 125 ha (castor 65, groundnut 10, sole pigeonpea 8 and intercropped pigeonpea 42) in 5 villages of Wanaparthy mandal, Mahabubnagar district during *kharif* 2004. Components of the modules were seed treatment with *Trichoderma*, foliar spray with neem oil, local isolate of Bt spray, granulovirus spray, and release of *Trichogramma* egg parasitoid tested against insecticidal applications.

Semilooper incidence started in mid-July and peak oviposition occurred during the third week of July. Population counts of immature stages were found on the crop till the end of August. A second flush of egg laying was noticed in mid-October.



Polyphagous pests (*Helicoverpa* and *Spodoptera*) were monitored (10 pheromone traps per village) on castor and groundnut crops. *Helicoverpa* adult catches were low except in August and October when pigeonpea came to flowering. Adult moth activity of *Spodoptera* reached peak level in mid-August. A second flush of activity was noticed during mid-September. Farmers were alerted to take up manual collection of *Spodoptera* infested leaves from their fields as these could be easily identified from a distance. Data recorded on the manual collection in 5.6 ha of castor





indicated that on an average 80 infested leaves were removed per ha. Each infested leaf could harbor around 300-500 gregarious larvae.

Three IPM modules were evaluated in about 8 ha each and compared with farmers' practice at Nandimallagadda village. Population reduction in different IPM modules ranged between 67 and 95%. Average yield of castor varied in different modules between 700 and 772 kg ha^{-1} and was comparable to insecticidal check. Economics of IPM revealed that the bio-intensive IPM module resulted in a higher benefit: cost ratio despite the crop suffering from two prolonged dryspells during the season.

2.4.5 Seasonal dynamics of natural enemy populations in castor

2.4.5.1 Hyperparasitoids on *Microplitis maculipennis*

Two species of hyperparasitoids on *Snellenius (=Microplitis) maculipennis*, the most common parasitoid on castor semilooper (*Achaea janata*)

Economics of bio-intensive IPM in castor at Nandimallagadda village

Module	Module components	Number of fields	Yield (kg ha^{-1})		Returns (Rs ha^{-1})	Cost of cultivation (Rs.)	B:C ratio
			Range	Mean			
IPM1	Neem, Insecticide, GV	18	538-1050	760	11400	6478	1.76
IPM2	Trichogramma, Bt, GV	19	500-1325	773	11588	6540	1.77
IPM3	Neem, GV+1/2 Bt, GV	17	500-1025	713	10688	6540	1.63
Farmers' practice	Insecticides	12	525-1000	700	10500	6440	1.63

a) Mesochorus pilicornis; b) Brachymeria secundaria; c) Emergence holes of *Snellenius* and its hyperparasitoids

were recorded. The red coloured wasp was identified as *Mesochorus pilicornis* (Cameron) (Hymenoptera: Ichneumonidae) and the black coloured as *Brachymeria secundaria* (Ruschka) (Hymenoptera: Chalcididae). Both of these are solitary in nature. The former was more predominant (26-38%) than the latter (4%). The empty cocoons of *S. maculipennis* from which hyperparasitoids emerged were identified by a circular emergence hole on the lateral side at one end, whereas the cocoons from which *S. maculipennis* adults emerged were typical with a cap like opening at the tapering end. Thus, the nature of exit hole on the cocoons of *S. maculipennis* could be used to record level of hyperparasitism under field conditions. The extent of hyperparasitism was between 26 and 38 per cent during August to October.

2.4.5.2 Compatibility of granulosis virus with *M. maculipennis*

Out of 78 larvae of *A. janata* parasitized by *M. maculipennis* collected from plots treated with granulosis virus (GV) at 7 days after treatment, 54 (69.2 %) were found infected with the virus. All the parasitoid cocoons emerging from diseased larvae were healthy and yielded normal parasitoid adults similar to those obtained from larva with no infection of GV. This shows that GV could co-exist with *S. maculipennis* grubs in the same host without any detrimental effect on the parasitoid.

2.4.6 Crop diversity as a key component of IPM

The concept that 'heterogeneity of a popultion reduces the incidences of pests and diseases' was taken up here to quantify this in management of dryland pests. To have crop-crop diversity, several cropping systems were sown during *kharif* season of 2004-05 at two villages (Kolenu gudam and Akulal aylaram) of Ranga Reddy district, AP. The results from these on-farm trials are as follows:

- Incidence of various pests of castor and pigeonpea varied among intercropping systems. Insect pest fluctuations were noticed and temporal variation was quite evident. Higher incidence of leafhopper adults and nymphs were recorded in sole crop of castor and castor + sunflower systems. Low incidence was observed in castor + clusterbean, castor + cowpea and castor+ sorghum systems.
- Incidence of semilooper on castor was unimodal and the peak infestation was noticed once during the 32-37 meteorological weeks (end July-mid September). It coincided with the formation of primaries and the incidence varied across the intercropping systems. The incidence of semilooper was higher in castor + cowpea, castor sole and castor+ blackgram. The incidence of pest was low in castor + clusterbean and castor+ sunflower.
- Castor+clusterbean recorded less infestation of leafhopper and semilooper and exhibited more equivalent yield.
- Castor crop was smothered by sorghum crop in castor + sorghum system during second year of experimentation.
- Castor+clusterbean and castor+cowpea nurtured higher natural enemy population such as coccinellids and spiders which resulted in reduction of insect pest incidence.

- Pigeonpea-based system, pigeonpea + sorghum, recorded low incidence of insect pests.

2.4.7 Screening of microbial and synthetic pesticides

2.4.7.1 Isolation and testing of microbial pathogens for pest management

Soil samples from dryland tracts spread across the country were collected to isolate *Bacillus thuringiensis* (Bt) and screened for virulence against target insect pests. Colonies were isolated from 20 soil samples collected from different locations at Hayatnagar Reseach Farm, Hyderabad and several AICRPDA centres. All colonies showed presence of rods and spores and about 10-15% showed presence of crystals.

Insect bioassays were conducted against castor semilooper (*Achaea janata* L.). Two types of preparations were used in insect bioassays. The first was with Bt in T-3 broth (broth as such @ 300 µL per leaf disc) and bioassay with powders prepared from selected isolates grown in T-3 broth. In bioassays with Bt as T-3 broth, two samples (ID 31b & 43b) gave >50% mortality in test insects three days after exposure (Table 14). Thirteen isolates resulted in >50% mortality in six days after exposure. Highest mortality at six days time was with IDs 43b (>75%), 6b, 13b and 31b (70%), 11b, 14b, 25b and 27b (>60%).

Comparison of mean weight of survivors in bioassay with Bt as T3 broth at five days after exposure with control larvae indicated that seven samples (ID nos. 6b, 9b, 11b, 14b, 30b, 36b and 37b) were better in causing reduced feeding as reflected in lower survivor weight. Out of these 6b, 11b and 14b also resulted in higher mortality in 6 days.

Table 14 Results of insect bioassay with Bt isolates produced in T-3 broth

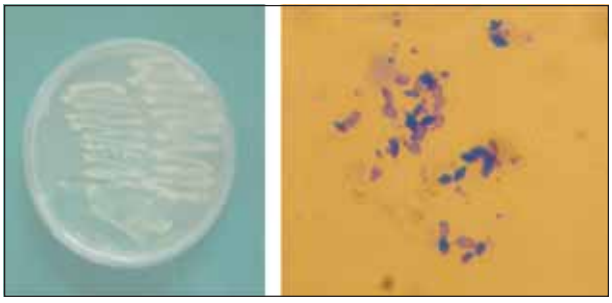
Sample ID	Cumulative mortality 6 days after exposure (%)	Mean weight of survivors at 5 days after exposure (g)
Control	0.0	0.188
1b	13.3	0.320
3b	56.7	0.210
4b	36.7	0.246
6b	70.0	0.102
8b	56.7	0.203
9b	43.3	0.136
11b	66.7	0.129
13b	70.0	0.187
14b	66.7	0.128
21b	30.0	0.255
22b	23.3	0.189
24b	40.0	0.184
25b	63.3	0.223
27b	60.0	0.274
28b	33.3	0.278
29b	46.7	0.225
30b	43.3	0.111
36b	56.7	0.124
37b	53.3	0.086
38b	36.7	0.206

Insect bioassay with Bt powders of selected isolates tested at 0.005% concentration along with untreated control indicated that sample IDs 47b and 48b resulted in significantly high mortality (>75%) after exposure and 100%

Mortality of semilooper larvae with Bt powders

Sample ID	Cumulative mortality*(%) days after exposure				
	1	2	3	4	5
Control	0.0	0.0	0.0	0.0	0.0
47b	76.7	100.0	100.0	100.0	100.0
48b	80.0	100.0	100.0	100.0	100.0
52c	20.0	33.3	50.0	50.0	50.0
55b	3.3	60.0	100.0	100.0	100.0

* Concentration of all Bt powders was @ 0.005% w/v



Streak culture of Bt | Stained Bt spores and crystals

mortality in 48 h. Sample 55b resulted in 100% mortality in 72 h.

2.4.7.2 Screening of synthetic pesticides

Insect bioassay experiments were conducted with a micro applicator (Burkard) using several new insecticides viz., Spinosad, Indoxocarb, Acetamiprid, Thiodicarb Imidachloropid and Profenofos against the larvae of castor semilooper, *Achaea janata*. Results indicated that Spinosad 50 ppm, Indoxocarb 145 ppm, Profenofos 500 ppm, Imidachloropid 178 ppm and Acetamiprid 200 ppm recorded 100 per cent mortality in 24-168 h after the treatment. Efforts are underway to work out the LC_{50} for these insecticides.

2.4.8 Training in IPM and technology transfer

CRIDA provided need-based guidance and training programmes for the benefit of NGOs rural youth, unemployed youth, farmers and the like.

Trainees enumerating virus inclusion bodies

2.5 Alternate Land Use Systems

In marginal shallow soils of rainfed areas, due to erratic behaviour of monsoon in time and space, adoption of arable crop production alone has not been successful in many years. This calls for diversification of agriculture by incorporating appropriate crops, and perennials and animal components and value addition to the dryland products. CRIDA has been in the forefront in this respect and had done useful work on forestry and agro-forestry systems, aromatic, medicinal and dye yielding plants, agri-horti-pasture systems and has made valuable recommendations. Of late, looking at the importance of biodiesel yielding trees, a number of studies have been taken up on them. Highlights of some of the activities conducted are given here under.

2.5.1 Forestry and agro-forestry systems

2.5.1.1 Canopy management of leucaena

A project was initiated during *kharif* 2000 on a silvipasture system involving small ruminants (16 sheep ha^{-1}) to study the effect of pollarding and non pollarding of leucaena on light infiltration and growth of two pasture species, *Cenchrus ciliaris* and *Stylosanthes hamata,* and the support the system provides to maintain the animal component. The three year study revealed that:

- sheep grazed under silvi-pastoral system showed significantly higher growth rate as compared to natural grazing (95 vs 55 g h^{-1} d^{-1}). Animals consumed more of Leucaena leaves followed by *Cenchrus ciliaris* and *Stylosanthes hamata*,
- the above ground dry biomass of the pasture species was maximum in open plots, where as under trees, pollarded plots registered more biomass than that of non-pollarded ones,
- 0.50 ha silvipasture system supported 8 sheep without resorting to external supplementation of feed/concentrates during the grazing period.

2.5.1.2 Evaluation of leucaena and eucalyptus-based agroforestry systems for industrial biomass production

This on-farm study was aimed at increasing the industrial biomass production from leucaena and eucalyptus-based agroforestry systems, identification of suitable combination of crops with these trees for marginal and degraded areas of watersheds, and to optimize their planting geometry to suit small and marginal farmers. This study was conducted in 3-year-old plantations covering 6 ha. Six farmers were selected from six villages of Bhadrachalam and Kukkunuru mandals in Khammam district of A.P. Following significant findings emanated.

- Tree height, collar girth and girth at breast height in both eucalyptus and leucaena were not significantly influenced by spacings. However, maximum collar girth and girth at breast height were with 3x2 m spacing, and minimum with closer one (1x1m). Higher eucalyptus tree height, collar girth and girth at breast height were recorded with 3x2 m spacing which is farmers' practice (Table 15a). Biomass production of the trees would be recorded at the end of the study.
- Cowpea grown as an inter-crop in eucalyptus yielded higher green biomass with 10 x 1.5m triple row treatment. All the wider tree row spacings in eucalyptus recorded significantly higher green biomass over 3x2 m (farmers' practice) (Table 15b).

Table 15a Tree growth attributes of Eucalyptus and Leucaena

Treatments	Tree height (m)	Collar girth (cm)	Girth at breast height (cm)
Eucalyptus			
3x2m (Farmers' practice)	12.09	34.07	26.60
6x1m	12.45	36.35	27.75
7x1.5m (paired rows)	11.26	33.57	25.50
11x1m (paired rows)	10.99	31.78	24.37
10x1.5m (triple rows)	12.18	32.55	19.21
CD	NS	NS	NS
Leucaena			
1x1m	11.17	24.63	23.60
1.3x1.3m	12.71	32.03	24.87
3x0.75m	13.32	29.43	23.20
3x1.0m	12.97	28.20	22.03
3x2.0m	13.22	34.10	26.50
5x0.8m	13.66	32.68	25.43
CD	NS	NS	NS

Table 15b Green biomass yield of cowpea in Eucalyptus-based agroforestry system

Spacing (m)	Mean yield (kg ha^{-1})
3x 2 (Farmers' practice)	658
6x1	1124
7x1.5 (Paired rows)	1104
11x1 (Paired rows)	1145
10x1.5 (Triple rows)	1212
Control (crop without tree)	1319
CD (0.05)	412

2.5.1.3 Influence of agroforestry models on soil fertility and resource conservation

A three-year study was initiated in 2002 to study the effect of different agro-forestry models on soil fertility, resource conservation, and productivity of the marginal lands of SAT. These studies revealed that:

- In general, soil fertility improved under different tree components of these agro-forestry models. Organic C (0.2 to 0.45%) and available N (122 to 182 kg ha^{-1}) increased, more so from leucaena

and tamarind-based agro-forestry systems indicating beneficial effect to the soil.

- There was decrease in P (19 to 11 kg ha^{-1}) and K (374 to 230 kg ha^{-1}) with trees, indicating fixing of these elements in the trees. The depletion in soil P and K was more in leucaena and *amla*.
- Significantly higher yield of *amla* (4394 kg ha^{-1}) was obtained with a combination of vermi-compost and inorganic fertilizers. Higher fruit drop in *amla* was with FYM. This trend was observed during 2003, too.
- Greengram as an intercrop recorded 59, 66 and 15% of sole crop yield under *amla*, tamarind and Acacia, respectively. More or less, similar trend was observed with castor (Table 16). The competition of crops with trees increased with age of the trees, maximum being from Acacia. The fruit yield from *amla* compensated more than the yield loss from arable crop.

Table 16 Effect of tree species on yield of castor and greengram

Tree species	Average castor bean/seed yield (kg ha^{-1})	Average greengram yield (kg ha^{-1})
Sole crop	979	762
Amla	616 (37)	555 (27)
Tamarind	613 (37)	404 (47)
Acacia	376 (62)	334 (56)
Mean	646 (34)	519 (32)

Figures in parentheses indicate percentage decrease over sole crop

2.5.1.4 Performance of micropropagated teak on farmers' fields

Tissue cultured (TC) neem and teak plants were being evaluated in Nalgonda and Mahabubnagar district since 1999 on farmers' fields for their growth performance vis-à-vis seedlings or stumps. In Nalgonda, the mean annual increment in height and girth of TC teak plants was marginally superior to the plants grown in Mahabubnagar (Table 17). Individual plantations in both the districts performed well with good management. However, soil depth had a distinct influence on the growth rate (Fig. 24 & 25).

To assess the comparative performance of TC vs stumps on farmer's fields, a large on-farm trial was initiated in Gaddipalli village during *kharif* 2002. Tissue culture and stump derived

Table 17 Annual increment in height and girth of tissue cultured teak

Age of the plantation	Mean annual increment in height (m)		Mean annual increment in girth (cm)	
	Nalgonda*	Mahabubnagar**	Nalgonda*	Mahabubnagar**
Year I	1.4	1.2	5.5	4.5
Year II	1.5	1.3	5.6	5.2
Year III	1.0	0.8	5.6	5.3
Year IV	0.8	0.6	7.0	6.5

*Mean of 6 farmers **Mean of 5 farmers

Fig.24. Comparative performance of stump raised and tissue cultured plants of teak (Nalgonda, Alfisol, meager rainfall)

Fig.25. Two year old plantation of tissue cultured teak (Krishna, Vertisol, good rainfall)

plants were raised on 8 ha each. Initial growth showed a marginal superiority of TC plants over stumps. After 6 months of planting, the height of TC plants ranged from 90-200 cm while stumps attained a height of 40-170 cm. The girth of TC ranged from 5.45-8.5 cm while that of stumps from 4.55-7.25 cm. The uniformity index of TC plants was 0.86 as against 0.45 for stumps (Fig. 24). However the growth differences disappeared by the second year, but TC plants still maintained high uniformity over stumps.

In Rajendranagar mandal of Rangareddy district, a distinct difference was observed between stumps and tissue cultured plants in a clay loam soil both in terms of height and girth. In an Alfisol near Zaheerabad Mandal of Medak district, tissue cultured teak attained an average height of 2.7m and girth of 9 cm after 6 months which was significantly superior to stumps. There was also high degree of uniformity in the TC plants. In a plantation in Gidwal village of Medak district, water harvesting through half moon terraces resulted in 20% higher height gain over control. The best height and girth increments were recorded in Kanchikacherla village of Krishna district (Fig.25).

The successful transfer of micro-propagation technology to the NGOs was evident from the fact that more than 1.5 lakh tissue cultured plants could be produced during 6 years (1999 to 2004) in the pilot laboratories at CRIDA and SAIRD. Initially the plants were distributed free of cost to the farmers in the target villages as a part of awareness generation activities. During second phase(2001-2004), however, the plants were marketed within and outside the target districts on cost basis by SAIRD while at CRIDA these were supplied both free for collaborative trials and on cost basis for individual farmers for block/boundary plantations (Fig.26).

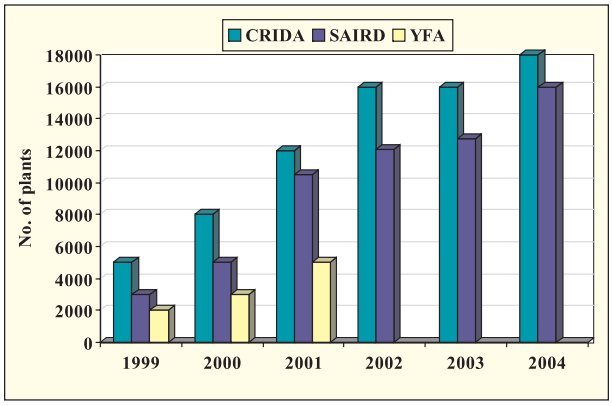


Fig.26. Production of tissue cultured plants (teak + neem) during 1999-2004 at different centers under the project (The project was discontinued at YFA after 2001)

2.5.2 Agri-horti-pasture system

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

Mango (cv Kesar) and guava (cv Lucknow 49) orchards were established in 1993 to experiment upon the success of dryland horticulture in marginal lands, and to study the effect of nutrient management, intercropping, irrigation and the like on tree growth and yield. The major results from these experiments and conclusions drawn are:

Mango

- In Alfisols of low fertility, groundnut can be grown successfully even up to ninth year in mango-based agri-horticultural system, with nutrient management to offset the tree interaction.

- In closely planted mango trees (5x5 m), pruning of over lapping branches is desirable, atleast after 10 years of plantation, to promote more vigorous growth and yield.
- Application of organic and inorganic forms of nutrients individually or in combination increased fruit number and weight significantly over control.
- All irrigation levels produced comparable fruit yield, but drip irrigation at 0.75 Ep produced significantly higher fruit yield (27.8 kg tree^{-1}) than no irrigation (17.0 kg tree^{-1}).
- Conjunctive use of recommended NPK + 75 kg FYM tree^{-1} recorded maximum fruit yield of 37.1 kg tree^{-1}. Drip at 0.25 Ep resulted in maximum water use efficiency.
- Recommended levels of manure and fertilizers (5 t FYM+20 kg N: 40 kg P_2O_5: 20 kg K_2O ha^{-1}) given to sole groundnut need to be maintained even under agri-horticultural system.

Guava

- Guava can be promoted with suitable agro-techniques even in slightly slopy and marginal lands.
- Semi perennial/annual fodders can be encouraged for generation of nutritious fodder for use during off-season. Some good species suggested are *Stylosanthes hamata* (semi perennial legume), *Cenchrus ciliaris* (semi perennial grass) and annual fodders (cowpea, horsegram and fodder sorghum).
- The fruit yield of guava was not negatively influenced by fodder inter crop up to 8-10 years and hence can be promoted in orchards. However, after 10 years of establishment it is desirable to cultivate fast growing leguminous intercrops for improving soil fertility.

2.5.2.2 Agri-horti and agroforestry systems for *kharif* sorghum area decreasing regions

The productivity of sorghum and other nutritious cereals in rainfed regions is becoming uncertain and not remunerative due to erratic rainfall. The area under *kharif* sorghum is declining year after year. Hence there is need to diversify the existing sorghum production system with agri-horti-pastoral and agri-silvi-pastoral systems to achieve the overall sustainability. In this context, the studies conducted over a period of four years under on-farm conditions indicated the following:

- There is a substantial shift towards perennial horticultural fruit trees viz., mango, custard apple, tamarind, sapota, *ber*, guava, pomegranate, *amla* and the like apart from growing vegetables, and timber yielding and multipurpose tree species in place of coarse cereals.
- Farmers preferred teak, neem, leucaena, *Acacia*, *Dalbergia*, *Hardwickia* and *Gmelina arborea* mainly on farm bunds.
- Higher mango yield was realized ranging from 2.3 to 2.89 t ha^{-1} in 5-7 year-old orchards and 8.83–10.60 t ha^{-1} in > 10 year-old orchards (means of four consecutive years) by following interventions like *in situ* moisture conservation practices, preparation of crescent shaped or round basins, making bunds at 45 cm height across the slope and mulching the basins along with the application of recommended doses of nutrients. On the other hand, with farmers own practices the average mango yield was 0.74 and 2.72 t ha^{-1} in young and older orchards, respectively in Mahabubnagar district of A.P.
- Raising intercrops like stylo, cenchrus, cowpea and horsegram for fodder purpose in between orchard rows and inclusion of small ruminants like 'Nellore zodpi' (Mahabubnagar) and local-based (Ranga Reddy)sheep alleviated fodder shortages and added extra income to the fruit-based production system.
- In a silvi-pasture experiment, fodder sorghum reduced growth (height and girth) of young *Acacia nilotica* and *Leucaena leucocephala* plantations in Mahabubnagar district. Here growing stylo or cenchrus was found beneficial in alleviating the fodder shortages. Similar trend was observed in *Dalbergia* and *Leucaena* plantations in Ranga Reddy district of A.P.
- In a feeding trial on Nellore zodpi lambs, increase in body weight was observed with cenchrus+topfeed (@1% bw with gliricidia/ leucaena/neem) followed by sorghum+top feed, sorghum+stylo or cenchrus+stylo treatments

when compared to any single fodder, in Mahabubnagar district. In Ranga Reddy district also the lambs had put on higher body weight with cenchrus+stylo. In Maharashtra, Osmanabadi goats fed with sorghum+ topfeed followed by cenchrus+top feed or cenchrus+stylo, had put on higher body weight when compared to those on sorghum or cenchrus.

2.5.3 Aromatic, medicinal and dye-yielding plants

A number of preliminary studies were carried out on aromatic (lemon grass, palma rosa, ocimum), medicinal (andrographis, *ashwagandha*, senna) and dye-yielding (*henna,* indigo, bixa) plants so as to standardize agronomic practices for their cultivation in rainfed areas, and for their value addition. Some of the significant findings are detailed below:

2.5.3.1 Aromatic plants

- In ocimum, application of NPK alone, neem cake and castor cake recorded higher yield i.e., 6300, 5100, 4900 kg ha^{-1}, respectively as against FYM (2500 kg ha^{-1}) and vermi-compost (3500). Higher oil content (0.58%) was recorded with FYM treatment. However, higher oil yield was obtained with inorganic fertilizer and castor cake application.
- Among lemon grass cultivars cv Cauvery recorded higher foliage yield (18.12 t ha^{-1}) over cv Krishna (14.43 t ha^{-1}). However, cv Krishna recorded higher oil yield (0.9%) over cv Cauvery (0.6%).

2.5.3.2 Medicinal plants

- Application of neem cake and NPK led to higher yield in senna, 1269 and 1233 kg ha^{-1}, respectively. FYM treatment yielded only 327 kg ha^{-1}. Application of neem cake also increased sennesoide content over other treatments.
- In Ashwagandha, vermicompost, neem cake and castor cake recorded 536, 529 and 649 kg ha^{-1} of dry roots, respectively whereas FYM application recorded only 393 kg ha^{-1}. However, FYM treatment recorded higher alkaloid content (0.87%) over other treatments. NPK alone recorded lower yields and alkaloid content. These results will be confirmed through subsequent trials along with cost-benefit analysis.

2.5.3.3 Dye-yielding plants

- Application of 30 kg P ha^{-1} recorded higher indigo yield (14980 kg ha^{-1}) than FYM and vermi-compost : 10560 and 10650 kg ha^{-1}, respectively.
- Higher indigo dye yield was also recorded with 30 kg P ha^{-1}.
- Higher doses of N and P (120 kg N ha^{-1}, 60 kg P ha^{-1}) reduced lawsone content in *henna*.
- The quality of bixa was superior when stored in polythene or brown paper cover.
- In *henna,* shade drying recorded higher lawsone content, but the quality deteriorated faster than that from oven-dried one.

2.5.4 Initiatives in tree-borne biodiesel yielding plants

Of late, research and development activity on biodiesel has assumed greater importance because of environmental concern and the depletion of petroleum reserves. There are atleast 50 species of biodiesel yielding trees in India. Among them Jatropha (*Jatropha curcas* – Euphorbiaceae) and Pongamia *(Pongamia pinnata* – Fabaceae) are of significance since they can be grown on marginal and waste lands, are quite hardy and yield good quality oil. The institute during the past couple of years has taken a number of initiatives, which are summarized below.

2.5.4.1 Collection of germplasm

As a first step towards foundation of a successful study, germplasm survey and collection was made in nine districts of Andhra Pradesh. A number of accessions were collected, and these are under evaluation (Table 18).

Table 18 Germplasm accessions of Jatropha and Pongamia from A.P.

District	Jatropha	Pongamia
Vishakhapatnam	8	13
Vizianagaram	2	5
Srikakulam	9	7
East Godavari	9	8
Adilabad	18	10
Chittoor	8	10
Kadapa	0	10
Anantapur	6	2
Kurnool	0	1
Total	**60**	**66**

Jatropha (left) and Pongamia plantations at HRF

2.5.4.2 **Evaluation studies**

New Pongamia and Jatropha plantations were raised at Hayatnagar Research Farm a couple of years back. Results of some very preliminary studies were:

- Among the three Jatropha accessions (Jabua, Raipur and Local), Jabua exhibited higher seed length and seed width, where as Raipur accession showed higher seed thickness. Higher number of seeds kg^{-1} was observed in the Local variety. The average yield per plant was maximum in Local (110 g) followed by Jabua (90 g) and Raipur (60 g).
- There was not much difference in growth parameters of Pongamia plants raised at different spacings (6 x 4, 6 x 6 and 8 x 6 m). Castor and pigeonpea were taken as intercrops. Since the plantation was quite young, there was not much difference between effect of different spacings on crop yield.
- A new design of mini oil extraction machine was conceptualized and fabricated to extract more oil from Pongamia seeds and at low energy input (for details please see section on "Farm Machinery').

2.6 Farm Machinery and Power

Dryland agriculture is heavily dependent on rainfall which is generally meager and erratic. To derive the most from moisture availability, timeliness and precision in sowing and other agricultural operations become essential. Dryland agriculture is characterized by low power availability for timely operation and lack of precision machinery to improve resource use efficiency. CRIDA has been in the forefront in designing, developing and spread of low-cost, time saving and efficient agricultural implements and machinery and has already commercialized over a dozen of them. The initiative taken by the Institute in establishing farm machinery custom hiring centers at a number of locations all over the country has brought laurels. Continuing this tradition, research was undertaken to characterize energy gaps, design tools for removal of drudgery of farm women, design new machinery, and develop mechanization package for different rainfed crops.

Seed parameters of Jatropha accessions

Accession	100 seed weight (g)	No. of seeds kg^{-1}	Germination (%)	Average yield $plant^{-1}$ (g)
Jabua	74.67	1363	82	90
Raipur	75.67	1350	96	60
Local	75.67	1371	98	110

A couple of new projects on development of a multipurpose machine and a bed forming machine have been initiated this year. In the near future too farm power and mechanization research priorities will continue to be on design of tools and equipments for drudgery reduction of women, to achieve timeliness and precision in field operations, to improve resource utilization efficiency and to popularize new implements for improving profitability of dryland farming, improving availability through custom hiring centres and facilitating quality production of implements by local industries. The major achievements made this year are given below:

2.6.1 Energy use in crop production and livestock rearing in A.P

Changes in energy use pattern in crop production and livestock rearing were studied in Krishnamareddipally village in Anantapur district of Andhra Pradesh following a gap of 16 years. The data available for 1988-89 was compared with that collected during 2004-05. Significant findings were:

- Over the period farm power availability increased from 0.44 to 0.98 kw ha^{-1}. Contribution of animal power decreased from 0.11 to 0.04 kw/ha whereas significant increase in electrical power (0.25 to 0.39 kw ha^{-1}) and mechanical power (from 0.00-0.45 kw ha^{-1}) was observed (Table 19). Improved high capacity farm implements for tillage, sowing, plant protection, harvesting and threshing operation have come to the villages along with tractors.
- Marginal shift in cropping pattern was observed. Horticulture area increased from 19.6 to 22.0 ha. Mulberry cultivation decreased from 6.1 to 1.0 ha. Irrigated paddy and groundnut decreased from 17.2 to 12 ha. Total irrigated area decreased from 42.9 to 35 ha. Energy use pattern in agriculture also changed due to increased input and output values.
- Draft animal population reduced from 176 to 60. Milch cattle decreased from 239 to 174 and small ruminants increased from 1026 to 1435. Milk production per animal doubled. More attention towards livestock management was observed in recent times than earlier.
- The results thus indicate that the energy scenario is dynamic in nature and needs to be monitored every 5 years for planning technological inputs to match changing needs.

2.6.2 Implement for drudgery reduction of women

Sunflower threshing device

Local method of sunflower threshing for removal of seeds by hand causes drudgery to women workers. In order to overcome this, a portable threshing device was developed to reduce the drudgery and improve efficiency of women workers. It consists of a 750 x 750 mm square frame made of 25x25x3 mm angle iron. Small pins of 3mm dia and 10mm length are welded (10mm row to row and 15mm pin to pin) on to 20mm flats, which were fixed on the frame. The device is simple and can be locally fabricated. Two women can work at a time and give output of 12-15 kg grain h^{-1}. It saves 25% time as compared to local method, apart from reduction of drudgery of women.

Table 19 Temporal shifts in farm power in Krishnamareddipally village in Anantapur district

Parameters	Farm power (kw ha^{-1})		Change (%)
	1988-89	2004-05	
Human	0.08	0.10	25 (+)
Animal	0.11	0.04	64 (-)
Electrical	0.25	0.39	56 (+)
Mechanical	0.00	0.45	45 (+)
Total power density, kw/ha	0.44	0.98	123 (+)

Simple sunflower thresher for reduction of drudgey

designed and developed for precision drying of medicinal and aromatic plants. It consists of a drying chamber coupled with external gas fired furnace through which the hot air is blown inside using 0.5 hp electric blower. The set temperature inside is controlled through a microprocessor-based relay control. The dryer is most suitable for horticulture products like *amla*, curry leaf, drum stick leaves, and medicinal and dye yielding plants like senna and *henna*. The machine dried product maintained its natural colour and quality.

2.6.3 Design, development and performance evaluation

2.6.3.1 Gas fuelled automatic control dryer for medicinal, aromatic and horticultural crops

An indirect heating system with liquid petroleum gas fuelled auto control dryer was

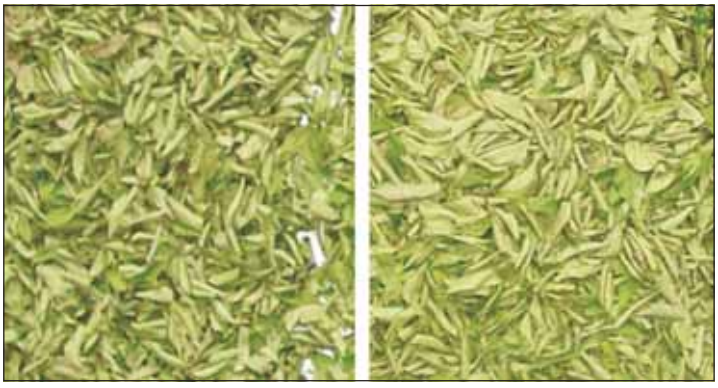
2.6.3.2 Performance of CRIDA planter

On-farm performance of planter over a large area (26-228 ha) for groundnut, soybean, cotton, castor and maize was evaluated (Table 20). Significant saving in time (36-86%) and cost (15-34%) were recorded.

Table 20 Performance of tractor drawn inclined plate planters

Parameters	Crops				
	Groundnut	Soybean	Cotton	Castor	Maize
No. of rows	9	9	5	5	6
Row spacing (cm)	30	30	70	60	45
Field coverage (ha day^{-1})	8.0	9.0	8.4	8.8	8.5
Cost of operation (Rs ha^{-1})	212	188	150	200	200
Yield (kg ha^{-1})	390	900	1440	430	1200
Savings as compared to local practice					
a. Time (%)	54	36	61	86	82
b. Cost (%)	15	33	24	22	34
Area covered (ha)	228	31	26	72	164

CRIDA herbal dryer



Sun-dried curry leaf Machine-dried curry leaf

2.6.4 Processing technology for Pongamia and Jatropha oil as biodiesel

Pongamia and Jatropha plantations are being promoted on a large scale to produce biodiesel to achieve self-sufficiency in fuel requirement. However, technology for seed oil extraction and processing to get economic biodiesel under on-farm conditions is essential to make a farmer self sufficient in his fuel needs and improve his income, as well. In order to achieve this goal, experiments were conducted to extract more oil from existing machine by giving pre-treatments to seeds. Pretreating pongamia seeds increased 3% oil yield. Oil extraction plants available in the market were basically designed for edible oils. The screw mechanism of extractor was inefficient and could extract only 24% of oil from pongamia leaving 8% oil in the cake. New design of mini oil extraction machine was conceptualized and fabricated to extract more oil at low energy input. The new machine with toggling mechanism is under test and refinement process.

Newly designed mini seed oil expeller for Pongamia and Jatropha

2.6.5 Development of mechanization system for residue incorporation

The quality of fresh biomass incorporation and the way it is incorporated in the soil is of importance for its timely availability to the crops. In an attempt to find out suitability of machines and depth of biomass incorporation, trials were conducted at Hyderabad (Alfisols) and Solapur (Vertisols). The results were :

- M.B. Plough + rotavator incorporated higher biomass of different green manure plants (sunhemp, horsegram, cowpea) (84-90%) followed by M.B. Plough + disc harrow (80-89%). Cultivator + disc harrow was found unsuitable for biomass incorporation. Higher incorporation with M.B. plough + rotavator was mainly due to inversion, chopping and covering of biomass with fine soil aggregates.

2.6.6 Mechanization of dryland crops

Mechanization of dryland crops was expanded to cover 2416 ha area in 27 villages in 9 districts benefiting 514 farmers during 2004-05. Major crops covered were groundnut, castor, soybean, cotton, pearlmillet, fingermillet, *rabi* sorghum, maize and rainfed rice.

2.6.6.1 Maize

CRIDA 6-Row Planter was adopted by 44 farmers in 4 villages in Mahabubnagar and Medak district covering 175 ha area for maize crop. The on-farm performance in Gajwel village of Medak district is given in Table 21. The results show that even if farmers shift to only mechanical seeding, the profit level would be enhanced by Rs.7000 ha^{-1}. If the shift is towards total mechanized package of tillage, seeding, interculture and shelling, the profit margin would be almost doubled.

2.6.6.2 Groundnut

Mechanization package (cultivator, CRIDA 9-row planter, sprayer, groundnut digger-shaker, harvestor, thresher and decorticator) for groundnut crop was adopted by 64 farmers in 8 villages of Anantapur district covering 111 ha. The evaluation (Table 22) showed that mechanization converted loss into profit due to 50% reduction in operation cost and 16% increase in pod yield. Payback of investment in machinery could be achieved in one season.

Table 21 Performance of maize mechanization in Gajwel, Medak district

Operations	Cost of operation (Rs ha^{-1})		
	Indigenous	Indigenous/Improved	Improved
Tillage, interculture, shelling	6100	6100	2440
CRIDA 6-row planter	600	200	200
Total	6700	6300	2640
Yields and receipts			
Grain yield (t ha^{-1})	2.8	4.0	4.0
Receipts (Rs ha^{-1})	8400	12000	12000
Fodder yield (t ha^{-1})	18	24	24
Receipts (Rs ha^{-1})	9000	12000	12000
Total receipts (Rs ha^{-1})	17400	24000	24000
Profit	(+)10700	(+)17500	(+)21360

Initial Cost : Rs.25000; initial cost of total improved package: Rs. 1,40,000

Table 22 Performance of groundnut mechanization in Venkatapuram, Anantapur district

Implements/Inputs	Initial Cost (Rs.)	Cost of operation (Rs ha^{-1})		Savings as compared to local tools (%)
		Indigenous	Improved	
Operation				
Cultivator (TD)	9500	750	600	06
CRIDA 9-row Planter	29500	600	200	67
Weeding attachment with iron wheel (TD)	10000	1650	920	44
Boom sprayer (TD)	11000	500	200	60
Digger shaker (TD)	22000	1500	975	35
Thresher (power)	21000	700	200	71
Sheller (power)	14000	1000	200	80
Sub total	117000	6700	3295	51
Inputs				
Seed cost (Rs ha^{-1})	–	3000	2100	30
Fertilizer cost (Rs ha^{-1})	–	500	300	40
Total cost (Rs ha^{-1})	–	10,200	5695	44
Yield and Receipts				
Pod yield (kg ha^{-1}) **	–	330	390	18
Receipts (Rs ha^{-1})*	–	6600	7800	18
(-) Deficit (loss)				
(+) Surplus (profit)	–	(-) 3600	(+) 2105	-

* Sale price of pod assumed as Rs.20 kg^{-1}. ** Yield low due to drought

CRIDA 9-row groundnut planter

Interculture implement with small iron wheels

2.6.6.3 **Soybean**

CRIDA 9-row planter, NRCS power weeder and Vardan reaper were used by 81 farmers covering 151 ha area in two villages of Indore district. CRIDA planter uniformly gave better crop stand. Reaper saved Rs. 1200 ha^{-1} in harvesting, and power weeder Rs. 800 ha^{-1} in weeding operations.

2.6.6.4 ***Rabi* sorghum**

Rota till drill, V-Blade for summer tillage and cycle hoe for weeding were adopted on 95 ha by 40 farmers in 5 villages. Mechanization increased 26% grain yield.

2.6.6.5 **Castor**

CRIDA 6-Row planter was adopted by 14 farmers in 4 villages in Mahabubnagar district covering 75 ha. The operations of interculture and shelling were mechanized by adopting tractor drawn blade hoe and CRIDA castor sheller. This way farmers obtained extra income of Rs.4530 ha^{-1}, because of an yield increase of 25% (Table 23).

2.6.6.6 **Cotton**

Rotavator for tillage, sowing with 6-row inclined plate planter and interculture with sweep was adopted for rainfed cotton cultivation in Akola district. This led to an extra income of Rs. 2560 ha^{-1} by way of savings made in sowing and higher yield (Table 24).

2.6.6.7 **Fingermillet**

Tractor drawn fluted roller drill, tractor drawn interculture, harvesting with front mounted tractor drawn reaper and power thresher was the package of mechanization adopted for fingermillet in Bangalore. Economic performance (Table 25) showed an extra income of Rs. 6100 ha^{-1} by savings in increased grain and fodder yield. About 800 ha was covered under mechanization package during 2004-05 in North Bangalore Taluk.

2.6.6.8 **Pearlmillet**

Ridger seeder was adopted for sowing pearlmillet in Shivani and Bhiwani districts of Haryana. There was significant increase in grain and fodder

Table 23 Economics of castor mechanization

Parameter	Cost/income		Saving/extra income
	Conventional method (Rs ha^{-1})	Mechanized castor crop (Rs ha^{-1})	by mechanization (Rs ha^{-1})
Operation cost	2600	1090	1510
Seed and fertilizer input	830	510	320
Income for produce*	10800	13500	2700
Total			4530

* Market price Rs. 1800 q^{-1}; average yield before the study : 6 q ha^{-1}

Table 24 Economics of mechanization interventions in rainfed cotton

Parameters	Cost/income (Rs ha^{-1})		Saving/extra income
	Local practice	Mechanization	(Rs ha^{-1})
Operation cost (sowing + interculture)	365	290	75
Rotavator	1700	970	730
Income from produce*	5535	7290	1755
Total			2560

*Market price Rs. 36.90 lint kg^{-1}; Average yield in non mechanized plot:150 kg lint ha^{-1}

Table 25 Economics of finger millet mechanization

Parameter	Local practice	Mechanized cultivation	Saving/extra income from produce
Operation cost* (Rs ha^{-1})	3400	1937	1463
Income from grain (Rs ha^{-1})	6680	10224	3544
Income from fodder (Rs ha^{-1})	1000	2100	1100
Total, Rs ha^{-1}			6107

Grain = Rs.800 q^{-1}; Fodder = Rs.1000 t^{-1}; *Sowing, interculture & harvesting

Table 26 Economics of pearlmillet mechanization

Parameter	Local seeding	Ridger seeding	Saving/extra income from produce
Operation cost (Rs ha^{-1})	2698	2441	257
Income from grain (Rs ha^{-1})	2295	3060	765
Income from fodder (Rs ha^{-1})	800	1000	200
Total (Rs ha^{-1})			1222

yield due to optimum use of moisture due to mid-ridge sowing. Extra income of Rs. 1200 ha^{-1} was recorded (Table 26). Total area covered was 187 ha.

2.6.6.9 **Rainfed rice**

Tractor drawn disc harrow, seed cum ferti drill, self propelled reaper, and power thresher was the package adopted for rainfed rice in Mirzapur district of U.P. About 428 ha was covered in 4 villages. Economics of mechanization (Table 27) showed a significant saving in operation cost, increase in yield and extra cost of input in mechanized system enhancing income by Rs. 7900 ha^{-1}.

2.6.7 **Farm machinery custom hiring centre**

Custom hiring centre (CHC) for implements was established at Kalwakurthy in Mahbubnagar district to make costly implements available to

Inauguration of a custom hiring centre at Choudarpalli village, Mahabubnagar district

Table 27 Economics of rainfed rice mechanization

Parameter	Local method	Mechanization	Saving/extra income from produce
Operation cost (Rs ha^{-1})	9320	4619	4701
Input cost (Rs ha^{-1})	2640	4446	-1806
Income from grain (Rs ha^{-1})	12072	17100	5028
Total (Rs ha^{-1})			7923

Local method yield: 2.19 t ha^{-1}

Table 28 Impact of custom hiring centre

S.No.	Item	Before CHC	After CHC
1.	Increase in implement number:		
	Disc harrow	0	35
	Maize sheller	5	70
	Orchard sprayer	0	8
	Planters	0	5
	Tractor weeders	0	15
	Castor shellers	4	20
2.	Increase in area (ha) under cultivation (Sample: 10 farmers)	100	300
3.	Increase in labour employment (mandays)	2500	4500
4.	Number of implement industries	1	3
5.	Increase in castor yield (q ha^{-1})	6	9

farmers on rental basis. The implements were extensively used by farmers. The demand was much higher during cropping season. Eleven different implements were used by 267 farmers covering about 1020 ha during cropping season. The centre generated net returns of Rs. 72,290. The entrepreneur was a progressive farmer who employed 4 persons for operating the CHC.

Exposure of farmers to usefulness of improved implements through custom hiring centre created such an impact that many farmers purchased their own equipment (Table 28).

2.6.8 Industry linkages

Four new industries from Hyderabad and Bangalore signed MoUs with CRIDA for manufacture and sale of implements designed by CRIDA. Designs were licensed by charging a nominal fee of Rs. 1000-5000 per design, and royalty @ 2% on net sale price.

Signing of MoU on farm implement design

2.7 Socio-economic Studies

Transfer of agricultural technologies, especially in rainfed areas, is a difficult task because of the inherent complexity, diversity and risk prone nature of rainfed agriculture. It becomes very important to take into account the components of transfer of technology like technological, economic, socio-psychological, situational, infrastructural, managerial, communicational, political and administrative. CRIDA since its inception has been carrying research on some of these components particularly socio-economic, technological and managerial ones. This year too a number of studies were conducted, results of which are summarized below:

2.7.1 Enabling rural poor for better livelihoods through improved NRM

Most of the poor people living in rural areas of the semi-arid tropics depend heavily on natural resources for their livelihood. These resources, because of over exploitation and neglect, are now degraded. There is thus an urgent need to restore them in order to sustain agricultural production. To implement useful NRM interventions, a two-year comprehensive scheme was launched in three villages in Anantapur district, four in Mahabubnagar

district (both in Andhra Pradesh), and two in Tumkur district (Karnataka). Some of the highlights and key learnings are mentioned here:

- Capacity building was promoted as a continuous process through training programmes, exposure visits, and awareness programmes in the selected cluster of villages. Inter cluster visits were organized to share the mutual experience of the selected cluster impact. As a part of this, the *Salah Samithi* members and some selected farmers from Mahabubnagar visited Anantapur cluster and exchanged information on *Salah Samithi* activities and discussed with farmers about the impact of technological interventions. Informal bodies *(Salah Samithis)* representing different sections of villagers facilitated better targeting of interventions and better people's participation without conflicts.
- In the target districts soil and water conservation structures like trench-cum-bund, farm ponds and check dams created very good impact among the farmers and changed their mindset.In Anantapur supplemental irrigation was provided to *rabi* groundnut through water stored in farm ponds dug under this project. Two acre CPR land was made accessible for cultivation by two landless women farmers in Mahabubnagar cluster of villages. Fodder and vegetable crops were grown in this land. Gliricidia and Pongamia were planted along trenches' border.
- Under agriculture interventions the farmers were supported with improved crop and fodder varieties. Improved crop management practices like mulching with coconut husk, dried leaves, and use of vermicompost were adopted for horticulture plantations. Promotion of alternate crops to paddy like chickpea, *ragi* and fodder were taken up for efficient management of available ground water. Diversified farming systems, including tree planting and a range of livelihood options for landless and marginal farmers, such as vermiculture, sheep rearing and the provision of an artificial insemination service were continued.
- Custom hiring centres worked out to be a prudent solution for small farm mechanization and means of livelihood for rural unemployed youth besides reducing drudgery and improving productivity. The improved agricultural implements from CRIDA were provided to custom hiring centers. Farm youth were trained in handling and use of implements.
- Lessons learned were a) promotion of informal and non-political institutions *(Salah Samithis)* representing different stake holders in the village helped in stronger community ownership, avoided conflict and helped in equity and sustainability, and b) participatory monitoring of groundwater helped in creation of awareness of depletion of ground water and need for conservation through crop diversification by growing useful crops.

Custom hiring center at Mahabubnagar

Sheep rearing in Mahabubnagar district

Trench-cum-bund for conserving water

2.7.2 Farmer indebtness in KVK adopted villages

A survey was under taken to look into the credit utilization pattern by farmers in four KVK-adopted villages. The survey also assessed the existing cropping pattern, input use and productivity level of crops in these villages. Besides, various representatives of institutional agencies providing credit to farmers were contacted to gain an understanding of credit disbursement and recovery procedures. The findings of the survey are described hereunder.

- The average outstanding household loan was higher in Utlapally (Table 29). Further, the outstanding loan was high in case of non-institutional credit. The flexibility in obtaining the credit in terms of amount, timing, purpose and the relative ease with which the loan could be obtained were criteria in obtaining loans.
- Majority of farmers availing institutional credit also borrowed from local moneylenders. The converse was less frequently observed. The inadequacy of institutional credit, the rigid procedures to be followed and the requirements of non-productive credit were major hindering factors.
- The interest rates charged by the local moneylenders were high, and varied from 24-48% compared to 12-15% charged by the institutional sources.
- Whereas credit from the local moneylenders was taken for both productive (crop, fertilizer, irrigation) and non-productive (personal use) purpose, the institutional credit was taken for productive purpose only. In both cases, there were instances where the credit was not used for the purpose for which it was actually taken.

Table 29 Outstanding loan in different villages

Village	Institutional (Rs. household^{-1})	Non-institutional (Rs. household^{-1})
Mucherala	8267	28067
Puchanmma thanda	7000	32214
Saireddy guda	10000	28813
Utalpalli	29533	55333

- Farmers who were largely dependent on non-institutional credit were forced to sell their produce to the local merchants immediately after harvest. As a result remuneration received by non-institutional borrowers were less than that received by institutional borrowers.
- The differences between the remuneration received by institutional and non-institutional borrowers varied with crop and villages. The non-institutional borrowers growing castor received significantly lower prices than their institutional counter-parts (Table 30). The prices did not vary much for cereals.

Table 30 Average price received by institutional and non-institutional borrowers

Crop	Institutional borrowers (Rs q^{-1})	Non-institutional borrowers (Rs q^{-1})	Change (%)
Castor	1291	1062	-17.7
Cotton	2230	2160	-3.1
Maize	469	452	-3.7
Sorghum	465	442	-5.0
Rice	491	478	-3.6

2.7.3 Socio-economic development of rural women through self help groups

Since women form a major part of rural population and since they are not much involved in decision making process and have independent livelihood, a study was undertaken in Ranga Reddy district to study the contribution of SHGs in their upliftment. Thirty SHGs, with an average size of 13, formed between 1994-2004 in 8 villages of Ranga Reddy district were selected for the purpose. The following observations were made:

- Nearly 66% of SHG's monthly thrift amount was Rs.30.
- Nearly all the rural women folk (95%) were brought in to the fold of SHG and had access to credit at lower interest rates.
- Recovery was by "Peer pressure" and recovery percentage was 90%.
- Average credit repayment capacity either in the form of interest or principal amount of a wage earning rural women was Rs. 100-300 $month^{-1}$.
- About 80% of the credit was spent on contingency needs and only 20% on income generation activity. It is proposed to reverse this trend, atleast to some extent, in the time to come.

2.7.4 Social Science Information Repository

The study was initiated in 2001 to build up a panel database for all the seven agro-climatic zones of Andhra Pradesh so as to generate key inputs to policy level decision making. Data were therefore collected on crop economics and other related aspects from 15 farmers of seven villages, representing seven zones. The salient findings related to economics of crop production in two zones only i.e., the Southern Telangana and Scarce Rainfall zones are presented here since they closely match CRIDA's mandate.

- In the drought-prone Southern Telangana zone, intercropping was popular. Farmers, who had access to well irrigation, grew rice twice. The yield of *kharif* rice was 45 q ha^{-1} as against 62 ha^{-1} in *rabi*. Fertilizer use was higher for *rabi* rice. Sorghum yield from intercropping system with pigeonpea appeared to be better than from the sole crop even though similar inputs were used. Similarly, castor+groundnut and pearlmillet+pigeonpea intercropping systems yielded better. The returns from cultivation of rainfed crops in this zone were not attractive, sometimes even negative, because of the high input cost, especially human labour and seed, and lower yield. The cultivation of rice under irrigated condition, however, was profitable.
- A number of crops were grown in Scarce Rainfall zone, as is the case with the Southern Telangana zone. However, groundnut, generally intercropped with pigeonpea, was the most dominant one. Its average yield was 6.7 q ha^{-1}. Pigeonpea, intercropped with groundnut, yielded only 0.3 q ha^{-1}. Among other crops, sorghum and pearlmillet were popular but were poor yielders (1.88 q ha^{-1} of sorghum and 3.54 q ha^{-1} of pearlmillet) because of low input use. Farmers applied higher levels of fertilizer for commercial crops like tomato, cucumber and sunflower.

- Even though groundnut was the major crop in Southern Telengana zone, the returns from it were negative. A look into cost structure indicated that seed alone accounted for more than one-third of its total cost of cultivation. Farmers who cultivated cucumber earned a net return of Rs.9600 ha^{-1}. Cultivation of sorghum and pearlmillet was either loss making or marginally profitable.

2.7.5 Assessment of adoption and impact of IPM in rainfed crops

The study was started in later part of the year with an objective to examine adoption and impact of IPM practices in cotton, groundnut and pigeonpea in Guntur, Anantapur and Rangareddy districts, respectively. The following preliminary observations were made:

- The variability in production of groundnut in Anantapur district over the past decade did not show any significant trend. Cotton production in Guntur district increased at an annual rate of 14%. The area, production and productivity of pigeonpea in Rangareddy district increased at 3.24, 11.07 and 7.57%, respectively during the same period.
- The variability in the share of the crop concerned in the total cropped area of the district was relatively high for cotton than the other two crops. The share of groundnut was more than 70% in most of the mandals of Anantapur district. In case of Rangareddy, only four mandals had > 30% cropped area under pigeonpea. In Guntur district, cotton cultivation was prominent in eight mandals with a share of at least 40%.

2.7.6 Economics of milk production

A study on economics of milk production with particular reference to optimal allocation of feed and fodder to dairy animals was under taken in one Mandal / Tahsil in one district each of Andhra Pradesh, Karnataka and Tamilnadu. Though economics of milk production was worked out in case of local cows and buffaloes, optimal allocation of feeds and fodder combinations were not worked out due to fast decline of local cows / buffaloes at these three locations. Some of the results and conclusions drawn are as under.

- The cost of calf rearing was profitable in crossbred cows at all the locations. It was 13% in A.P., 22% in Karnataka and 25% in T.N. The age at first calving was estimated to be 865, 890 and 902 days, respectively. There was still a scope to decrease the cost of calf rearing for maximizing profitability in crossbreds.
- Cost-return analysis indicated feed to be the major item in total cost accounting for more than 70-80% at all three locations in crossbreds, and 65-75% in local cows and buffaloes. The profit ranged from 46 to 57% in AP, 45 to 59% in Karnataka and 17 to 22% in TN. Rearing of Holstein Friesian was more profitable at all the three locations due to its high yielding capacity. Jersey crossbreds were profitable next to Holstein Friesian in AP but mixed crossbreds were more profitable in Karnataka and TN. The net returns were negative in rearing of both local cows and buffaloes in TN, local cows in Karnataka and buffaloes in AP. Linearity existed in case of concentrate feeds in all places, and it was higher in TN. The importance of rearing dairy animals, particularly crossbreds, has increased in the three states due to increased income and gainful employment even during drought years.
- The profits can further be maximized through adoption of efficient and improved exotic germplasm, scientific feeding, judicious management and prevention and control of diseases. Dairying will thus become 'an effective wheel to uplift the rural people' in India. It is suggested that dairying be encouraged among the rural people by providing incentives as a measure of assured livelihood.

2.8 Transfer of Technology

Transfer of technology is an integral part of agriculture and without it, technology generated becomes useless. The Institute, and the KVK attached to it, since their inception have been conducting training programmes, field demonstrations and the like at various levels. This year too good number of activities were conducted which are summarized below :

2.8.1 Training programmes

The TOT section organized sponsored training courses as per the following schedule:

Period	Title of the Course	Participants
February 2-5, 2005	Improved Techniques in Rainfed Agriculture (sponsored by Andhra Pradesh Scheduled Tribes Cooperative Finance Corporation, Hyderabad)	Project Agricultural Officers, Project Horticulture Officers and Horticulture Officers working in Integrated Tribal Development Agency
February 8-15, 2005	Moisture Conservation Techniques for Dryland Agriculture (Sponsored by Directorate Of Extension, Govt. of India, New Delhi)	Subject Matter Specialists & Extension Functionaries from State Dept. of Agriculture, Watersheds, Tribal Welfare and SAUs

2.8.2 Krishi Vigyan Kendra

Krishi Vigyan Kendra (KVK) provided training and spot guidance, and conducted on-farm demonstrations to improve farm income through crop production and development of other rural enterprises. The following were the major activities:

- KVK conducted 114 need-based, skill oriented training programmes covering 9887 farmers. In addition it organized training programmes on 'Women Empowerment' in collaboration with Farmers' Training Centre, Department of Agriculture (AP) in 25 mandals of Ranga Reddy district. These programmes, covering all aspects pertaining to rural development and livelihoods, were attended by more than 1000 farm women.
- Four hundred and nine Frontline Demonstrations were conducted on maize (251), castor (25), pigeonpea (13), pearlmillet (48), sorghum(21), paddy (28) and vegetables (23). Directorate of Oilseeds Research, Hyderabad and KVK conducted 22 demonstrations on castor cv Jyothi for breeder seed production under 'Village Seed Production Programme' covering 35 acres belonging to 26 farmers.

Training being imparted to women farmers

Frontline demonstrations on maize

- To improve livestock position, nine Nellore Brown rams (sheep) and 588 Vanaraj (poultry) birds were supplied to the needy.
- Two hundred and ninety seven drumstick seedlings, 2500 glricidia, 20 guava, 25 acid lime, 2 sapota, 10 jamun, 10 custard apple, 25 bamboo, 20 citrus, 375 curry leaf seedlings and 40 dryland manual weeders were also supplied to farmers of KVK adopted villages.
- Ten sericulture units were initiated in collaboration with Department of Sericulture, Govt. of A.P. About 50 acres of wasteland / tank-bed areas were covered with forest species including Jatropha.
- Training-cum-demonstration programmes of 10-day duration each for farmwomen was conducted with the assistance of NATP. These empowered women to prepare and sell products through their shops. School drop out girls were also trained for 45 days in tailoring to create more livelihood options.
- One Field Day, three Farmers' Days and one animal health camp were conducted in KVK adopted villages of Ranga Reddy district.

3 Technologies Assessed and Transferred

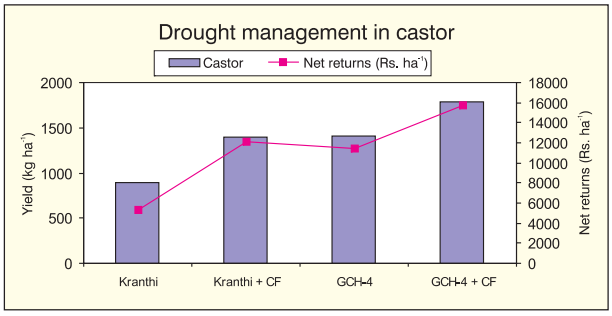
The technology assessment and refinement through Institute Village Linkage Programme (IVLP) under nutritious cereal-based production system was implemented in participatory mode at Antharam, Manmarri, Bodampohad and Kakuloor villages of Yacharam Mandal in Ranga Reddy district of Andhra Pradesh during this year. The main objectives of the programme were to assess and refine the technologies pertaining to sorghum + pigeonpea – castor system in rainfed Alfisols and maize + pigeonpea – cotton in rainfed Vertisols. The theme areas included in this programme were cropping systems, integrated nutrient and pest management and small farm mechanization. About 32 interventions were implemented and the perception of the farmers and technologies was assessed.

3.1 Assessment and Refinement of Technologies

Rainfed Alfisols

In order to improve production and productivity, technological interventions like improved varieties, fertilizer management and drought management practices were evaluated in sorghum + pigeonpea – castor system. The salient findings were:

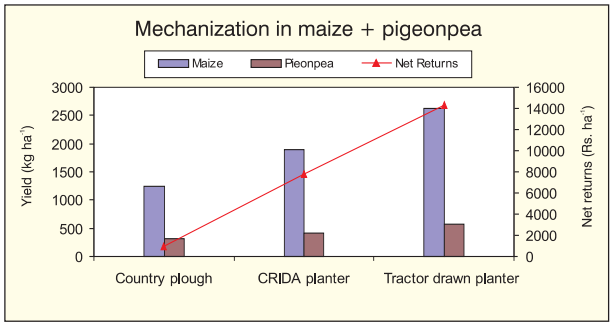
- Use of improved varieties of sorghum (SPV-462) and pigeonpea (PRG-100) in an inter-cropping system (5:1) resulted in additional gross returns (Rs.2113 ha^{-1}) as compared to the local varieties of sorghum and pigeonpea. The improved varieties of sorghum and pigeonpea in another intercropping system (3:1) recorded additional returns (Rs.1728 ha^{-1}) as compared to the local varieties.
- Use of NPK @ 10:30:0 ha^{-1} in sorghum and pigeonpea intercropping system as a basal along with 20 kg N as top dressing were found economically optimum and gave additional net returns (Rs.1283 ha^{-1}) as compared to the recommended dose of 40:30:0 even in an year like this when there was ill-distribution of rainfall.
- Formation of conservation furrows for every three rows along with 10 kg N ha^{-1} in sorghum + pigeonpea intercropping system (3:1) with local varieties gave additional gross returns (Rs. 1316 ha^{-1}) compared to no conservation furrows (Rs. 7282 ha^{-1}). Conservation furrows with 10 kg N ha^{-1} using improved varieties gave additional returns of Rs. 1791 ha^{-1} as compared to the control (Rs. 9549 ha^{-1}).
- Involvement of improved castor varieties (Kranti and GCH-4) in sole castor along with conservation furrows (CF) enhanced productivity by 507 and 3074 kg ha^{-1} respectively as compared to no conservation furrows leading to higher net returns.



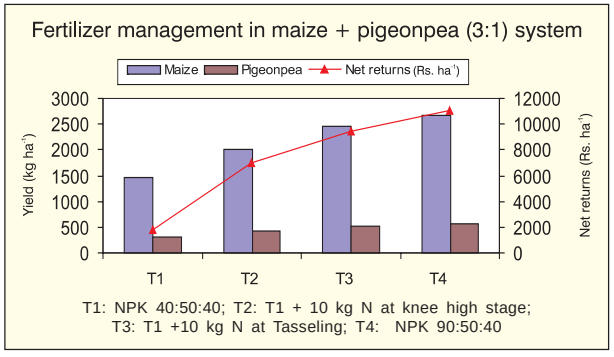
Rainfed Vertisols

- Use of improved cultivars of maize (Ganga-2, Kargil and DHM-105) and pigeonpea (PRG-100) in an intercropping system (5:1) yielded net returns of Rs. 21536, 18805 and 17587 ha^{-1}, respectively. Conversely, use of pigeonpea varieties Local, PRG-100, Maruthi and ICPL with maize (cv Kargil) system (1:5) gave net returns of Rs.20536, 18005, 16837 and 14294 ha^{-1}, respectively. Maize cultivars DHM 105 and Ganga 2, and pigeonpea cultivar PRG-100 were found drought tolerant since they performed better in an erratic rainfall year like this.

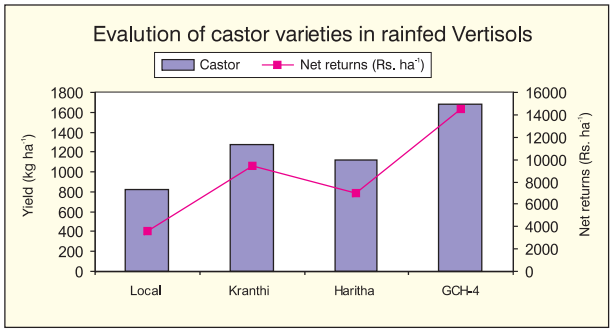
- Sowing of maize and pigeonpea with CRIDA Planter improved plant stand by 20% which led to improvement in net income of Rs.7530 ha^{-1} as compared to the CRIDA bullock drawn plough (Rs.6817 ha^{-1}). The CRIDA Planter covered 75% additional area and made a labour saving of Rs.150 ha^{-1} compared to the farmers' method of seeding with country plough.



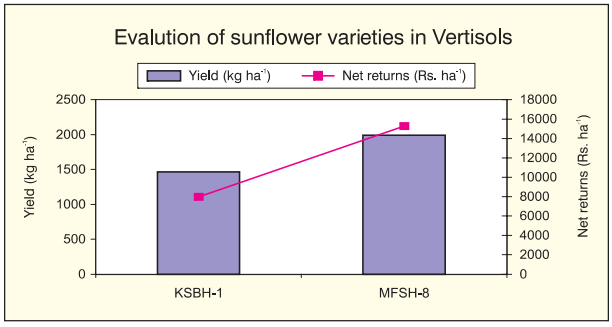
- Application of 40:50:40 NPK ha^{-1} along with top dressing of 10 kg N at tasselling stage in maize + pigeonpea system was found economically optimum as compared to the recommended dose of 90:50:40.



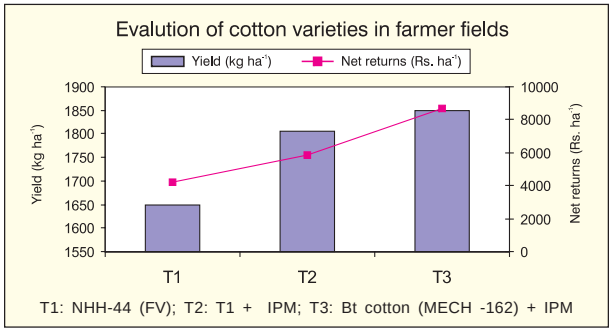
- Among castor cultivars, Kranti recorded additional net returns of Rs.2389 ha^{-1} as compared to cv Haritha (Rs.7035) in Vertisols while cv GCH-4 gave additional bean yield of 396 kg ha^{-1} as compared to cv Kranti (1279 kg ha^{-1}).



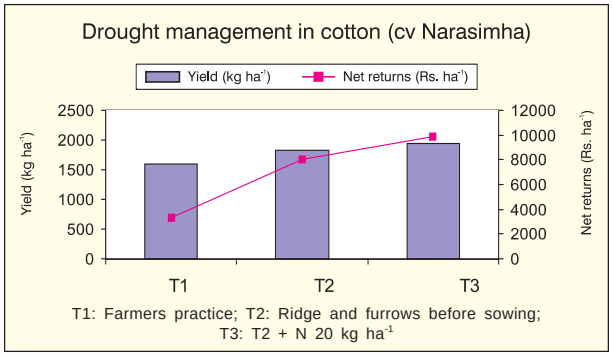
- Sunflower hybrid MSFH-8 gave additional higher yield (528 kg ha^{-1}) and net returns (Rs.7310 ha^{-1}) as compared to KBSH-1 which yielded 1465kg.



- Bt cotton cv MECH-162 together with integrated pest management recorded higher net returns (Rs.8700 ha^{-1}) followed by NHHS-44 (Rs.8550 ha^{-1}) . On an average the integrated pest management technology contributed to an increased net return of Rs.1650 ha^{-1} as compared to no IPM in NHHS-44.

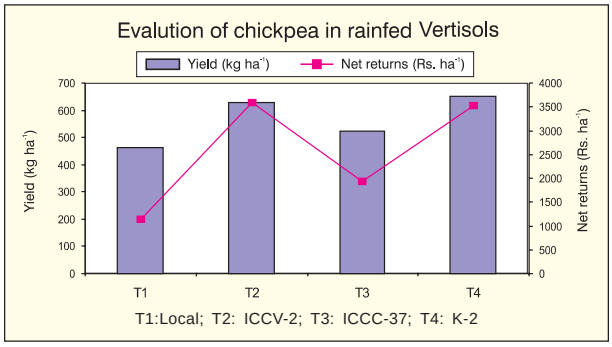


- In sole cotton involving improved cv Narasimha, ridge and furrows before sowing along with 20 kg N gave additional net returns of Rs.1850



ha^{-1} compared to ridge and furrows alone. This intervention enhanced profitability by Rs.1650 ha^{-1} as compared to the farmers' practice.

- Improved varieties of chickpea (K-2 and ICCV-2) gave higher yield (650-625 kg ha^{-1}) than cv ICC 37 (525) . On an average, cvs K-2 and ICCV-2 exhibited a B:C ratio of 1.62 over the local cv (1.2).



3.2 Impact of IVLP

Awareness levels towards IVLP technology introduced in Nazdiksingharam village on the effect of mineral nutrition in milk yield of cows was studied. The analysis identified various constrains faced by the farming community. The following are the major findings :

- Ninety per cent of the farmers had high level of awareness about the effect of mineral nutrition on milk yield.
- Adopters rated overall direct impact of mineral nutrition as very strong to strong.
- Adopters had high level of extension contact and moderate level of mass media exposure.
- Improvement in standard of living and material possession, because of adoption of mineral nutrition, was moderate.
- The social impact was strong due to high level of participation in the Milk Cooperatives of the village.

Adopters perceived the following constraints:

- The most severe constraints, irrespective of the technology adoption, were non-availability of quality feed in summer months, and non-availability of improved breeds and their high cost.
- Non availability of veterinarians, vaccines, AI facilities, short-term loans at marginal interest rates and market information were moderate constraints.
- Distance from market facilities and non availability of human labour were considered minor constraints.

4 Education and Training

4.1 Vocational Course on Dryland Agriculture

B.Sc. Vocational course on Dryland Agriculture was conducted for the fifth year in collaboration with P.G College of Science, Saifabad, Osmania University. On job training was imparted for hands on experience for students of 3rd year during December 2004 to January 2005. Till date two batches have successfully completed the course requirement and were awarded bachelor's degree by Osmania University. Presently the third and final batch comprising 18 students is on rolls.

4.1.1 Project study for a foreign national

Ms. Madeline Pirat, a graduate student from Institute Nationale d'Horticulture Angeri, France did her project work during May-August, 2004 on the effect of Arbuscular Mycorrhiza on growth of neem seedlings.

4.2 Education

4.2.1 Post graduate research

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

Scientist	Student	Discipline	Institute/University
Dr. K.P.R.Vittal	Er. C.R.Thyagaraj	Water Resource	JNTU, Hyderabad
Dr. J.V.Rao	Km. S.Sujatha	Agronomy	ANGRAU, Hyderabad
Dr. S.Desai	Sri. N.Ramakrishna	Bio-technology	Bangalore University, Bangalore
	Sri. Ch.Narayaniah	Bio-technology	S.K. University, Anantapur
	Km. Ch.Kranti Kumari	Bio-technology	S.K. University, Anantapur
Dr. M.Maheshwari	Sri Ravikumar K	Bio-technology	JNTU, Hyderabad
Dr. P.K.Mishra	Sri Kumud Sahu	Soil & Water Conservation Engineering	IIT, Kharagpur
Dr. V.M.Mayande	Er. I.Srinivas	Bio-fuel processing	JNTU, Hyderabad
	Er. R.V.Adake	Residue management	JNTU, Hyderabad
	Sri Devesh P. Pimple	Non-conventional energy	Dr. PDKV, Akola
	Sri R.Nitin	Mechanical Engineering	JNTU, Hyderabad
	Sri B.Sai Babu	Mechanical Engineering	JNTU, Hyderabad
	Sri K.Pawan Kumar Gaud	Mechanical Engineering	JNTU, Hyderabad
Dr. K.V.Rao	Sri Vijay Kumar	Agricultural Engineering	JNTU, Hyderabad
Dr. K.L.Sharma	Km. J.Kusuma Grace	Environmental Sciences	JNTU, Hyderabad
	Smt K.Usha Rani	Environmental Sciences	JNTU, Hyderabad

4.2.2 Higher studies

The following scientists have been deputed for pursuing Ph.D. studies

Scientists	Institute / University
1. Er. C.R.Thyagaraj, Principal Scientist	JNTU, Hyderabad
2. Sri K.Ravi Shankar, Scientist	ANGRAU, Hyderabad
3. Smt. Sreedevi Shanker, Scientist	ANGRAU, Hyderabad
4. Er. I.Srinivas, Scientist (Selection Grade)	JNTU, Hyderabad
5. Er. Ravikanth Adake, Scientist (Sr. Scale)	JNTU, Hyderabad
6. Sri D.B.V.Ramana, Scientist	ANGRAU, Hyderabad

4.3 Training

Deputation within the country

Name	Topic	Venue	Period
Smt. A.Prema Kumari	Establishment and personal matters for officers of ICAR	ISTM, New Delhi	9 -13 February, 2004
Sri R.Joseph	Hybrid seed production in tropical vegetable crops	IIHR, Bangalore	16-23 February, 2004
Dr. P.K.Mishra	Hydrologic modeling	NIH, Roorkee	28 February - 4 March, 2005
Sri P.R.Singh	Hi-tech floriculture	IIHR, Bangalore	3-10 March, 2004
Smt. Hemalata Kapil Smt. Laxminarasamma	PIMSNET	NAARM, Hyderabad	12-13 July, 2004
Sri I.Ram Mohan Sri P.Chandrasekhar	Networking and ernet connectivity	NAARM, Hyderabad	2-6 August, 2004
Dr. Ch.Srinivas Rao	Developing winning research proposals	NAARM, Hyderabad	17-21 August, 2004
Dr. M.Prabhakar	Statistical tools for data analysis	IASRI, New Delhi	23-28 August, 2004
Dr. A.K.Mishra	Transfer of appropriate rural technology for sustainable livelihood-livestock sector	NIRD, Hyderabad	30 August - 4 September, 2004
Sri P.Chandrasekhar Sri G.Lakshminarayana	PERMISNET	IASRI, New Delhi	1-2 September, 2004
Er. Ravikant V. Adake Dr. G.Nirmala	Mechanization of dryland agriculture	CRIDA, Hyderabad	1 - 21 September, 2004
Dr. G.Rajeswara Rao	Strategies for improvement and utilization of tree-borne oilseeds	TNAU, Mettupalayam	20 - 30 September, 2004
Sri P.Chandrasekhar	Feeding the data of PERMISNET	IASRI, New Delhi	14 - 21 October, 2004
Dr. Sreenath Dixit	Deputation	ICRISAT, Patancheru	25 October, 2004-24 October, 2005
Dr. G.G.S.N.Rao	Data ware housing and data quality	IASRI, New Delhi	7 - 9 November, 2007
Smt. K.Usha Rani	Soil water and plant analysis	EEI, Hyderabad	29-30 November, 2004

Name	Topic	Venue	Period
Dr. K.Nagasree	IT for rural development	NIRD, Hyderabad	6-18 December, 2004
Dr. Mohd.Osman	Sabbatic	ICRISAT, Patancheru	1 January-31 December, 2005
Dr. G.Rajeswara Rao	Agri-tourism concepts, approaches, educational, entertainment and entrepreneurial opportunities	ICAR Complex, Old Goa	17-21 January, 2005
Dr. G.G.S.N.Rao Dr. P.Vijayakumar	PRECIS modeling system	IITM, Pune	24- 27 January, 2005
Sri G.Lakshminarayana	Financial and disbursement procedure	ASCI, Hyderabad	7-12 February, 2005

Deputation abroad

Name	Topic	Venue	Period
Dr. Y.G.Prasad	Development and dissemination of forecasts for pest insects of outdoor crops	Horticulture Research International, Warwick, UK	29 March-9 April, 2004
Dr. N.N.Reddy	Land degradation and sustainable livelihoods	ODG, University of East Anglia, Norwich, UK	20 April-5 May, 2004
Dr. Y.S.Ramakrishna	Use of climate information to develop and apply decision making tools to manage disease risks for improved crop production	University of Western Sydney, Australia	25-29 May, 2004
Dr. G.Ravindra Chary	Sustainable land management	i) NCSCRL, Morris, Minnesota, USA ii) NGPRL, Mandan, North Dakota, USA	24 July 2004 - 6 August, 2004
Sri Ashish Roy	Strategic human resource management	ASCI and Singapore, Malaysia	2-16 August, 2004
Dr. Y.S.Ramakrishna	Participatory watershed management for reducing poverty and land degradation in SAT India (Traveling Workshop)	Thailand, Vietnam and China	8-16 September, 2004
Dr. K.L.Sharma	Techniques for assessing soil quality	Ohio State University, Colombus, USA	11-25 October, 2004
Dr. G.Rajeswar Rao	Sustainable natural management of agro-forestry systems	Massey University, New Zealand	18-31 October, 2004
Dr. S.Desai	International Peanut Conference 2005	Bangkok	9-12 January, 2005

5 Women in Agriculture

CRIDA has a fair representation of women in all spheres. There are 10 women in the scientific, 11 in the technical, 14 in administrative and 19 in supporting staff categories. They are actively involved in research projects and other institution building activities. Women scientists undertake both institute and externally funded projects. 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 IMC, RAC and IJSC. It is a matter of pride to state here that Dr. Kausalya Ramachandran was selected as an ICAR National Fellow this year. She would be working on "Assessment of sustainability of treated/developed watersheds of peninsular India using GIS and remote sensing".

Projects handled by women scientists

	Project title	Handled by
Institute Projects		
1.	Evaluation and exploitation of plant species for alternate value added products in marginal lands	Dr. G.Pratibha (PI) Dr. M.Vanaja (Asoc.)
2.	Low till farming strategies and integrated plant nutrient supply for rainfed SAT	Dr. V.Maruthi (Assoc.)
3.	Spectral characterization of rainfed *kharif* sorghum	Dr. M.Vanaja (Assoc.)
4.	Evaluation of maize for nutritive and sustainable grain, fodder and silage production	Dr. M.Vanaja (Assoc.)
5.	Managing abiotic stress tolerance in drylands: physiological and molecular approaches	Dr. M.Maheswari (PI) Dr. M.Vanaja (Assoc.) Dr. N.Jyothi Lakshmi (Assoc.)
6.	Studies in extraction and storage of curry leaf essence	Dr. M.Vanaja (Assoc.)
7.	Life table analysis, economic threshold levels and IPM modules for major pests of castor	Dr. K.Nagasree (Assoc.)
8.	Sustainable land use through agri-horti and horti-pasture system in a rainfed Alfisol watershed	Dr. N.Jyothi Lakshmi (Assoc.)
9.	Building strategies for farm women empowerment- an action research project	Dr. G.Nirmala (PI)
10.	Zero energy cool chamber storage studies on dryland fruits and vegetables	Dr. K.Sreedevi Shanker (PI)
11.	Impact assessment of IVLP project	Dr. K.Nagasree (PI)
12.	Development of farming situation-based extension for Ranga Reddy District	Dr. G.Nirmala (PI)
13.	Organic management for sustainable production of medicinal and aromatic plants	Dr. G.Pratibha (PI)
14.	Performance evaluation and modification of manual seed and fertilizer applicator	Dr. V.Maruthi (Assoc.)
15.	Mechanism of drought tolerance in rainfed short duration pulses	Dr. N.Jyothi Lakshmi (PI) Dr. M.Maheswari (Assoc.) Dr. M.Vanaja (Assoc.)

	Project title	Handled by
16.	Genetic transformation of greengram for enhancing abiotic stress tolerance	Dr. M.Maheswari (Associate) Dr. N.Jyothi Lakhsi (Associate) Dr. M.Vanaja (Associate
17.	Interaction of elevated carbon dioxide and water deficit on growth and pod yield of groundnut	Dr. M.Vanaja (PI) Dr. M.Maheswari (Assoc.) Dr. N.Jyothi Lakshmi (Assoc.)
18.	A critical evaluation of conservation furrows in semi arid Alfisols	Dr. G.Prathiba (Assoc.)
NATP		
19.	Evaluation of cultivars of major oilseed crops for moisture and nutrient constraints in different soil type	Dr. G.Pratibha (CCPI)
20.	Development of sustainable alternate landuse systems for industrial biomass production from dryland	Dr. G.Pratibha (Assoc.)
21.	Landuse planning and management of agricultural resources in rainfed agriculture	Dr. G.Pratibha (Assoc.) Dr. G.Nirmla (Assoc.) Mrs. A.Vidhyadhari (Assoc.)
22.	Identifying systems for carbon sequestration and increased productivity in semi-arid tropical environment	Dr. M.Vanaja (Assoc.) Dr. V.Maruthi (Assoc.)
23.	Influence of different agroforestry models on soil fertility and resource conservation under conditions in SAT	Dr. G.Pratibha (CoPI)
Externally funded		
24.	Enhancing tolerance of sorghum to abiotic stress through genetic manipulate (AP-NL)	Dr. M.Maheswari (PI) Dr. M.Vanaja (Assoc.) Dr. N.Jyothi Lakshmi (Assoc)
25.	Network project on agroforestry in A.P. (AP-Cess)	Dr. G.Pratibha (Assoc.)
26.	Interaction of elevated CO_2 and moisture stress on seed viability, seed germination and initial plant establishment of different dryland crops (AP-Cess)	Dr. M.Vanaja (PI) Dr. M.Maheswari (Assoc.)
27.	Crop diversification for sustainability of drylands through dye yielding crops (AP-Cess)	Dr. G.Pratibha (PI)
28.	Enabling rural poor for better livelihood through improved natural resource management in SAT India (DFID)	Dr. K.Nagasree (Assoc.) Dr. V.Maruthi (Assoc.)
29.	Biointensive integrated pest management (AP-NL)	Dr. G.Nirmala (Assoc.) Dr. V.Maruthi (Assoc.)
30.	Crop-crop diversity as a key component of IPM management (AP-Cess)	Dr. G.Pratibha (Assoc.) Dr. V.Maruthi (Assoc.)
31.	Empowerment of women through participatory dryland technology interventions (UNDP)	Dr. V.Maruthi (PI) Dr. G.Pratibha (Assoc.) Dr. K.Nirmala (Assoc.)
32.	Micro-propagation of neem and teak plants (APNL)	Dr. G.Pratibha(Assoc.) Dr. M.Vanaja (Assoc.)
33.	Assessing soil quality, key indicator for development of soil quality index under predominant management practices in rainfed agro-ecology (AP-Cess)	Dr. Kausalya Ramachandran (Assoc.)

	Project title	Handled by
34.	Evaluation of regenerative agricultural technology with low external inputs (AP-Cess)	Dr. V.Maruthi (PI) Dr. M.Vanaja (Assoc.)
35.	Assessment of impact of sustainable land management practices in watersheds (AP-Cess)	Dr. Kausalya Ramachandran (PI) Dr. M.Vanaja (Assoc.) Dr. G.Nirmala (Assoc.)
36.	Survey, collection, evaluation and multiplication of elite germplasm of pongamia and jatropha (AP-Cess)	Dr. G.Pratibha (Assoc.)
37.	Strategies for decentralized planning for Hyderabad metropolitan region (UGC)	Dr. Kausalya Ramachandran (Co-PI)
38.	Assessment of adoption and impact of IPM in rainfed crops (AP-Cess)	Dr. V.Maruthi (Assoc.)

5.1 Research

There are two ongoing research projects specifically oriented towards women viz., "Empowerment of women through participatory dryland technological interventions" and "Building strategies for farm women empowerment - an Action Research Project".

5.1.1 Empowerment of women farmers through participatory dryland technology

Women farmers play an important role in rainfed agriculture production systems, specially in respect of seeding, weeding, plant protection and post-harvest operations of crops. But they do not have access to resources and are also unaware of the improved production technologies. Lot of drudgeries are involved in performing various agricultural operations. In this context a research project under on-farm conditions was initiated in Mahabubnagar, Medak and Karimnagar districts of Andhra Pradesh to expose farm women on improved technologies through appropriate skill oriented training and also interventions related to crop production technologies.

Demonstrations conducted on various crop production technologies by CRIDA team showed significant impact on attitude of the women farmers. They are now confident of sharing their experience with fellow women farmers. The livelihood of the farm women improved by introducing backyard poultry activities with improved strain (Vanaraja / Giriraja). This activity was self replicated and generated good income to improve their livelihood.

Summary of some activities / interventions is given below :

- Demonstration trials with improved varieties of *bajra* (WCC-75), sorghum (CSV-15, SPV-462 and M 35-1)), pigeonpea (LRG-30 and PRG-100), maize (Ganga), greengram (WGG-37), chickpea (Annigeri) and safflower (Annigeri) enhanced the yield by 15-35 % over the local and existing cultivars. Greengram cv WGG-37 yielded nearly 70% more than local cv ML-362.
- Top dressing with fertilizers and conservation furrows enhanced yield by 5-20% over the

traditional practice of no top dressing and no conservation furrows.

- Women farmers were made aware of the low cost pest management practices like bird perches and pheromone traps.
- Awareness about improved practices was high in Mahabubnagar followed by Medak and Karimnagar.
- For the benefit of the farmers, animal health camps were organized wherein they were sensitized about the importance of nutrition and immunization (Table 31).
- Vanaraja, an improved poultry breed, was introduced under backyard poultry development programme as they were proven to produce more number of eggs (175 eggs in Vanaraja against 40-50 eggs in *desi* hens) and gain body weight rapidly than *desi* birds. The average body weight of 10 month-old bird was 3.78 ± 0.34 kg in cockerels and 3.24 ± 0.22 kg in hens. The farmers are thus making a good margin, and earning profit by selling eggs of the improved breed at a premium price.

5.2 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)

Mrs. V.Savitri (Technical)

Mrs. K.V.Manikyam (Administration)

Mrs. K.Rajamani (Supporting)

5.3 Women Empowerment

KVK under CRIDA conducted many activities for empowerment of farmwomen. They included training programmes for skill development, and exposure visits.

5.3.1 Training Programmes

Twenty seven training programmes were conducted in Ranga Reddy district in which 930 farm women were provided with need-based, skill oriented training in various aspects of agricultural development, farm and home improvement with emphasis on crop production, use of improved implements, preparation of vermicompost, IPM, soil and water conservation, integrated watershed management, sericulture, rural livelihood options, food and nutrition, and the like. In addition, three vocational courses funded by NATP on rural entrepreneurship (*adda* leaf making, fruit and vegetable preservation) were conducted, which were attended by 80 progressive farm women, rural youth, women entrepreneurs and members of water user association and watershed committees.

Table 31 Livestock immunization during the year 2003 and 2004

District	Mandal & Village	Cows		Buffaloes		Goats	
		Immunization	Mineral mixture & Medicine	Immunization	Mineral mixture & Medicine	Immunization	Medicine for deworming
Mahabubnagar	Masayapally	41	4	2	2	103	103
	Goplapur	56	13	4	2	10	5
Medak	Sultanpur	11	8	16	7	40	16
	Mirjapur	52	12	12	8	14	20
Karimnagar	Basavpur	76	27	46	15	24	6
	Regunda	74	35	28	16	15	12
	Total	**310**	**99**	**108**	**50**	**206**	**162**

The KVK also organized training programmes on women empowerment in collaboration with Farmers' Training Centre, Department of Agriculture, Govt. of AP in 25 mandals of Ranga Reddy district. These programmes, covering all aspects of rural development and livelihoods, were attended by more than 1000 farm women.

5.3.2 **Radio talk**

Two radio talks by KVK women staff on "Farm women training programmes on income generation" (1 September, 2004) and "Employment generation schemes for rural women" (30 September, 2004) were broadcast by AIR, Hyderabad.

5.3.3 **Exposure visits**

A group of 50 progressive women farmers from KVK adopted villages was taken on study tour to Central Tobacco Research Institute, Rajahmundry and other places of agricultural interest to acquaint them of recent agricultural developments.

5.4 **ICAR Sport Meet**

A good contingent of women participated in the ICAR sports meet conducted at DOR, Hyderabad. They brought laurels by wining two medals in caroms and chess.

6 Awards and Recognitions

- Dr. Y.S.Ramakrishna, Director, CRIDA, as a partner with ICRISAT was co-recipient of the Doreen Margaret Mashler Award for the year 2004.
- Dr. V.M.Mayande, Principal Scientist (FM&P) was appointed Member, Academic Councils of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and Marathwada Agricultural University, Parbhani.
- Dr. V.M.Mayande, Principal Scientist (FM&P) was appointed as an expert member, Farm Mechanization Committee, Government of A.P, Hyderabad.
- Dr. V.M.Mayande, Principal Scientist (FM&P) and Er. I.Srinivas, Scientist (Selection Grade) (FM&P) were selected for "Best Invention Award" by "Trade Trends Business Weekly" Guntur, A.P., for their innovation of zero energy portable fruit/vegetable preservator.
- Drs. Kausalya Ramachandran, Senior Scientist (Geography) and K.L.Sharma, Senior Scientist (Soil Science) were selected as National Fellows of ICAR for a period of five years.
- Young Scientist Fellowship was awarded to Dr. M.Prabhakar, Scientist (Sr. Scale) (Entomology) for three years by the Department of Science and Technology, Govt. of India.

Dr. Kausalya Ramachandran

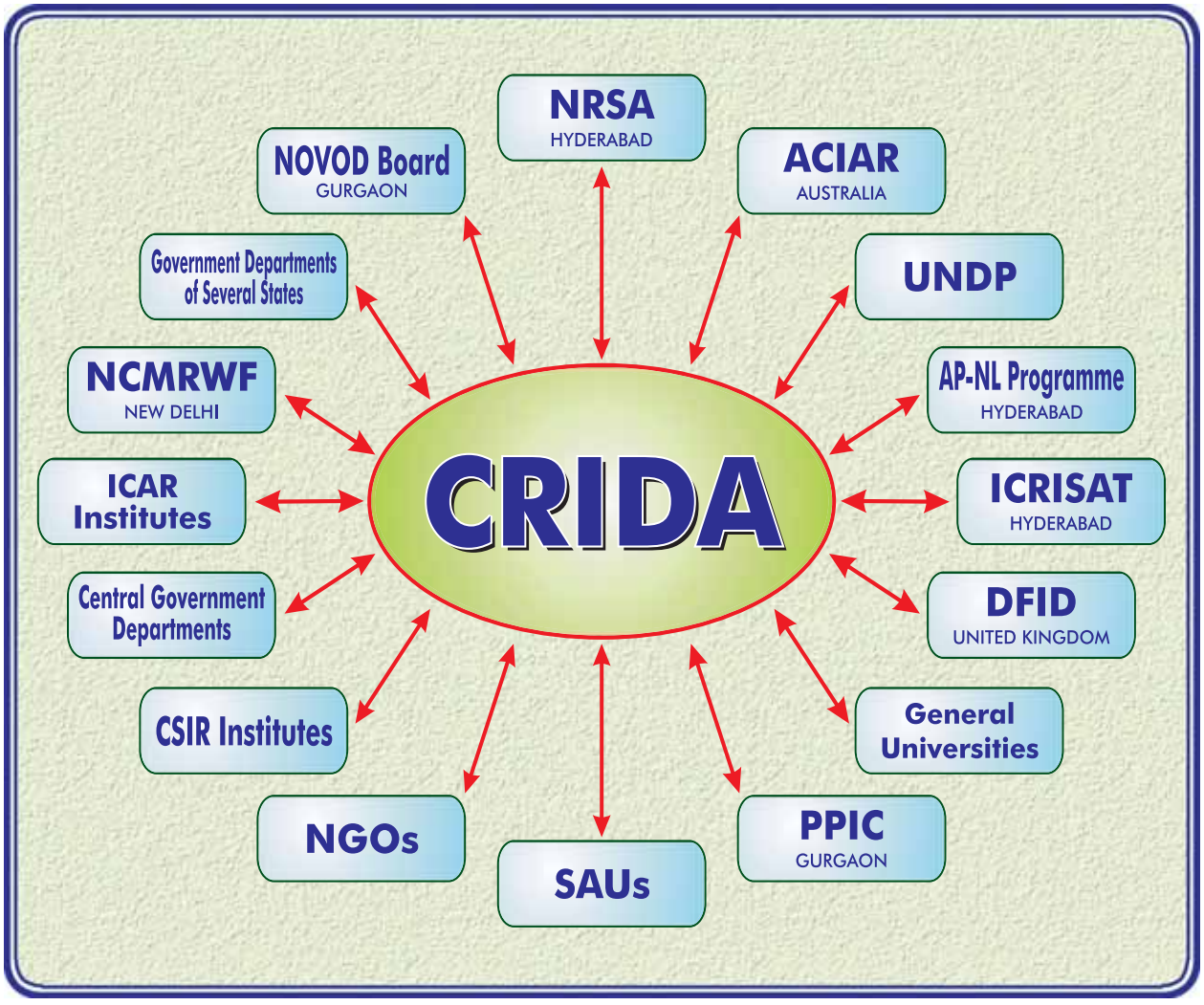
Dr. K.L.Sharma

- Dr. J.V.N.S.Prasad received P.S. Deshmukh Young Agronomist Award-2002 of the Indian Society of Agronomy, New Delhi.

Dr. J.V.N.S.Prasad receiving the Award

- Dr. V.M.Mayande, Principal Scientist (FM & P) was elected Fellow of the Indian Society of Agricultural Engineers, New Delhi.

7 Linkages and Collaborations



8 AICRP/Coordination Units/NATP

8.1 All India Coordinated Research Project for Dryland Agriculture

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) has a network of nineteen centers with State Agricultural Universities/ Technical Universities and three centers of Indian Council of Agricultural Research Institutes. The research work was carried out at research stations and on-farm during this year. The project also handled Front Line Demonstrations on pulses and oilseeds, two Mission Mode Projects funded by NATP and several AP Cess Fund Projects. The research was carried out under the themes of cropping systems, crop improvement (in association with All India Coordinated Research Projects on crop improvement for drought screening), integrated nutrient management, conservation tillage (tillage, nutrient and weed management), rainwater management, energy management, and alternate land use in the crop-based production systems of rice, maize, sorghum, pearlmillet, fingermillet, soybean, groundnut and cotton.

8.1.1 On-station research

A total of 300 experiments were conducted at the research centers. There were 56, 46, 33, 36, 20, 23, 41, 43 and 2 experiments on rice, maize, soybean, groundnut, cotton, fingermillet, pearlmillet, *rabi* sorghum and *kharif* sorghum-based production systems, respectively. Among the themes of cropping systems, plant protection, crop improvement, integrated nutrient management including conservation agriculture (tillage, nutrient management and weed control), rain water management, energy management and alternate land use, there were 47, 3, 77, 79, 42, 40 and 12 experiments, respectively.

From past experiences of statistical analysis of data from several experiments over years, it was found that significant treatments have a narrow range among themselves with relation to yield. From the cluster of significant treatments, it was difficult to focus a superior treatment based on profitability because data is obtained from small plot experiments and not amenable to meaningful economic analysis. Hence a measure of sustainability, in relation to rainfall and achievable maximum yield has been used to select the superior treatment. This Sustainable Yield Index (SYI) needs at least three years of continuous experimentation. Using SYI, a treatment is rated for sustainability after usual statistical analysis. The rating of the SYI for a treatment is highly sustainable (SYI $>$ 0.67), moderately sustainable (0.33 $<$ SYI $<$ 0.67), and least sustainable (SYI $<$ 0.33) in rainfed agriculture. From the others with 1-2 years of experimentation period, promising treatments were identified based on economic yield. The results, (promising or having SYI more than 0.33), are presented for on–station work on rice, sorghum, maize, fingermillet, pearlmillet, cotton, groundnut and soybean-based production systems below:

8.1.1.1 Rice-based production system

In the rainfed rice production system four centers viz., Varanasi and Faizabad in Uttar Pradesh, Ranchi in Jharkhand and Phulbani in Orissa are in the network. The climate here is sub-humid with high rainfall. Sequence cropping is mostly practiced. Major soil orders are Inceptisols and Entisols in Uttar Pradesh, Alfisols in Jharkhand and Orissa. Faizabad received a rainfall of 1054.2 mm compared to normal rainfall of 1057 mm. Ranchi received a rainfall of 1538.3 mm, which was more than the normal of 1300 mm. Varanasi received a rainfall of 1103.1 mm as against normal rainfall of 1078. Phulbani received a rainfall of 1422.2 mm during 2003 as against normal of 1378 mm indicating an excess of about 44 mm.

Upland rice-based

Centre	Research theme	Promising practices/salient findings
Ranchi	Cropping system	• Sole pigeonpea (75 x 25 cm) • Rice + okra (2:2) • Lentil (30 cm) with 30 kg N ha^{-1} • Niger (cv Birsa Niger) with 30 kg N ha^{-1} • Rice (cv RR 348-6) in rice-toria sequence
Faizabad	Cropping system	• Chickpea line sowing (30 cm)
Phulbani	Cropping System	• Rice + blackgram
Varanasi	Cropping system	• Pigeonpea at 0.67 million ha^{-1} • Pigeonpea (cv Bahar) + Rice (NDR-118)
Faizabad	Integrated nutrient management	• $ZnSO_4$ @ 40 kg ha^{-1} for chickpea • 100% N as urea in Maize + pigeonpea • 20 kg S ha^{-1} through gypsum in chickpea • 60 kg N ha^{-1} in niger
Ranchi	Integrated nutrient management	• 5 t ha^{-1} FYM + 50% NPK for rice • Compost @ 15 kg N + 10 kg N ha^{-1} for blackgram-coarse cereal rotation • Green manure @ 15 kg N + 20 kg N ha^{-1} for rice in cereal-legume rotation • Compost @ 15 kg N + 10 kg for blackgram + rice
Phulbani	Integrated nutrient management	• Sunhemp as green manure for maize • FYM 15 kg ha^{-1} + 20 kg urea for blackgram • 45 kg ha^{-1} urea for pigeonpea + rice • FYM @30 kg N + 20 kg P + 20 kg K ha^{-1} for rice • Cassia @ 20 kg N + 4 t ha^{-1} maize storer + 80:40:40:NPK for toria • FYM 5 t ha^{-1} + NPK 60:30:30 for rice • FYM @ 50% N + 50% N as urea for yam + maize
Varanasi	Integrated nutrient management	• 100% NPK for sole rice and rice + greengram • Green manure @15 kg N + 20 kg N ha^{-1} for sole greengram and rice + greengram • FYM @ 50% N + 50% N for rice in rice-lentil rotation • 2% urea spray for late season drought in rice • NPK 80:40:30 for rice and residual effect for rice-linseed rotation
Phulbani	Rainwater management	• Mimosa leaf manure @ 5 t ha^{-1} for maize + pigeonpea
Varanasi	Rainwater management	• Ridging in pigeonpea
Ranchi	Rainwater management	• Supplemental irrigation (3 cm) at seeding + 3 cm every week for mustard, coriander and radish
Faizabad	Tillage and nutrient management	• Conventional tillage + 2 inter culture + 100% N for rice-lentil system • Conventional tillage + 2 inter culture + 100 % N (urea) for lentil in rice-lentil system

Centre	Research theme	Promising practices/salient findings
Ranchi	Tillage and nutrient management	• 50% conventional tillage + 2 hand weedings + 50% N (organic) + 50% N (urea) for rice
Varanasi	Tillage and nutrient management	• Conventional tillage + 50% (organic) + 50% N (urea) for rice • 100% N(urea) for lentil in rice-lentil rotation
Faizabad	Varieties	• Barley cv NDB-2 • Chickpea cv Avrodhi • Lentil cv NDL-1 • Linseed cv Garima • Mustard cv NDK-1 • Rice cv Vandana • Wheat cv Atal • Niger cv GA-10
Phulbani	Varieties	• Rice cv RR-166-645
Ranchi	Varieties	• Rice cv RR 345-167, RR 348-6 • Rice cv Birsa Dhan-101 • Groundnut cv BAU 20 • Sesame cv CST 93 • Pigeonpea cv Gwalior
Varanasi	Varieties	• Rice cv Anand • Lentil cv HUL-62, L 311 • Sesame cv TC 25
Ranchi	Energy management	• Pantnagar zero till drill for lentil
Varanasi	Energy management	• Roto till drill for rice
Ranchi	Energy management	• One ploughing + one plough by Birsa ridger + planking + seeding by traditional plough for rice

8.1.1.2 **Groundnut-based production system**

There are two important centers in the groundnut-based production system viz., Anantapur and Rajkot. Both have arid climate. Anantapur has predominantly shallow Alfisols while Rajkot has Vertisols. At Anantapur, there was a rainfall of 256.2 mm as against a normal of 615 mm. Rajkot received a high rainfall of 1016.5 mm as against a normal of 590 mm.

Groundnut - based

Centre	Research theme	Promising practices/salient findings
Rajkot	Cropping system	• Castor-Groundnut, Pearlmillet-Groundnut, Sesame-Sesame
Anantapur	Cropping system	• Groundnut + cowpea / horsegram / pigeonpea; hand pulling of *Celosia* after 70 days for groundnut
Rajkot	Integrated nutrient management	• 50% RDF + vermicompost @ 0.5 t ha^{-1} for greengram • FYM @ 6t ha^{-1} for blackgram or soybean • 100% RDF for cowpea

Centre	Research theme	Promising practices/salient findings
		• 100% N as urea for sole groundnut • Compost/FYM @ 6 t ha-1 for groundnut • 100% N for pearlmillet • 15 kgN (compost) + 20 kg urea for sole pearlmillet • 50% RDF + 0.5 t ha^{-1} vermicompost for sorghum or pearlmillet • 6 t ha-1 FYM for sesame
Anantapur	Integrated nutrient management	• Gliricidia 25% N + 75% N for sole groundnut
Rajkot	Alternate land use system	• Straw mulch or soil mulch for *aonla*
Anantapur	Tillage & nutrient management	• Conventional tillage + 100% N (organic) for groundnut
Rajkot	Tillage & nutrient management	• 100% N (organic) for sesame
Rajkot	Varieties	• Greengram cv GM 4 • Sesame cv AT 84 • Groundnut cv 9920; JSP 39 • Sorghum cv 9-1003 • Groundnut cvs Chico, TAG 24, JAL 66
Anantapur	Energy	• *Eenati gorru* for groundnut sowing

8.1.1.3 **Soybean-based production system**

In the soybean-based production system, Indore and Rewa centers of Madhya Pradesh are actively participating in dryland research. The soils here are typical deep Vertisols. Indore has semi-arid climate while Rewa is in sub-humid region. There was above normal rainfall of 1005.6 mm against a normal of 944 mm at Indore. Rewa received a rainfall of 1542 mm against a normal of 1087 mm.

Soybean - based

Centre	Research theme	Promising practices/salient findings
Indore	Cropping system	• 10-15 cm deep sowing for soybean
Rewa	Cropping system	• Soybean-chickpea as sequence crop • Pigeonpea cv NPWR-15 + soybean
Indore	Integrated nutrient management	• 100% N (urea) for maize • FYM @ 6 t ha^{-1} + 20 kg N + 13 kg P for safflower
Indore	Alternate land use system	• Drumstick + soybean
Rewa	Integrated nutrient management	• 100% N (compost) in rice / blackgram-wheat / chickpea system • 100% NPK + secondary & micro nutrients for chickpea & rice
Indore	Tillage & nutrient management	• Conventional tillage + RDF + off-season tillage + hand weeding for soybean • Low tillage + weedicide + inter culture + 50% organic + 50% inorganic for soybean
Indore	Varieties	• Soybean cvs Samrat, JS 335, JS 71-05 • Pigeonpea cv ICP - 8863

Centre	Research theme	Promising practices/salient findings
Rewa	Varieties	• Linseed cv 2 K-0107 • Blackgram cv JU-2 • Chickpea cv RWG-12
Rewa	Rain water management	• Trenches across the slope for blackgram
Indore	Rain water management	• Sowing across the slope+ mechanical bund for soybean • Flat sowing + earthing after 30 days for maize

8.1.1.4 **Cotton-based production system**

The research work on cotton-based production system in semi-arid region is being carried out at Akola (Maharashtra) and Kovilpatti (Tami Nadu). Kovilpatti is located far south in peninsular India receiving rainfall mostly during northeast monsoon period. Thus it is more exposed to receding moisture condition. Akola receives normal *kharif* rainfall. The length of growing period at Kovilpatti is limited compared to Akola even though the soils are heavy black in nature. Akola received only 449.7 mm rainfall as against a normal of 825 mm. Kovilipatti received a rainfall of 670.5 mm against normal of 728 mm.

Cotton - based

Centre	Research theme	Promising practices/salient findings
Kovilpatti	Alternate land use systems	• *Ailanthus* + *Cenchrus*
Akola	Integrated nutrient management	• 25 kg N + 25 kg P + 25 kg K ha^{-1} for cotton + greengram • Compost @ 4 t ha^{-1} + 100: 50: 50 (NPK) for maize
Kovilpatti	Integrated nutrient management	• 15 kg N (compost) + 10 kg N (urea) for sorghum + cowpea • 20 kg N (greenmanure) + 20 kg N (urea) for cotton + blackgram • 20 kg N (urea) + 20 kg P (FYM) + SSP @ 20 kg P ha^{-1} for sorghum in cotton-sorghum + cowpea system • 50% N (FYM) + 50 % N (urea) + 10 kg P ha^{-1} for sorghum
Akola	Rain water management	• Ridges & furrows / soil mulch + K @ 20 kg ha^{-1} for cotton • Crop residue mulch/soil mulch + K @ 20 kg ha^{-1} for fodder • Ridges & furrows / soil mulch for soybean
Akola	Tillage & nutrient management	• Low tillage + hand weeding + 50% N + 50% N (organic) for sorghum
Akola	Varieties	• Castor cv AKC-1 • Pearlmillet cv BBH - 7
Akola	Cropping system	• Soybean-mustard cv B-85

8.1.1.5 *Rabi* Sorghum-based production system

Research needs of *rabi* sorghum-based production system is being tackled by Solapur, Bijapur and Bellary. The latter two centers are in hot arid Vertisols, while Solapur is in semi-arid region with shallow to medium deep Vertisols. Bijapur received a below normal rainfall of 274.6 mm as against a normal of 594 mm. Solapur also received a below normal rainfall of 351.1 mm as against a normal of 722 mm. The normal rainfall at Bellary is 513 mm.

***Rabi* sorghum- based**

Centre	Research theme	Promising practices/salient findings
Solapur	Cropping system	• Sunflower to be sown in 28 SMW • Pearlmillet + pigeonpea (2:1)
Bijapur	Cropping system	• Sole cotton (60 x 30 cm) • Cotton (60 x 10 cm) + sunflower (60 x 20 cm) (2:4) • Cotton (60 x 30 cm) + castor (60 x 15 cm) (2:4) • Wider row (120-135 cm) for pearlmillet in pearlmillet-sunflower system • Mustard cv GM-2 sowing in mid October • Pigeonpea + greengram (2:4) • Greengram-Onion-*rabi* sorghum
Solapur	Varieties	• Sorghum cv DSH-129
Bellary	Integrated nutrient management	• 15 kg N green manure + 20 kg N for chickpea and sorghum + chickpea • 100% N for sorghum
Bijapur	Integrated nutrient management	• Green manure + RDF for sunflower in pearlmillet + sunflower system • Incorporation of stubbles / sunflower stalks for sorghum and sunflower • Incorporation of pigeonpea residue for *rabi* sorghum + chickpea and pigeonpea-*rabi* sorghum + chickpea system • Incorporation of cucumber and greengram residues + sunhemp incorporation at 40-45 DAS for *rabi* sorghum and sunflower
Bijapur	Rainwater management	• Sand mulch (5 cm) for sunflower and *rabi* sorghum • Retention of sunflower stalks reduced runoff and soil loss • Water weirs or drop inlet spill ways for uniform distribution of rain water for yield increase in sorghum and sunflower • Compartmental bunding in mid July in two directions for *rabi* sorghum and sunflower
Solapur	Rainwater management	• Ridges & furrows (45 x 30 cm) for sunflower
Bijapur	Alternate land use system	• Mulbery cv S-1635
Solapur	Alternate land use system	• Drumstick + pearlmillet
Solapur	Integrated nutrient management	• 50 kg N : 25 kg P ha^{-1} for castor • 50:25 NP kg ha^{-1} for sunflower

Centre	Research theme	Promising practices/salient findings
Solapur	Soil & water conservation	• Compartmental bunding and ridges and furrows for *rabi* sorghum and sunflower
Bijapur	Tillage & nutrient management	• Conventional tillage + 100% N for *rabi* sorghum
Bellary	Tillage & nutrient management	• Medium tillage + 100% N for sorghum
Solapur	Tillage & nutrient management	• Conventional tillage + 100% N for pearlmillet
Bellary	Varieties	• Sorghum cv CSH-19R
Bijapur	Varieties	• Prosomillet cv PMLT0-7 • Littlemillet cv LMLT-1 • Foxtail millet cv FMLT-9
Solapur	Varieties	• Castor cv CK-03-AHT-56, Aruna • Horsegram cv PHG-9, K-42 • Pearlmillet cv Shradha

8.1.1.6 **Pearlmillet-based production system**

Research on pearlmillet-based production system is being carried out at three centers viz., Agra (Uttar Pradesh), Hisar (Haryana) and SK Nagar (Gujarat). The climate is hot arid. Agra and Hisar centres have primarily rainfed Inceptisols. The soils at SK Nagar are Aridisols. Agra received a rainfall of 510.5 mm 2003 as against normal of 669 mm. SK Nagar (Dantiwada) received a rainfall of 766.7 mm during June to September as against a normal of 782 mm. Hisar received above normal rainfall of 640.6 mm against a normal of 411 mm.

Pearlmillet - based

Centre	Research theme	Promising practices/salient findings
SK Nagar	Alternate land use system	• *Aonla* + cenchrus • Stylo and greengram • Dalbergia + clusterbean
Agra	Alternate land use system	• *Sada Bahar* and Palmarosa
Hisar	Cropping system	• Pearlmillet-mustard • Pearlmillet at 45 cm spacing with straw mulch after 30 DAS • Pearlmillet + greengram (8:4)
SK Nagar	Cropping system	• Early sown pearlmillet at 45 cm spacing • Late sown pearlmillet needs straw mulch at 30 DAS
Agra	Integrated nutrient management	• 50% N + 50% N (compost) for pearlmillet • Recommended N for sole pearlmillet • 15 kgN(green manure) + 20 kgN for sole cluster bean • 50% N + 50% (FYM) for pearlmillet • 10% N for cluster bean in agro - forestry
SK Nagar	Integrated nutrient management	• 50% N + 50% (FYM) for pearlmillet • 10% N for clusterbean in agro forestry

Centre	Research theme	Promising practices/salient findings
Hisar	Integrated nutrient management	• FYM @ 4 t ha^{-1} + RDF for mustard • 100% N for pearlmillet + greengram • 100 % NPK + bio-fertilizer in pearlmillet • 20 kgN + 40 kg P ha^{-1} for greengram • 20 kgN + 40 kg P ha^{-1} for chickpea • 40 kgN ha-1 + Azotobacter for mustard
SK Nagar	Rainwater management	• Compartmental bunding (3.6 x 6.0 m) for castor • Kaolin 6% for castor
Agra	Rainwater management	• Row catchment (with 6% slope) for *Aonla*
Hisar	Energy management	• Two row ridger seeder for mustard • Tractor drawn ridger seeder for pearlmillet and chickpea
Hisar	Tillage & nutrient management	• Low tillage + 2 inter culture + 40 N + 20 P for pearlmillet
SK Nagar	Tillage & nutrient management	• Low tillage + compost @ 4 t ha^{-1} + hand weeding + RDF for clusterbean
SK Nagar	Varieties	• Castor cv SK-111
Hisar	Varities	• Mustard cv RH-9324, MCN-03-35 • Chickpea cv H-96-99, RSG-931 • Pearlmillet cv HHB-67 • Pearlmillet cv HC-98-46 • Sesame cv HT-1 • Clusterbean cv HG-563 • Greengram cv Asha • Blackgram cv 7-9 • Mothbean cv RMO-40 • Mustard cv Luxmi • Barley cv HB - 393

8.1.1.7 **Maize-based production system**

The research in the maize-based production system is being carried out at Arjia (Bhilwara District, Rajasthan), Ballowal Saunkhri (Punjab) and Rakh Dhiansar (Jammu & Kashmir). Among these, high rainfall is received at Ballowal Saunkhri and Rakh Dhiansar. The soils are Inceptisols, Entisols etc. Arjia is under typical semi-arid tract with Alfisols. Arjia received a rainfall of 493.8 mm against a normal of 658 mm. Ballowal Saunkhri received a deficit of 25% of rainfall. The center received 750.5 mm as against a normal of 1012 mm. Rakh Dhiansar received above normal rainfall of 1007.3 mm as against a normal of 860 mm.

Maize - based

Centre	Research theme	Promising practices/salient findings
Arjia	Alternate land use system	• Cenchrus + stylo
Rakh Dhiansar	Alternate land use system	• Sole *gobi sarson* in agro-forestry system
Arjia	Cropping system	• Maize + blackgram

Centre	Research theme	Promising practices/salient findings
Ballowal Saunkhri	Cropping system	• Chickpea @ 60 kg ha^{-1} • Greengram and wheat as sole in *kharif* and *rabi* • Lentil @ 30 kg ha^{-1} • Maize + greengram / blackgram (2:1) • Mustard to be sown at 7-8 cm depth, with a spacing of 30 cm
Arjia	Rainwater management	• Flat sowing and ridges for maize
Ballowal Saunkhri	Integrated nutrient management	• 15 kg N (Compost) + 20 kg N for lentil and wheat • 15 kg N (green manure) + 10 kg N for greengram and maize • 12.5 kg N + 40 kg P ha^{-1} for greengram
Rakh Dhiansar	Integrated nutrient management	• 100% NPK + $ZnSO_4$ @ 20 kg ha^{-1} for maize • 100% NPK for maize or maize + legume • FYM @ 10 t + 40 kg N ha^{-1} + recommended P&K for maize in maize-wheat system
Arjia	Tillage & nutrient management	• Low tillage + herbicide + one weeding + 100% N (urea) for blackgram
Ballowal Saunkhri	Tillage & nutrient management	• Conventional tillage + interculture + 100% N (organic) for maize
Rakh Dhiansar	Tillage & nutrient management	• Conventional tillage + interculture + 100% RDF for maize for maize-wheat system
Arjia	Varieties	• Horsegram cv AK-42, AK-21 • Maize cvs EC-3116, Aravali Makka-1, Mahi Kanchan • Sesame cv SPRT-23 • Sorghum cvs, CSV-10, CSV-15 • Groundnut cv TAG-24 • Sesame cv RT-125 • Blackgram cv T-9 • Greengram cv RMG-62 • Clusterbean cv RGC-936
Ballowal Saunkhri	Varieties	• Chickpea cv PBG-1 • Groundnut cv SML-668 • Mustard cv RLM-619 • Linseed cv V-8

8.1.1.8 **Fingermillet-based production system**

The one center which works on fingermillet is Bangalore. It received a rainfall of 838.8 mm as against a normal of 926.6 mm. The recommendation domain is the semi-arid deep sandy Alfisols.

Fingermillet -based

Centre	Research theme	Promising practices/salient findings
Bangalore	Integrated nutrient management Soil & water conservation	• Sunhemp incorporation for fodder maize • *Nase* live barrier for horsegram • Soybean across the slope with conservation furrow

Centre	Research theme	Promising practices/salient findings
	Tillage & nutrient management	• Conventional tillage + 25% N(FYM) + 25% N(Gliricidia) + 50% N (urea) for fingermillet
	Varieties	• Chili cv Ceylon • Cowpea cv C-15 • Soybean cv KHSB-2 • Niger cv CHH-1 • Blackgram cv K3 • Sesame cv Uma
	Cropping system	• Sole chili

8.1.2 Operational Research Project work

A total of 132 trials were conducted in seven production systems under various themes at the eight ORP centers. The trials were carried out in rice(8 trials), maize(63), soybean(19), groundnut(8), fingermillet(6), pearlmillet(15) and *rabi* sorghum-based(13) production systems. There were 35 dryland demonstration packages. Among the themes of nutrient management, rain water management, energy management, cropping systems, crop improvement, plant protection and alternate land uses, the number of trials conducted were 14, 15, 2, 26, 22, 9 and 9, respectively.

ORP Centre	Research theme	Promising practices/salient findings
Ranchi	Cropping system	• Sole wheat • Maize + pigeonpea (1:1) • Groundnut + pigeonpea (2:1) • Rice + pigeonpea (3:1)
	Weed management	• Inter culture at 25 DAS for linseed • Weeding by grubber at 30 DAS for dryland rice
	Integrated nutrient management	• 20 kg N + 20 kg P for rice
	Varieties	• Rice cv Vandana
Anantapur	Cropping system	• Shrivelled seed for groundnut crop
	Livestock	• Block demonstrations for grazing + feeding on concentrates
Hisar	Integrated nutrient management	• 40 kg N ha-1 for mustard / pearlmillet • 30:60 NP + 20 kgS ha-1 to soybean
	Varieties	• Mustard cv RH-9306 • Pearlmillet cv HHB-94 • Chickpea cv SG-412
	Weed management	• Wheel hand hoe (20 DAS) + *Kasola* (30 DAS) for pearlmillet • Weeding by *Kasola* (25 and 40 DAS) for mustard
Bangalore	Rain Water Management	• Contour cultivation and contour sowing for fingermillet
	Varieties	• Fodder maize cv Africa Tall • Horsegram cv PHG-9 • Cowpea cv ICBC-2
	Cropping systems	• Fingermillet + pigeonpea (10:2)

ORP Centre	Research theme	Promising practices/salient findings
Arjia	Varieties	Block demonstrations: • Maize cv Navjot; groundnut cv JL-24; blackgram cv T-9; greengram cv K-851; clusterbean cv RGC-936; fodder sorghum cv M.P. Chari
	Weed Management	• Deep ploughing + Atrazine in maize
	Cropping systems	• Groundnut + sesame (block demonstrations)
	Tillage & integrated nutrient management	• Deep tillage + 100% FYM + 100% NPK for maize • 50% organics + 50% inorganic for maize + blackgram
Ballowal Saunkhri	Varieties	• Maize cv Megha • Wheat cv PBW-5 • Groundnut cv SG-84 • Sesame cv TC-289 • Greengram cv SML-668
	Cropping systems	• Chickpea + mustard • Gobi sarson + taramira • Mid-March sowing for fodder bajra • Chickpea @ 40 kg ha^{-1} • Mustard + lentil
	Seed treatment	• Chloropyriphos @ 4 mL kg^{-1} wheat seed
	Weed management	• Pendimethalin @ 2.5 L ha^{-1} for greengram • Hoeing at 25 DAS in blackgram • Atrazin @ 1.25 kg ha^{-1} + *halod* for maize
	Alternate land use	• Mustard, chickpea, lentil and wheat in guava
Solapur	Cropping system	• Greengram in *rabi* sorghum
	Varieties	• Pigeonpea cv ICP-8863 • Sorghum cv M-35 • Sunflower cv SS-56 • Pearlmilled cv Shradha • Chickpea cv Vishal
	Cropping systems	• Greengram-*rabi* sorghum

8.2 All India Coordinated Research Project on Agrometeorology

The highlights of the research activities conducted by 25 centres of AICRPAM spread across various agro-climatic conditions are detailed below:

8.2.1 Agroclimatic characterization

- A detailed analysis of the rainfall characterization of 10 districts during *kharif* and *rabi* seasons in Himachal Pradesh was carried out by Palampur centre. The winter rainfall was high in Chamba (500 mm) and low in Sirmour districts (200 mm). However, in *kharif* season, the rainfall varied from 200 mm in Kinnaur to 1000 in Mandi and Sirmour, and 1700 in Kangra district. Winter rainfall due to passage of western disturbances over the state was regular. Analysis of rainfall pattern during winter in Palampur region over the last 30 years showed that rains can begin as early as 1 to 11 October and

continue up to the end of May. The probabilities of occurrence of such scenarios of the rainfall was delineated and contingency crop planning for the same worked out.

- Teleconnection in the monsoon rainfall for 1970-99 of Haryana with global parameters like El-Nino, La-Nina and SOI was carried out at Hisar. The results indicated that out of 30 years, 9 years were of El-Nino, 8 of La-nina, and 13 were neutral. It was revealed that El-Nino had no influence on monsoon. Three classes of SST anomalies in pacific were corrected with three categories of monsoon rainfall of the state. The results showed no association.
- Trends in seasonal and annual rainfall recorded in Lakhimpur, Jorhat, Nagoan, Guwahati, Karimganj and Dhubri districts in Assam were analyzed at Jorhat. It did not indicate any definite trend. However, minor increasing trend in rainfall in Nagoan and decreasing trend in Jorhat was noticed. The annual temperature trend at the above places showed it to be within the normal range.
- Influence of premonsoon rainfall on the sub-sequent season's rainfall was studied for Bangalore. This showed that excess rainfall during premonsoon may cause deficit rainfall during peak monsoon season.
- The agroclimatic analysis for Nadia district in West Bengal was carried out at Mohanpur. The rainfall probability analysis showed that sowing of upland *kharif* crops like jute and rice can be taken up in 19 SMW with certain amount of risk. The LGP for transplanted rice at 50 per cent probability worked out to be of 12-week duration. A suitable short duration rice variety hence should be identified to match the water availability period.
- Temperature variation in the mid-hill regions of Himalayas for 1982-2002 was studied at Ranichauri. Minimum temperature showed increasing trend during summer, winter and post-monsoon, while a sharp decline was noticed in the monsoon period. In case of maximum temperature, all the seasons showed a decreasing trend.

8.2.2 Crop weather relationships

Rabi Season

Wheat

- At Faizabad, thermal and radiation use efficiencies as influenced by sowing dates and genotypes were studied. This revealed that early sown crop was efficient in converting both thermal and radiation energies into higher biomass. The grain yield of wheat was influenced by minimum temperature at different crop stages.
- Grain yield of wheat over five different growing environments was analyzed in relation to temperature during reproductive phase at Hisar. 19°C was optimum thermal regime and any deviation resulted in lowering of the yield.
- At Ranichauri, regression equations were fitted between total drymatter, actual evapotranspiration and growing degree days:

$$TDM = 0.21\ AET - 36.2 \qquad R^2 = 0.71$$
$$TDM = 0.05\ GDD - 21.0 \qquad R^2 = 0.56$$

Chickpea

- At Jabalpur, the variability in yield across dates of sowing was explained through temperature variations recorded during different growth stages. Significant exponential relationship was obtained and it was revealed that yield started declining as the temperature rose above 20°C.
- At Faizabad, negative correlation was detected between grain yield and maximum temperature prevailing during reproductive period. Rise in temperature by 1°C at reproductive stage reduced the grain yield by 1.9 q ha^{-1}.
- At Solapur, correlation between weather parameters and seed yield of chickpea showed

that maximum temperature and bright sunshine at 50 percent flowering and at pod formation stage had significant positive relationship. Minimum temperature during 50 per cent flowering had negative relationship with yield.

Sorghum

- At Kovilpatti, rainfall at all stages of growth was related positively with grain yield. From the lysimeter observations, crop coefficients (ET/ Eo) were computed and it was found that they varied from 0.30 (seedling stage) to 0.80 (vegetative).

Mustard

- At Mohanpur, yield under irrigated and rainfed conditions was related to minimum temperature during 50 per cent flowering to maturity:

Irrigated $Y = 2186.6 - 128.7*Tmin + 2.2.\ RF$ $R^2 = 0.88$

Unirrigated $Y = 1263.5 - 83.8*Tmin + 3.5\ RF$ $R^2 = 0.90$

Safflower

- At Solapur, the relation between seed yield and average temperature during reproductive period was significantly related. Decrease in temperature by 1°C over the mean during the reproductive stage decreased seed yield by 71 kg ha^{-1}.

$Y = -875 + 70.1* Tmin$ $R^2 = 0.68$

***Kharif* Season**

Rice

- At Faizabad, the impact of dry spells at different growth stages on yield was studied on cvs Sarjoo-52, NDR-359 and PantDhan-4. The results indicated that the reduction in grain yield over the control was 44, 19 and 12 % when the crop was subjected to water stress condition during terminal, vegetative and tillering stages, respectively.
- At Jorhat, correlations were worked out between grain yield and mean meteorological parameters recorded during different phenophases. Mean rainfall and mean maximum temperature recorded higher correlations at most of the crop growth stages. Also rainfall during reproductive stage had significant correlation with yield.

Cotton

- At Parbhani, rainfall during emergence to seedling, and boll bursting to first picking had significant positive effect on seed yield. Similarly, minimum temperature during seedling to square formation, boll setting to boll bursting and to first picking had significant positive relationship with seed yield. Boll setting to bursting and boll bursting to first picking appeared to be critical growth stages as most of the weather parameters during these stages showed significant association with seed yield.

8.2.3 Crop growth modelling

- At Raipur, potential yield of rice was simulated using CERES-Rice model for 30 years (1973-2002) separately for irrigated and rainfed conditions under clay and sandy loam soils. The results indicated that potential yield under irrigated conditions was much higher than in rainfed in both soil types. The annual variability in potential yield under irrigated conditions was less when compared to rainfed. In the same study, decrease in minimum temperature by 1, 2 and 3°C over the normal value increased grain yield under irrigated and to some extent under rainfed conditions.
- At Anand, experimental data of wheat crop was used to validate the results obtained by WTGROWS and InfoCrop models. The results revealed that the models predicted duration of anthesis as 56 and 58 days against the observed value of 57 days. For estimation of phenological events, the WTGROWS model performed better than InfoCrop. The models were tested with increased and decreased levels of mean air temperature by 5°C. WTGROWS model predicted a fall in

production by 28.5 % while it was 17.1 by InfoCrop model with increased temperatures. The increase in yield by 35.2 and 14.9 % was possible with decreasing temperature by 5°C.

- The potential yield of wheat was simulated for Raipur Station using CERES-Wheat Model based on the average weather conditions. By changing the maximum and minimum temperatures by 1°C at reproductive stage, the model predicted reduction of grain yield by 2.7 %. When the average temperature increased by 2° and 3°C at the same stage, decrease in yield by 5.8 and 9.6% was expected over the yield obtained at normal conditions.

8.2.4 **Weather effects on pests and diseases**

- At Kovilpatti, multiple regression equations were fitted between weather variables and light trap catches of jassids and bollworm using the data collected over 1996-2002:

  For Jassids:

  $Y = 5528 - 211.3\ Tmax + 105.2\ Tmin + 0.53\ RF - 18.6\ RH + 57.1\ WV + 106.8\ SSH + 61.6\ PE$ $\quad R^2=0.96$

  For Bollworm:

  $Y = 240.3 - 55.9\ Tmax + 17.8\ Tmin - 0.15\ RF - 10.1\ RH - 32.6\ WV - 8.1\ SSH + 47.8\ EE$ $\quad R^2=0.99$

- At Akola, periodic aphid population in safflower grown under two dates of sowing were related to weather parameters recorded inside the canopy. The following regression equation was fitted.

  $Y=7870-56.5X_1-1.67\ X_2 \quad R^2=0.83$

  Where, Y = aphid population, X_1 = average relative humidity (%) and X_2 = average air temperature within the canopy.

- Mohanpur centre identified range of the following weather parameters that were conducive for the development of aphid population in mustard. This has direct relevance in agro-advisory services.

Max. Temp	-	25.5 to 31 °C
Min. Temp	-	11.2 to 16.5 °C
Mean Temp	-	18.9 to 23.8 °C
Wind Direction		NW
RH2	-	37 to 58 %
VPD1	-	01 to 0.021 Kpa
VPD2	-	1.45 to 2.26 Kpa

- At Ludhiana, a field experiment on radish (cv Punjab Safed) was conducted wherein the disease intensity of Alternaria blight under three dates of sowing was recorded. The mean disease index was observed to be nil around 37 days of crop sowing and increased gradually to reach a peak value at 77 days.

- At Palampur, the effect of weather parameters and the management practices on the incidence of rice blast disease were studied. The results revealed that the incidence was higher in late transplanting than in early, and that higher fertility caused higher incidence of the disease. The peak intensity of the disease could be attributed to the sudden fall in minimum temperature below 20°C, increase in RH above 75 percent, and increase in number of sunshine hours, respectively.

- At Mohanpur, peak incidence of rice pests like leaf folder and rice hispa and the prevailing weather was recorded. The results showed that maximum temperature of around 33 to 35°C, minimum between 24 to 25°C and RH1 above 95 % were conducive for peak occurrence of leaf folder. In case of rice hispa, favourable weather conditions for the peak development were maximum and minimum temperature (31-33°C) and RH1 (>98%).

- At Anantapur, relationship between weather and powdery mildew on *ber* was developed. The data on the percentage of disease index of powdery mildew using 0-5 foliar disease rating scale were recorded one week after each spray. The corresponding temperatures recorded were used to develop the following regression equations for different varieties.

Variety	Prediction equation	Multiple R
Gola	Ý = 392.1-10.53X	0.59
Seb	Ý = 392.3 – 6.79 X – 6.36 Y	0.67
Mundla	Ý = 667.4 – 14.0 X – 8.1	0.79
Umran	Ý = 614.5 – 12.3 X – 7.7 Y	0.73
Kithali	Ý = 432.4 – 6.95 X – 7.67	0.71
Gangiregu	Ý = 495.6 – 10.53 X – 5.4 Y	0.74

Ý=Percent Disease Index; X=Maximum temperature; Y=Minimum temperature

8.2.5 Crop weather outlook

The www.cropweatheroutlook.org website which is in operation since 2003 has been added with more information modules such as a weather-based agricultural management plan, state-wise crop and contingency plans, and weekly crop contingency plans. The first module on weather-based agricultural management practices provides links to ICAR website that gives information on weather-based agro-advisories for different regions in the country. The state-wise crop and contigency plans and week-wise crop plans for different rainfed areas in the country are being updated regularly based on the climate and real time weather conditions. They give information on the state-wise crop plans, in respect of different agroclimatic regions in the states, and weather-based crop contingency plans in the rainfed regions of the country. It has expanded the existing network of stations from 25 to 107 Agromet Field Units 9 AMFUs for which separate pages along with password have been provided to the respective centre that are mostly operating under State Agricultural Universities.

8.3 National Agricultural Technology Project (NATP)

Covering 66% of the cultivated area, Rainfed Agro-Eco System (AES) occupies an important place in Indian agriculture. Besides supporting 40% human population, the rainfed AES also supports two thirds of the livestock. Low and erratic rainfall, degraded soils and poor resource base of farmers are some principal constraints affecting productivity and sustainability. Following a new paradigm of eco-region based research initiated under NATP, the rainfed AES was sub divided into five homogenous production systems i.e. rainfed rice, oilseeds, pulses, cotton and nutritious cereals. In all, 103 sub projects were taken up in a network mode to address critical gaps identified in each of these production systems. The year 2004-05 marked the conclusion of most projects. Based on synthesis of 5 years data, the following conclusions were drawn from the PSR projects.

In the rainfed rice-based production system, 35 projects were taken up covering rainwater management, crop diversification, integrated nutrient management, IPM, horticulture and fisheries. The main objective was to improve the productivity and sustainability of rainfed rice-based production system as a whole through increased yield, cropping intensity and better management of natural resources. In a network project in Chhattisgarh, Jharkhand and Orisssa, surplus rainwater during *kharif* season could be successfully harvested and recycled through construction of on-farm reservoirs (OFR) on a field scale. This OFR technology helped in managing drought in standing rice crop and also increased the cropping intensity through *rabi* cropping. The entire cost of water harvesting could be recovered by additional income generated from the project in a period of 3 years. Based on the success of the project, the Government of Chhattisgarh took a major initiative to construct two lakh such structures in a five year period under drought relief programme. Similarly in semi-arid areas of the country, large number of *in situ* moisture conservation practices like ridge and furrow method of planting, conservation

furrows, compartmental bunding and wide row planting were field tested on more than 2000 farmers' fields on cotton, oilseeds, *rabi* sorghum and pearlmillet. These technologies gave additional returns of 20-25% over farmers practice translating in to monetary benefit of Rs.800-2000 ha-1 depending on the crop/cropping system.

In Chhattisgarh and Jharkhand, participatory on-farm research demonstrated opportunities for additional income generation of Rs.1000-2000 ha-1/year through introduction of pulse and oilseeds-based intercropping systems in place of rainfed rice on uplands. In medium and low lands, it was possible to increase cropping intensity through a second crop of gram or vegetables by adoption of moisture conservation practices during *rabi*. This technology, if adopted on community basis, could bring large areas of *rabi* fallows in eastern India under productive use.

Bio and chemo intensive IPM modules were evaluated on farmers' fields on rainfed rice, oilseeds and pulse-based cropping systems. In general, these modules performed on par in terms of yield and benefit-cost ratios, but proved significantly superior over farmers' practice. Adoption of bio intensive modules, however contributed to 45-60% reduction in use of pesticides, benefiting the environment and also resulted in a significant build up of beneficial insects and natural enemies after three years. Similarly, INM experiments demonstrated that sustainable yield on long-term basis can be realized with balanced fertilization or when chemical fertilizers are combined with organic sources of nutrients at least up to 25% of the recommended level. In view of the shortage of FYM across the country, the adoption of green leaf manuring or incorporation of intercropped legumes emerged as a viable alternative in all the production systems.

In the area of varietal development, the sub projects supported the on-going programmes with focus on participatory varietal evaluation which resulted in identification and release of two varieties of rainfed rice, one variety of jute and one variety of dual purpose sorghum. As a significant development, four high quality *arboreum* cotton varieties were identified through extensive on-farm trials in Maharashtra, A.P. and Karnataka. These varieties performance was on par with *hirsutum* hybrids with 40% lower cost of cultivation, particularly on use of pesticides. Mill tests also confirmed their superiority and suitability for textile industries on par with well known hybrid cottons. This opens up immense opportunities for popularizing *desi* cottons in rainfed areas both to save cost of production and reduce the chemical load on the environment.

Significant successes were achieved in the area of post harvest technology and value addition from more than a dozen projects taken up on sweet sorghum, safflower, oilseeds and minor millets. Cultivars of sweet sorghum with high biomass yield (upto 40 t ha^{-1}) were identified. Contract farming trials on pilot basis in Karnataka and A.P. revealed that 40-50 liters of fuel grade ethanol can be produced from one ton of sweet sorghum stalks. Rainfed farmers can earn a net income of Rs.15,000 to 20,000 ha^{-1} by growing this new crop. Following this promising outcome, a stakeholders meeting was organized on promotion of this technology during August, 2004 in Hyderabad inviting representative from sugar and distillery industries. The meeting concluded that considering the biomass yield, short duration and low water requirement as compared to sugarcane, sweet sorghum has immense potential as raw material in view of the Government of India's decision to mix 5% ethanol in auto fuels.

Technologies for production of natural colours, herbal tea and card boards were standardized from safflower which attracted the attention of entrepreneurs in Maharashtra. Farmers growing this low input crop have opportunity to upgrade their income, once these products are commercialized. A contract farming project is planned in Maharashtra

for production of sufficient raw material to dye 5000 m cloth. Protocols for production of complete feed using sunflower heads (which otherwise go waste) were developed. Buffaloes, cattle and sheep supplied with such feed recorded 1-1.5 kg day^{-1} of increased milk yield over farmers practice. Similarly, a detoxification technology for utilization of castor cake as animal feed was standardized and transferred to an oil mill in Vadodra. Feed trials are in progress in Gujarat.

An integrated paddy-cum-fish-cum-duck farming system was tested in Jharkhand and West Bengal for tribal farmers. This system proved quite beneficial not only in utilizing the small ponds in the rice landscape for fish and duck culture but also utilizing the duck manure for improving paddy productivity. This farming system module was adopted by ATMA project in Dumka district of Jharkhand and has potential to improve the income and livelihoods of small farmers in 10-15% of the rice area.

Overall, the 103 sub projects resulted in development of 49 usable technologies in different production systems, out of which 20 technologies were transferred to TAR-IVLP programme for assessment and refinement. Twelve technologies have potential for upscaling/commercialization out of which two have been already commercialized. The production system research covered 8000 farmers in 2000 villages in a four-year period providing extensive opportunities for horizontal learning among farmers in the target districts through formal training programmes, *krishi* melas and exposure visits. It resulted in improved institutional mechanism to carry out network research. The involvement of multi disciplinary inter institutional teams and electronic connectivity introduced effective partnerships which reduced the transaction time and contributed to timely completion of project milestones. Thirty five of the 103 projects were targeted towards generating technologies for small and marginal farmers in rainfed areas and five projects specifically developed technologies for improving income and nutritional security of tribals by crop diversification and integration of livestock in the cropping systems. Through successful validation of IPM modules on more than 1000 farms across the country, the research clearly demonstrated that pesticide use can be brought down to 40% of the current level, if concerted efforts are made to augment the availability of bio agents and encourage farmers for whole village adoption of IPM.

Overall, the production system research provided valuable experience in multi institutional problem oriented eco-region based research and generated many usable technologies which can be adopted by the user agencies for improving productivity and reducing risk in the rainfed farming system. On the flip side, linkages between scientists working in NATP and others involved in the core programmes at the Institutes/SAUs, remained weak. The eco-region approach followed in the project for PSR emerged as a powerful model for addressing complex problems but it needs to be institutionalized in the regular ICAR programmes funded through network projects and Cess fund schemes etc. Otherwise there is a risk of continuing with the existing commodity/discipline-wise approach where as the livelihoods of most farmers in rainfed areas are never linked to a single crop or animal but to the entire farming system.

8.4 Technology Assessment & Refinement – Institute Village Linkage Programme (TAR – IVLP)

The Rainfed Agro Eco-system Directorate also coordinated TAR-IVLP programme at 24 network centers in five production systems with main objective of assessing the potentials of rainfed technologies through verification trials and refine the technologies under different micro farming situations through on-farm trials with active involvement of farmers. Major theme areas covered were natural resource management, crops and cropping systems, integrated

nutrient management integrated pest management, agroforestry, post harvest value addition, gender issues and animal-based interventions. The focus was on assessment of proven technologies in comparison to the farmers' practices. Due priority was given to integrate the technological modules on farming system mode for stable productivity by getting synergistic effects of different enterprises. The 24 centers assessed and refined 126 technologies through 2580 on-farm trials, covering about 20,000 ha and involving 300 villages. Besides, these centers documented 87 success stories covering 26, 13, 13, 32 and 3 in rainfed rice, oilseeds, cotton, nutritious cereals and pulses-based production systems, respectively in different theme areas. These success stories were brought into publication form to bring wider awareness on profitability of rainfed technologies.

In order to upgrade the skills of the farmers for effective implementation of the technological modules along with the awareness of the improved production technology in rainfed agriculture, TAR-IVLP centers conducted 1181 training programmes on crop production, cropping systems, IPM, dryland horticulture, improvement in productivity of livestock with participation of 25,601 farmers from the inception of the project activities. Focus was given on skill oriented training programmes for farm women on reduction of drudgery in agricultural operations, use of millets in diet, nutritious food for children and hygienic practices, entrepreneurship, self help group in women and off season income generating activities for better rural livelihood.

The outcome of the results emanated from the TAR-IVLP was made in the form of publications in research journals, bulletins/folders, presentations in symposia/seminar, popular articles and TV and radio talks to popularize successful technologies among the farming community. The Rainfed Agro Ecosystem Directorate at CRIDA developed effective linkages with PIs of PSR and TAR-IVLP centers and ATMA (NATP), SAUs, local research organizations, department of agriculture and animal husbandry and NGOs and worked as a facilitator in implementing the programme in a holistic manner. Over all, the TAR-IVLP provided valuable experiences of participatory research, identification of location specific programmes through scientific agro ecosystem analysis, assessment and refinement of site specific technologies suitable for different micro farming situations besides encouraging the scientists to become a part of the process of technology assessment refinement and documenting results from OFTs. The project made an excellent impact on the mind set of scientists in timely implementation of the programme.

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10 Ongoing Projects

10.1 Institute Projects

Institute Code No.	Title of the Project	Investigators	Year of start	Likely year of termination
1	2	3	4	5
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 K.P.R.Vittal G.R.Korwar B.Venkateswarlu G.R. Maruthi Sankar U.K.Mandal V.Maruthi K.V.Rao V. Ramesh	1998	2008
2. RM/LU/13	Spectral characteristic of rainfed *kharif* sorghum	**U.K.Mandal** N.N.Srivastava V.Ramesh K.L.Sharma M.Vanaja	2001	2005
3. RM/LU/14	Improving soil health and tree establishment of Alfiosl with fly ash	**V.Ramesh** G.R.Korwar U.K.Mandal J.V.N.S.Prasad	2001	2006
4. RM/FM/01	Energy use in crop production and livestock rearing in A.P.	**C.R.Thyagraj** B.Sanjeeva Reddy J.V.N.S.Prasad	2003	2006
5. RM/AM/16	Radiation and water use efficiency of sorghum-pigeonpea intercropping system	**N.N.Srivastava** P.Vijaya Kumar J.V.N.S.Prasad M.S.Prasad	2003	2007
6. RM/20/12	Organic cultivation of vegetable type pigeonpea	**N.N.Nimbole** J.V.N.S.Prasad	2003	2006
7. RM/SC/01	Rainfall erosivity assessment – spatial and temporal changes in A.P.	**K.V.Rao** P.K.Mishra N.N.Srivastava	2004	2007
8. RM/RM/01	Dynamics of water resource utilisation on ground water and crop productivity in selected lift irrigation systems	**K.V.Rao** P.K.Mishra U.S.Victor J.V.N.S.Prasad U.K.Mandal C.A.Rama Rao	2004	2006
9. RM/NM/01	Development of field kit for estimating labile carbon to assess the soil quality under different land use	**U.K. Mandal** K.L. Sharma V.Ramesh S.K.Yadav	2004	2005

1	2	3	4	5
10. RM/FM/02	Mechanical incorporation of biomass for soil fertility improvement	**R.V.Adake** V.M.Mayande I.Srinivas V.Ramesh U.K.Mandal A.L.Pharande M.Prabhakar	2004	2007
11. RM/ALU/01	Organic management for sustainable production of medicinal and aromatic plants	**G.Pratibha** G.R.Korwar K.Srinivas S.R.Yadav I.Srinivas B.Venkateswarlu	2004	2009
12. RM/AM/17	Performance of drought indices in the detection and monitoring of agricultural droughts	**U.S.Victor** K.V.Rao Y.S.Ramakrishna	2004	2006
13. RM/FM/03	Performance evaluation and modification of manual seed and fertilizer applicator for rainfed crops to reduce dredgery of farm women	**B.Sanjeeva Reddy** C.R.Thyagaraj V.Maruthi	2004	2006
14. RM/FM/04	Feasibility of using Pongamia/ Jatropha oils as a biodiesel in compression ignition engines	**I.Srinivas** V.M.Mayande R.V.Adake S.K.Yadav	2004	2007
Division of Crop Sciences				
15. CS/CP/07	Evaluation of maize for nutritive and sustainable grain, fodder and silage production	**P.R.Reddy** I.A.Khan D.B.V.Ramana A.K.Mishra M.Vanaja S.Venkateswarlu	2002	2007
16. CS/CP/06	Managing abiotic stress tolerance in drylands : Physiological and molecular approaches	**M.Maheswari** M.Vanaja N.Jyothi Lakshmi P.R.Reddy S.K.Yadav B.Venkateswarlu G.Subba Reddy	2002	2007
17. CS/ALU/01	Studies on extraction and storage of curry leaf essence	**S.K.Yadav** G.R.Korwar B.Venkateswarlu M.Vanaja	2002	2004
18. CS/FU/12	Onfarm generation of organic matter - a potential source of nutrient supply and soil health	**B.Venkateswarlu** P.R.Reddy V.Ramesh	1994	Long term
19. CS/AF/04	Sustainable land use through agri-horti and horti-pasture systems in rainfed Alfisol watershed	**J.V.Rao** V.S.Rao N.N.Reddy N.Jyothi Lakshmi	2000	2007
20. CS/Hort/02	Development of suitable agrotechniques for horticultural crops in drylands	**V.S.Rao** N.N.Reddy	2001	2005

1	2	3	4	5
21. CS/SS/01	Integrating the multi nutrient extracts into existing soil test interpretation	**S.S.Balloli** V.Ramesh	2003	2005
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	2007
23. CS/ALU/02	Agro techniques for improvement of productivity and profitability of bush-based production system	**B.M.K.Reddy** V. Maruthi K.V.Rao C.A.Rama Rao	2004	2007
24. 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	2006
25. CS/CP/10	Interaction of elevated CO_2 and water deficit on growth and pod yield of groundnut	**M.Vanaja** M.Maheswari P.R.Reddy S.K.Yadav N.Jyothi Lakshmi B.Venkateswarlu G.Subba Reddy	2004	2007
26. CS/CP/11	Farming system model for marginal and small farmers of nutritive cereal-based production system in rainfed Alfisols	**G.Subba Reddy** A.K.Mishra C.A.Rama Rao S.S.Balloli	2004	2007
27. CS/PP/09	Isolation and testing of microbial pathogens for pest management in dryland crops	**Y.G.Prasad** M.Prabhakar M.Srinivasa Rao B.Venkateswarlu S.K.Yadav Ch.Srinivasa Rao	2004	2007
28. CS/CP/12	Drought management practices in castor	**S.Venkateswarlu** G.Subba Reddy	2004	2007
Transfer of Technology				
29. TOT/20	Zero energy cool chamber storage studies on dryland fruits and vegetables	**K.Sreedevi Shankar** V.S.Rao K.V.Subrahmanyam I.Srinivas	2002	2004 (suspended)
30. TOT/RM/1	A critical evaluation of conservation	**M.V.Padmanabhan** U.K.Mandal G.Pratibha K.V.Rao	2004	2007
Design and Analysis				
31. DA/01	Building strategies for farm women empowerment– an Action Research project	**G.Nirmala** M.S.Prasad B.Sanjeeva Reddy	2004	2006
32. DA/02	Development of farming situation based extension for Ranga Reddy district	**G.Nirmala** M.S.Prasad	2004	2006

10.2 **NATP**

Sl. No.	Project Title	Investigators	Year of start	Likely year of termination
1	2	3	4	5
1.	Near real-time monitoring of agrometeorological conditions for contingency planning in Andhra Pradesh (RRPS-32)	**A.V.R.Kesava Rao** Y.S.Ramakrishna G.Subba Reddy G.G.S.N.Rao U.S.Victor	2000	2004
2.	Develop agri-horticulture and agroforestry systems in *kharif* sorghum area decreasing regions for overall sustainability of the production system (RNPS-9)	**N.N.Reddy** J.V.Rao G.Rajeshwar Rao A.K.Mishra	2000	2004
3.	Development of weather based forewarning systems for crop pests and diseases (MM)	**Y.S.Ramakrishna** Y.G.Prasad, A.V.R.Keshava Rao G.G.S.N.Rao, M.Prabhakar M.Srinivasa Rao, P.Vijay Kumar	2001	2004
4.	Land use planning for management of agricultural resources (MM)	**K.P.R.Vittal** G.Ravindra Chary, U.K.Mandal K.Srinivas, K.L.Sharma V.Ramesh, G.R.Korwar G.Pratibha, J.V.N.S.Prasad K.V.Rao, P.K.Mishra M.Osman, V.S.Rao N.N.Srivastava, G.G.S.N.Rao G.Nirmala, N.Babjee Rao A.Vidhyadhari, C.A.Rama Rao	2001	2004
5.	Use of improved tools for mechanization of dryland agriculture (MM)	**V.M.Mayande** I.Srinivas, R.V.Adake	2001	2004
6.	Integrated National Agricultural Resources Information System INARIS (MMP)	**Y.S.Ramakrishna** A.V.R.Keshav Rao, G.G.S.N.Rao G.R.Maruthi Sanker P.Vijay Kumar	2001	2004
7.	Technology assessment and refinement of nutritive cereal-based rainfed agro-ecosystem through IVLP for Southern Telangana region, Andhra Pradesh (RE-IVLP-2)	**G.Subba Reddy**	1997	2005
8.	Influence of different agroforestry models on soil fertility and resource conservation conditions in SAT (COR)	**G.R.Korwar** G.Pratibha, K.Srinivas V.Ramesh	2002	2005
9.	Effective clonalization of high value horticulture and tree species for dryland agriculture (RNPS-27)	**B.M.K.Reddy**	2001	2004
10.	New approaches to integrated pest management in rainfed rice-based production systems (RRPS-22)	**Y.S.Ramakrishna** G.G.S.N.Rao A.V.R. Keshav Rao	2000	2004
11.	Evaluation of cultivars of major oilseed crops of the production system for moisture and nutrient constraints in different soil types (ROPS-12)	**G.Pratibha** K.L.Sharma G.R.Korwar	2000	2004
12.	Optimising nutrient supply in relation to moisture availability for enhanced productivity and stability of rainfed cotton based production system (RCPS-2)	**K.Srinivas** K.L.Sharma, B.M.K.Reddy G.R.Maruthi Sanker	2000	2004

1	2	3	4	5
13.	Development of regional scale watershed plans and methodologies for identification of critical areas for prioritised land treatment in the watersheds of oilseeds, pulses, cotton and nutritious cereals production systems (RNPS-2)	**P.K.Mishra** M.Osman, V.Ramesh	2000	2004
14.	Assessment and improvement of soil quality and resilience for rainfed production system (RRPS-20)	**K.L.Sharma**, U.K.Mandal K.P.R.Vittal, V.Ramesh	2000	2004
15.	Identifying systems for carbon sequestration and increased productivity in semi-arid tropical environments (RNPS-25)	**V.Ramesh**, M.Vanaja K.L.Sharma, B.Venkateshwarlu K.Srinivas, V.Maruthi	2000	2004

10.3 **Externally Funded**

Sl. No.	Project Title	Principal Investigators	Year of start	Likely year of termination
1	2	3	4	5
1.	Micropropagation of neem and teak plants and extension of technology through rural bio-centers (AP-NL)	**B.Venkateswarlu** G.Pratibha, G.R.Korwar M.Vanaja, S.K.Yadav	1997	2004
2.	Enhancing tolerance of sorghum to abiotic stress through genetic manipulation (AP-NL)	**M.Maheswari** S.K.Yadav B.Venkateswarlu, M.Vanaja N.Jyothi Lakshmi	2001	2004
3.	Biointensive integrated pest management in dryland crops in selected villages (AP-NL)	**Y.G.Prasad**, M.Prabhakar M.Srinivas Rao, G.Nirmala V.Maruthi, B.Venkateswarlu R.Dasharathrami Reddy	2002	2004
4.	Crop - crop diversity as a key component of IPM of dryland crop pests (AP-Cess)	**M.Srinivas Rao** M.Prabhakar, G.Pratibha V.Maruthi, C.A.Rama Rao K.Srinivas	2003	2006
5.	Interaction of elevated CO_2 and moisture stress on seed viability, seed germination and initial plant establishment of different dryland crops (AP-Cess)	**M.Vanaja**, M.Maheswari P.R.Reddy, S.K.Yadav K.Srinivas	2003	2005
6.	Crop diversification for sustainability of drylands through dye yielding crops (AP-Cess)	**G.Pratibha**, G.R.Korwar M.Srinivas Rao, S.K.Yadav B.Venkateswarlu	2003	2006
7.	Social Science Information Repository (NCAP)	Y.V.R.Reddy, C.A.Rama Rao	2001	2004
8.	Enabling rural poor for better livelihoods through improved natural resource management in SAT India (DFID)	**Y.S.Ramakrishna** K.V.Subrahmanyam B.Venkaeswarlu P.K.Mishra V.M.Mayande, M.Osman Sreenath Dixit, A.K.Mishra V. Maruthi, C.A.Rama Rao K. Nagasree	2003	2005
9.	Studies on economics of milk production with particular emphasis on optimal allocation of feeds and fodder to dairy animals in semi-arid regions (AP-Cess)	**Y.V.R.Reddy** Shaik Haffiz	2003	2004
10.	Watershed based NRM strategies for rainfed area of Prakasam district in Andhra Pradesh (AP-Cess)	**M. Osman** K.V.Rao	2002	2005

1	2	3	4	5
11.	Development of long-term hazard planning, management and vulnerability reduction action plan in respect of drought for the state of Andhra Pradesh (Govt. of A.P.)	**P.K.Mishra** M.Osman	2002	2004
12.	Empowerment of women through participatory dryland technology interventions (UNDP)	**V.Maruthi**, G.Pratibha G.Nirmala, G.Rajeshwar Rao M.Srinivas Rao, C.A.Rama Rao K.V.Rao, D.B.V.Ramana B.Sanjeeva Reddy, N.Babjee Rao	2003	2004
13.	Evaluation of Eucalyptus and Leucaena-based agroforestry systems for industrial biomass production for drylands (AP-Cess)	**J.V.N.S.Prasad**, G.R.Korwar K.V.Rao, G.Rajeshwar Rao U.K.Mandal, C.A.Rama Rao	2004	2006
14.	Evaluation of regenerative agricultural technology with low external inputs (AP-Cess)	**V. Maruthi**, K.Srinivas B.Sanjeeva Reddy, C.A.Rama Rao M.Srinivasa Rao, M.Vanaja	2003	2006
15.	Assessment of impact of sustainable land management practices initiated in developed / treated watersheds in rainfed agro-ecoregion of Telangana, A.P. - a GIS-based study (AP-Cess)	**Kausalya Ramachandran** U.K.Mandal, K.L.Sharma V.Ramesh, M.Vanaja G.Nirmala	2004	2007
16.	Assessing soil phosphorus and potassium supplying power under different rainfed production systems and yield maximisation of some dryland crops by optimum nutrient supply (PPIC)	**Ch.Srinivas Rao** G.Ravindra Chary, U.K.Mandal K.L. Sharma, K.P.R. Vittal	2003	2005
17.	Development of tree-borne oilseeds (NOVOD)	**G.Rajeswar Rao**	2003	2004
18.	Refining regional level prediction of yield for cotton (Technology Mission on Cotton)	**K.V.Rao**, J.V.N.S.Prasad U.S.Victor, K.P.R.Vittal	2003	2005
19.	National facility of Agromet Data Bank at CRIDA (AP-Cess)	**G.S.S.N.Rao** Y.S.Ramakrishna, K.P.R.Vittal U.S.Victor, P.Vijay Kumar	2003	2006
20.	Mitigation of fodder scarcity through fodder banks in drought prone areas (NABARD)	**G.Rajeswar Rao** D.B.V.Ramana, J.V.N.S.Prasad V.Ramesh, K.V.Rao	2003	2004
21.	Survey, collection evaluation and multiplication of elite germplasm of Pongamia and Jatropha (AP-Cess)	**G.Rajeswar Rao**, G.R.Korwar K.V.Rao, D.B.V.Ramana V.Ramesh, G.Pratibha	2004	2007
22.	Assessment of sustainability of treated/ developed watersheds in rainfed agro-eco-sub regions of peninsular India using GIS and Remote Sensing (ICAR National Fellow Scheme)	**Kausalya Ramachandran**	2005	2010
23.	Strategies for decentralized planning for Hyderabad Metropolitan region (UGC)	**Prof. S.Padmaja (PI)** Kausalya Ramachandran (Co-PI) Prof. Vijaya Bhole (Associate)	2005	2007
24.	Restoration of soil quality through conservation agricultural management practices and its monitoring using integrated Soil Quality Index approach in rainfed production system(s) (ICAR National Fellow Scheme)	**K.L.Sharma**	2005	2010
25.	Threshold temperatures, thermal constants and development models for major pests of dryland crops (DST)	**M.Prabahakar**	2005	2007

1	2	3	4	5
26.	Studies on Pongamia trees with special reference to utility, economics and markeing in India (AP-Cess)	**Y.V.R.Reddy**	2005	2006
27.	Assessment of adoption and impact of IPM in rainfed crops (AP-Cess)	**C.A.Rama Rao** M.Srinivasa Rao, V.Maruthi Y.V.R.Reddy	2004	2007
28.	Studies on spatial and temporal variations in production and marketing of coarse cereals (AP-Cess)	**C.A.Rama Rao** Y.V.R.Reddy, Shaik Haffiz	2005	2007
29.	Monitoring and evaluation of AP Micro-irrigation Project (Govt. of AP)	**K.P.R.Vittal** Y.S.Ramakrishna, K.V.Rao G.R.Korwar, C.R.Thyagaraj Ravikant V.Adake J.V.N.S.Prasad B. Sanjeeva Reddy, V.M.Mayande P.K.Mishra, M.V.Padmanabhan N.N.Reddy, V.S.Rao, K.Srinivas	2004	2006
30.	Developing decision support systems for major crops through long term agro-climatic data analysis (AP-Cess)	**P.Vijaya Kumar**, Y.G.Prasad Y.S.Ramakrishna, G.G.S.N. Rao K.V. Rao	2004	2007
31	National Food for Work programme, Kadapa district, A.P. (Govt. of A.P.)	**Y.S.Ramakrishna** G.Subba Reddy, G.R.Korwar B.Venkateshwarlu, B.M.K.Reddy A.K.Mishra, P.K.Mishra J.V.N.S.Prasad, C.A.Rama Rao	2005	2005
32.	Organic carbon assessment and its maintenance under rainfed production system (AP-Cess)	**Ch.Srinivas Rao**, K.P.R. Vittal G.Ravindra Chary, J.V.N.S. Prasad B. Venkateswarlu, K.L.Sharma G.R.Maruthi Sankar	2005	2007
33.	Rainfall-runoff-ground water dynamics in semi-arid regions (Ministry of Water Resources, GOI)	**P.K.Mishra**, K.V. Rao U.K.Mandal	2004	2007
34.	Assessing soil quality, key indicator for development of soil quality index under predominant management practices in rainfed agro-ecology (AP-Cess)	**K.L. Sharma**, U.K. Mandal K.P.R. Vittal, G.R.Maruthi Sankar G.Ravindra Chary, K.Srinivas Kausalya Ramachandran S.K.Yadav, Ch.Srinivas Rao	2005	2007

11 Consultancy, Patents and Commercialization

11.1 Consultancy

- Four projects sponsored by AP - Netherlands scheme through Institute of Public Enterprise, Hyderabad are currently in operation.
  i. Micro propagation of neem and teak plants (II Phase)
  ii. Network project on agro-forestry in Nalgonda and Mahabubnagar districts
  iii. Bio-intensive integrated pest management in dryland crops in selected villages
  iv. Enhancing tolerance of sorghum to abiotic stress through genetic manipulation
- Impact evaluation study of NWDPRA watershed at Peddagadda in Srikakulam district of A.P. (Ministry of Agriculture, Govt. of India)
- Development of long-term hazard planning, management and vulnerability reduction action planning in respect of drought for the state of A.P. (Govt. of A.P.)
- Enabling rural poor for better livelihoods through improved natural resource management in SAT India (DFID)
- National Food for Work programme, Kadapa district, A.P. (Govt. of A.P.)
- Monitoring and evaluation of A.P. Micro- irrigation Project (Govt. of A.P.)

11.2 Patents

Patents are pending for five equipments, viz., Banana Fibre Extractor, Orchard Sprayer, Vegetable Preservator, Castor and Groundnut Stripper, and Tractor Drawn Planter.

Till date the Institute has acquired the following patents :-

- Patent no. 181133 for drill plough
- Patent no. 18388 for groundnut planter

11.3 Commercialization

- During the year, ten new industries located in AP, Karnataka, MP, Maharashtra, Rajasthan and U.P. signed MoUs with CRIDA and adopted 9 designs of different equipments for production and sale. This makes a total of 17 industries which have taken up commercial production of CRIDA implements during the past two years.
- A combined income of Rs. 6,95,919/- (Rs. 2,51,560/- from GRF and Rs. 4,44,359/- from HRF) was generated by selling farm produce like grass, firewood, vegetables, fruits, *henna* leaf and powder, curry leaf and *henna* seedlings, and seed of castor, maize, sorghum, pigeonpea, leucaena and the like.
- Soil and plant analytical services worth Rs. 59,570/- were provided to farmers, NGOs, ICAR Institutes, SAUs and the like.
- Micro propagated neem and teak plants worth Rs. 53,340/- were sold to farmers and NGOs.
- Two hundred and fifty one dryland agriculture implements (manual weeders, 2,4,6 and 9 row planters, drill ploughs, castor shellers, orchard sprayers, groundnut strippers, paddy reapers, maize shellers and fruit and vegetable preservators) amounting to Rs. 12,83,962/- were sold.
- In all Rs. 33.81 lakhs were generated from consultancies, externally funded projects, commercialization and the like.

12 QRT, RAC, Management Committee, SRC

12.1 Quinquennial Review Team (QRT)

The quinquennial review of CRIDA and AICRPDA for 2000-2005 has become due. Once the team members are finalized and approved by ICAR, review would begin.

12.2 Research Advisory Committee (RAC)

Chairman

Dr. N.N. Goswami, Ex-Vice Chancellor, CSAUA&T, Kanpur

Members

Dr. A. Padma Raju, Director of Research, ANGRAU, Hyderabad

Dr. S.R. Verma, Ex-Dean, College of Agricultural Engineering, PAU, Ludhiana

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

Dr. H.N. Khajuria, Dean, P.G. Studies, SKUS&T, Jammu

Dr. Gurbachan Singh, ADG (Agronomy), ICAR, New Delhi

Sri Rajendra D. Pawar, Pune

Sri D. Ramakrishna Reddy, Hyderabad

Dr. Y.S. Ramakrisha, Director, CRIDA, Hyderabad

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

Major Recommendations

The XIV RAC meeting was held on February 23, 2005. The following recommendations were made:

1. Integrated farming system models for different situations in dryland areas may be developed.
2. More on-farm participatory research may be undertaken.
3. Diversification to grow medicinal plants, fruits, agro-forestry and xerophytic plants like prosopis/ cactus should be tried.
4. Gaps in watershed research, in-built system of livestock, fodder and other components in watershed programmes be identified and socio-economic issues brought out.
5. Selective mechanization in dryland areas should be adopted to meet timeliness and precision requirements. Research on machinery and implement design and modifications for improving adaptability should be continued.
6. Research on weed management through mechanical and chemical control should be emphasized in dryland farming.
7. CRIDA should develop a strategic plan for development of dryland agriculture in one or two backward districts out of the 150 identified by the Planning Commission.
8. Identification of research gaps and replication of success stories should be linked to transfer of technology programmes.

12.3 Institute Management Committee

Chairman

Dr. Y.S. Ramakrishna, Director, CRIDA

Members

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

Dr. A. Padma Raju, Director of Research,
ANGRAU, Hyderabad

Sri Rajendra D. Pawar, Chairman,
Agri. Dev. Trust, Pune, Maharashtra

Sri D. Ramakrishna Reddy, Vice-President,
Federation of Farmers Association,
Hyderabad

Dr. Gurbachan Singh, ADG (Agronomy),
ICAR, New Delhi

Sri Ashish Roy, SAO, CRIDA &
Member Secretary

Major recommendations

The XXXIV IMC was held on February 24, 2005. The following recommendations/approvals were made :

- The following projects were recommended for approval
  - I. The Andhra Pradesh Micro-irrigation Project, funded by Govt. of A.P., for evaluating drip irrigation systems installed by private entrepreneurs through out Andhra Pradesh
  - II. The Andhra Pradesh Food-for-Work Programme, funded by Govt. of A.P., for improving the livelihoods of rural poor of Kadapa Dist., Andhra Pradesh.
  - III. The projects on bio-diesel funded by NOVOD and AP Cess
- Approval of imported equipments purchased since March, 2004
- Approval of Part-time Medical Officer at CRIDA
- Approval for installation of two Open Top CO_2 Chambers to study the effect of elevated CO_2 and moisture stress on dryland crops.
- Approval for substitution of fifteen items mentioned in X Plan EFC by four more useful and immediately needed items, without incurring any additional finance.
- Approval of promotion of three Technical Officers (T-5) to next higher grade.

12.4 Staff Research Council (SRC)

The annual SRC meeting of the institute was held from 17-19 May and June 7, 2004 under the chairmanship of Dr. Y.S. Ramakrishna, Director. It reviewed 25 (10 Division of Resource Management, 10 Division of Crop Sciences, 5 Transfer of Technology) ongoing projects. Ten projects were concluded since they achieved their objectives and three were extended for periods varying from one to three years. Seventeen new project proposals were presented and sixteen were approved after incorporating minor technical modifications. The meeting also reviewed progress made under 26 NATP projects and 23 other externally aided projects in operation at CRIDA. The technical programme for 2004 – 05 was finalized for 32 projects (cf 10.1).

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

Period	Name of the Scientist	Conferences / Meetings / Workshops / Symposia	Venue
May 11-12, 2004	Y.S. Ramakrishna K.P.R. Vittal All Scientists	Tenth AICRPDA Working Group Meeting	CRIDA, Hyderabad
May 25-29, 2004	Y.S. Ramakrishna	Use of Climate information to develop and apply decision making tools to manage disease risks for improved crop production	University of Western Sydney, Australia
May 27-28, 2004	C.A. Rama Rao	Review workshop of VLS – SSIR	ICRISAT, Patancheru
May 29-30, 2004	A.K. Mishra	National Workshop on Planning and Management of Agricultural Extension Training	New Delhi
June 10-11, 2004	Y.S. Ramakrishna	National Symposium-cum-exhibition on Coastal Eco-system	Thiruvanantha-puram
June 18 - 19, 2004	Y.S. Ramakrishna	Drought Management – Space inputs	KSRSAC, Bangalore
July 21-27, 2004	C.A. Rama Rao	Mini Workshop on VLS and reality check in Asia and Africa	ICRISAT, Patancheru
July 25, 2004	Y.S. Ramakrishna K.P.R. Vittal G. Subba Reddy G.G.S.N. Rao G.R. Korwar P. Vijaya Kumar	Agromet Workshop	CRIDA, Hyderabad
July 29-August 1, 2004	V.M. Mayande	Workshop on "Intellectual Property Rights"	MAU, Parbhani
August 8-11, 2004	V.M. Mayande	Academic Council Meeting	Dr. PDKV, Akola
August 10-11, 2004	Y.S. Ramakrishna K.P.R. Vittal K.V. Subrahmanian Y.V. R. Reddy G. Subba Reddy G.R. Korwar	First annual workshop of AP Cess Fund Ad-hoc Projects	CRIDA, Hyderabad
August 24, 2004	Y.S. Ramakrishna K.P.R. Vittal G.G.S.N. Rao Many other scientists	Identification of suitable technologies for rainfed agriculture in different agro sub-regions of A.P.	CRIDA, Hyderabad
August 27, 2004	A.K. Mishra	Workshop on Fodder, Water and Livestock for Better Livelihoods	Dept. of Animal Husbandry, Hyderabad
August 30- September 4, 2004	A.K. Mishra	Course on Transfer of Ap-propriate Rural Technology for Sustainable Livelihood Livestock Sector	NIRD, Hyderabad

Period	Name of the Scientist	Conferences / Meetings / Workshops / Symposia	Venue
August 31, 2004	A.K. Mishra	23rd Technical Advisory Committee Meeting of RSFPD	Regional Station for Forage Production and Demonstration, Mammidipalli
September 6-10, 2004	G.G.S.N. Rao P. Vijayakumar	Indo-EU workshop on climate change and natural disasters	University of Hyderabad, Hyderabad
September 7, 2004	G. R. Korwar G.Rajeswar Rao	National seminar on BioFuels (Bioleum-2004) : Jatropha and Pongamia as a source of biodiesel – An Overview 2004	FAPCCI & Sampada, Hyderabad
Sept. 8-16, 2004	Y.S. Ramakrishna	Participatory watershed management for reducing poverty and land degradation in SAT Asia	Thailand, Vietnam and China
September 16-17, 2004	G. Rajeswar Rao	Pongamia and Jatropha : CRIDA's experiences and new initiatives 2004	WINROCK International India, New Delhi
September 16-18, 2004	G. Subba Reddy	Alternative farming systems	PDCSR, Modipuram
September 20-21, 2004	Mohd. Osman	National Learning Group Meeting on Sustaining Local Food Systems, Agricultural Biodiversity & Livelihoods	DDS, Zaheerabad
September 23 - 26 2004	V.M. Mayande	Workshop on "Inventors of India"	IIM, Ahmedabad
October 1, 2004	S. Desai	A strategy meeting on peanut stem necrosis	ANGRAU, Hyderabad
October 4-6, 2004	M. Prabhakar	International symposium on Rice : From rice revolution to gene revolution	DRR, Hyderabad
October 6-8, 2004	S. Desai	Building awareness of peanut stem necrosis	ARS, Ananthapur
October 11-13, 2004	S. Desai	Enhancing productivity of groundnut for sustaining food and nutritional security	NRCG, Junagadh
October 12-13, 2004	G.G.S.N. Rao	International Symposium on Rainfed Rice Eco-system: perspectives and potential	IGAU, Raipur
October 15-16, 2004	G. R. Korwar G.Rajeswar Rao	National Seminar on Jatropha Biodiesel & *Aloe vera*	Info Concepts India Inc., Hyderabad
October 19-20, 2004	G.G.S.N. Rao P. Vijayakumar	National Workshop on Remote Sensing with Resource Sat – I (IRS-P6)	NRSA, Hyderabad
October 19, 2004	Kausalya Ramachandran	ResourceSat (P6) Users Conference	NRSA, Hyderabad
October 24-27, 2004	G.G.S.N. Rao	XIII Annual Review Meeting on Agro-advisory services - first meeting on economic impact assessment	AAU, Anand

Period	Name of the Scientist	Conferences / Meetings / Workshops / Symposia	Venue
October 27-28, 2004	V.M. Mayande G.R. Korwar I. Srinivas R. V. Adake	Interface with farmers, custom hiring centers and implements manufacturing industries	CRIDA, Hyderabad
October 27-30, 2004	K. Srinivas	National Seminar on Developments in Soil Science	ANGRAU, Hyderabad
November 1, 2004	C.A. Rama Rao	Final workshop of Social Science Information Repository	RAU, Pusa, Samastipur
November 1-2, 2004	Kausalya Ramachandran	Indo-German Collaboration Program organized by DAAD, New Delhi.	University of Hyderabad, Hyderabad
November 2-3, 2004	C.A. Rama Rao	12th Annual Conference of Agricultural Economics Research Association	RAU, Pusa, Samastipur
November 3-4, 2004	A.K. Mishra	ICAR-IWMI-ICRISAT Inter-national Workshop on Water-shed Management Challenges: Improving Productivity, Resources and Livelihoods	Krishi Bhavan, New Delhi
November 17-19, 2004	G.R.Maruthi Sankar	Statistical refinements in the measurement and testing of sustainability of rainfed practices	JNKVV, Jabalpur
November 18-19, 2004	G. Nirmala	Micro enterprise promotion in rural India	IIT, New Delhi
November 19-20, 2004	G.G.S.N. Rao P. Vijaya Kumar	Seasonal climate prediction for sustainable agriculture	ANGRAU, Hyderabad
November 20, 2004	A.K. Mishra	Workshop on APRLP Livestock Productivity Enhancement	Hyderabad
November 20, 2004	V.M. Mayande	Workshop on "Bio-diversity, farmers rights and intellectual property"	NRC-Sorghum, Hyderabad
November 22-25 2004	G. R. Korwar M. Osman M. Srinivasa Rao J. V. N. S. Prasad V. Maruthi	National Symposium on Resource Conservation and Agricultural Productivity	PAU, Ludhiana
November 24-26, 2004	A.K. Mishra	V Biennial Conference of Animal Nutrition Association on New Dimensions of Animal Feeding to Sustain Development and Competitiveness	NIANP, Bangalore
November 24-26, 2004	P. K. Mishra	National Seminar on Impact Assessment of Watershed Development: Conceptual and Methodology Issues	TNAU, Coimbatore
November 25-27, 2004	Y.S. Ramakrishna G.G.S.N. Rao P. Vijaya Kumar	Input use efficiency in agriculture : issues and strategies	KAU, Trissur
November 30 - December 3, 2004	V.M. Mayande	Director's National Workshop on "Commercialization of Agricultural Technology"	NAARM, Hyderabad

Period	Name of the Scientist	Conferences / Meetings / Workshops / Symposia	Venue
December 3, 2004	Y.S. Ramakrishna	Workshop on Weather and Climate Research Programmes	Lucknow
December 3-4, 2004	G. Rajeswar Rao	Integrating Jatropha and Pongamia in Agroforestry systems	CIAE, Bhopal
December 3-4, 2004	I. Srinivas	National conference on Biodiesel for IC engines-Technologies and Strategies for Rural applications	CIAE, Bhopal
December 3-5, 2004	B. Venkateswarlu	Symposium on Microbes – The Wheels of Organic Farming	UAS, Bijapur
December 7-9, 2004	P. K. Mishra	National Conference "Resource Conservation Technology for Social Upliftment	CSWCRTI, Dehradun
December 8-11, 2004	Kausalya Ramachandran	International Conference on Soil and Ground Water Contamination: Risk Assessment and Remedial Measures	NGRI, Hyderabad
December 19-20, 2004	Y.S. Ramakrishna K.P.R. Vittal G.G.S.N. Rao M. Vanaja P. Vijaya Kumar	Launch workshop of Network Project on Impact, Adaptation and Vulnerability of Indian Agriculture to Climate Change	CRIDA, Hyderabad
December 27-29, 2004	M. Vanaja	Physiological basis for improving agricultural, horticultural and medicinal plant productivity	University of Pune, Pune
January 3-7, 2005	Y.S. Ramakrishna K.L. Sharma S.S. Balloli	92nd Indian Science Congress	Nirma University, Ahmedabad
January 20-21, 2005	Kausalya Ramachandran	International Workshop-2005 on 'Digital Geography and Mapping'	Survey of India, Hyderabad
January 20-22, 2005	G.R.Maruthi Sankar	Statistical modelling and optimization of fertilizer nutrients for rainfed crops based on soil and weather parameters under dryland conditions	CMFRI, Cochin
January 20, 2005	A.K. Mishra	Workshop on Preparation of Perspective Plan for National Food for Work Programme	MANAGE, Hyderabad
January 24-28, 2005	G.G.S.N. Rao P. Vijaya Kumar	Regional modeling studies and data applications using PRECIS model.	IITM, Pune
January 28- February 1, 2005	Y.S. Ramakrishna K.P.R. Vittal B. Venkateshwarlu K.L. Sharma Ch. Srinivas Rao S.S. Balloli U. K. Mandal V. Ramesh	International Conference on Soil Water and Environment: quality issues and strategies	IARI, New Delhi
February 2-3, 2005	Kausalya Ramachandran	Fifteenth User Interaction Workshop	NRSA, Hyderabad

Period	Name of the Scientist	Conferences / Meetings / Workshops / Symposia	Venue
February 3-4, 2005	K.V. Subrahmanyan	IFRI (CAPRI) ICRISAT Project Inception Workshop – Institutional and Organizational Innovations for Watershed Management: Collective action and Property rights for Poverty Reduction in Dryland areas	ICRISAT, Patancheru
February 4, 2005	Kausalya Ramachandran	Leica Geosystems-GIS Mapping User's Meet	ERDAS, India, Hyderabad
February 9, 2005	V.M. Mayande	National Seminar on "Emerging scenario of patent protection, valuation and commercialization"	NRDC, New Delhi
February 9-10, 2005	P. K. Mishra U.K. Mandal	5th Research and Development Session of Indian National Committee on Irrigation and Drainage (INCID) under Ministry of Water Resources	UAS, Bangalore
February 15-18 2005	G.G.S.N. Rao Kausalya Ramachandran	FAO-UNEP-Workshop on Global Land Cover Network(GLCN)	IIT, New Delhi
February 15-19, 2005	V.M. Mayande	Seventh Agricultural Science Congress	Pune
February 17, 2005	Y.S. Ramakrishna J.V. Rao G. R. Korwar G. Rajeswar Rao I. Srinivas	Bio Diesel as Bio-Fuel: Status of Research on Pongamia and Jatropha at CRIDA	CRIDA, Hyderabad
February 18, 2005	P. K. Mishra	AP-Water Vision Follow-up Review Workshop	MCHRD Institute, Hyderabad
February 25, 2005	A.K. Mishra	National Workshop on Fodder Innovations and Livelihoods for Poor Livestock Keepers	ILRI, ICRISAT, Patancheru
February 25 2005	S. Desai	Video conferencing in three village clusters of Tamil Nadu	MSSRF, Chennai
March 4-5, 2005	Y.S. Ramakrishna	International G – Wadi Modellling Workshop and Regional Meeting	NIH Roorkee
March 9, 2005	A.K. Mishra	Workshop on Preparation of Perspective Plan of Kadapa Dist. Under National Food for Work Programme	Kadapa
March 11, 2005	Y.S. Ramakrishna G.G.S.N. Rao P. Vijaya Kumar	Brain storming Session on Development of a Consortium Framework for IT-based Agro-advisory Information and Dissemination System	CRIDA, Hyderabad
March 15, 2005	K.V. Subrahmanyam	PME Workshop	NCAP, New Delhi
March 16-18, 2005	A.K. Mishra	National Seminar on Integration of Cattle and Buffalo Development Programmes with Rural Development Schemes	APLDA, Hyderabad

Period	Name of the Scientist	Conferences / Meetings / Workshops / Symposia	Venue
March 19, 2005	A.K. Mishra	24th Technical Advisory Committee Meeting of RSFPD	Regional Station for Forage Production and Demonstration, Mammidipalli
March 22-23, 2005	M.V. Padmanabhan	Workshop on "Drinking Water for the Rural Masses-Sustainability Concerns"	AMR-APARD, Hyderabad
March 22-23, 2005	Y.G. Prasad	Centernary Seminar	IARI, New Delhi
March 24, 2005	M.V. Padmanabhan	Workshop and 5th Anniversary celebrations of Indo-French Centre for Groundwater Research	NGRI, Hyderabad
March 25-26, 2005	Kausalya Ramachandran	National Seminar on Environmental Impact Assessment Studies-Planning Perspectives	Osmania University, Hyderabad

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

14.1 Workshops, Seminars, Summer Institutes, Farmers' Day

Programme	Period	Venue
X AICRPDA Workshop / Group Meetings	May 11-12, 2004	CRIDA, Hyderabad
Review on Agromet advisory services	May 17-18, 2004	CRIDA, Hyderabad
Custom Hiring Centers & Establishment	July 17, 2004	Pulivendala, Kadapa District
Training course on Agro-climatic methods and techniques for better agromet advisory	July 21-31, 2004	CRIDA, Hyderabad
Agrometeorology Workshops	July 25, 2004	CRIDA, Hyderabad
Workshop on Biotechnological interventions for abiotic stress tolerance in dryland crops	August 6-7, 2004	CRIDA, Hyderabad
Rythu Sadassu (Farmers' Day)	August 12, 2004	Macherla village, R.R. District
Farmers' Mela	August 13, 2004	Gunegal Research Farm, CRIDA, Hyderabad
Identification of suitable technologies for rainfed agriculture in different Agro-sub-regions of Andhra Pradesh	August 24, 2004	CRIDA, Hyderabad
Interactive session on "Sweet Sorghum"	August 28, 2004	CRIDA, Hyderabad
Winter School on Mechanization in Dryland Agriculture	September 1-21, 2004	CRIDA, Hyderabad
World Food Day	October 16, 2004	Saireddyguda village, RR District
Interface with Farmers, Custom hiring centers and implements manufacturing industries	October 27-28, 2004	CRIDA, Hyderabad

Programme	Period	Venue
Field Day	November 4, 2004	Veldanda village Mahabubnagar District
Launch Workshop of Network Project on Impact, Adaptation and Vulnerability of Indian Agriculture and Climate change	December 19-20, 2004	CRIDA, Hyderabad
Bio-diesel as Bio-fuel	February 17, 2005	CRIDA, Hyderabad
National Science Day	February 28, 2005	CRIDA, Hyderabad
Brainstorming session on Development of a consortium framework for IT based agro-advisory information as dissemination system	March 11, 2005	CRIDA, Hyderabad

14.2 National Science Day

The National Science Day-2005 was celebrated at CRIDA, Hyderabad on 28 February, 2005 coinciding with the World Year of Physics commemorating the land mark contributions made in 1905 by Sir Albert Einstein. About a dozen schools represented by 10-12 students each participated in the day long activities which included an elocution competition on "Physics and Society", and visit to laboratories. Winners in the elocution competition were awarded prizes in the form of books and certificates. While going through the laboratories, students evinced keen interest in bio-

technology, soil and water conservation research and experiments on the effect of elevated carbon-dioxide on crop plants.

14.3 **Hindi day / Fortnight**

Hindi Day valedictory function was organized in the Institute on 25 September, 2004. During the Hindi fortnight from 10-24 September 2004 several competitions like Hindi-English Technical Terminology, Hindi Noting & Drafting, Essay Writing in Hindi for Hindi Speaking and non-Hindi speaking employees separately, Hindi Elocution and Hindi Quiz etc. were organized and prizes were distributed among the winners by the Chief Guest of the function. Hindi Workshops were also organized on September 23 and December 24 2004 for the administrative and technical staff to overcome their hesitation while working in Hindi.

On the occasion of concluding Hindi Day function a book entitled "Barani Krishi, Agro-meteorology and Administrative Glossary" and 'CRIDA Profile' (in Hindi) were also released by the Chief Guest, Sri S.V.S.S. Narayan Raju, Professor, Dakshin Bharat Hindi Prachar Sabha, Hyderabad.

15 Distinguished Visitors

15.1 **Individual**

1. Sri N. Raghuveera Reddy, Hon'ble Minister for Agriculture, Govt. of AP
2. Dr. J.S. Samra, DDG(NRM), ICAR, New Delhi
3. Dr. Gurbachan Singh, ADG (Agronomy), ICAR, New Delhi
4. Sri Eric F. Ch. Niche, Ambassador to India, The Netherlands
5. Sri K. Keshav Rao, President, APCCI, Hyderabad
6. Sri Ediuberio Devos Santos, Municipal Coordinator, FFF Camiling, Taruac, Philippines
7. Dr. Ian Noble, World Bank Representative
8. Dr. Rosalinda M. Angeles, Federation of Free Farmers Provincial President, Bulacan, Philippines

Sri N. Raghuveera Reddy, Hon'ble Minister for Agriculture, Govt. of A.P. visiting the institute

9. Sri Kodanda Reddy, Ex-MLA
10. Dr. A.G. Babaev, Director, Regional Research and Training Centre on Desertification Control, Ashkhabad, Turkmenistan
11. Sri M.K. Miglani, IAS, Hon'ble VC, CCS HAU, Hisar
12. Dr. R.P. Singh, Retd. Director, CRIDA
13. S/Sri K. Sasidhar, Yogita Rana, A. Babu, Indian Administrative Service, Karnataka
14. Sri L.K. Gopala Krishna, General Manager, NABARD, Hyderabad
15. Mr. Mohab Aref, Sokhna Port Development Company
16. Dr. Phundan Singh, Director, CICR, Nagpur

Sri Eric F. Ch. Niche, Ambassador to India, The Netherlands

17. Mr. Sewagegna Tariku, Amhara Regional Agricultural Research Institute, Bahir- Dar, Ethiopia
18. Dr. Tibor Toth, Research Institute of Soil Science and Agricultural Chemistry, Hungarian Academy of Science, Hungary
19. Dr. Seyed Ata Rezari, Director General for International Affairs & Public Relations, Islamic Republic of Iran
20. Dr. Negahdar Eskandari, Director General for Range Technical Bureau, Islamic Republic of Iran
21. Dr. Mohammad Hussein Razzaghi, Director General for Training Bureau, Islamic Republic of Iran

Iranian delegates being briefed by Dr. Y.S. Ramakrishna, Director

15.2 **Group**

1. Five member Ethiopian delegation
2. Ten extension specialists from Dhaka, Bangladesh
3. Delegates from CSW&RI, Regional Station, Kota
4. MBA Students of Institute of Public Enterprises, Hyderabad
5. Delegates from Agricultural Engineering Department, Pudukkottai, TNAU, Vallanadu
6. ARS Probationers, NAARM, Hyderabad
7. Officers from State Bank Institute of Rural Development, Hyderabad
8. Farmers from Nizamsagar Catchment Area Watershed
9. Farmers from River Valley Project, Kalvakurthy
10. Trainees from Farmers' Training College, Ranga Reddy district
11. Trainees from Farmers' Training College, Suryapet
12. Trainees from SAMETI, Hyderabad
13. Farmers from various districts of Gujarat
14. Trainees from Farmers' Training Centre, Chittoor
15. Progressive Farmers from Shimla
16. Farmers from River Valley Project, Sadashivpet, Medak
17. Trainees from NIRD, Hyderabad
18. Trainees from NAARM, Hyderabad
19. M.Sc and Ph.D. researchers from ANGRAU, Hyderabad
20. Rythu Mithra group, Kurnool and Anantapur
21. Jatropha and Biodiesel plantation trainees from Medak
22. Trainees from Forage Production and Demonstration Centre, Hyderabad

Dr. K.P.R. Vittal, Project Coordinator (AICRPDA) briefing the Ethiopian team

Visitors from the Philippines

23. Trainees on Watershed Exposure visit from Pudukottai, T.N.
24. Traines from ATMA, Adilabad
25. Rythu Mithra Groups-B.K. Samudram Mandal, Ananthapur District
26. Rythu Mithra Groups from Kurnool

15.3 **Student**

1. B.Sc. students : College of Agriculture, Dharwad
2. B.Sc. students : Pt.JLN College of Ag. & Research Institute, Karaikal, Pondicherry
3. Post Graduate students : Annamalai University
4. B.Sc. (Ag.) students : Agricultural College and Research Institute, TNAU, Tiruchirapalli
5. B.Sc.(Ag.) students : Agricultural College & Research Institute, TNAU
6. B.Sc. students : ANGRAU, Bapatla
7. B.Sc. students :S.V. Agricultural College, ANGRAU, Thirupathi
8. B.Tech. Agril. Engg. Students : College of Agricultural Engineering, ANGRAU, Bapatla
9. B.Sc. Forestry students: College of Forestry, Nauni, Solan.
10. M.Sc. (Ag.) students : RBS College, Bichpuri, Agra
11. B.Sc. Students : ANGRAU, Hyderabad
12. B.Tech. Agricultural Engineering students of UAS, Bangalore
13. B.Sc. (Ag.) Students from UAS, Bangalore
14. B.Sc. (Ag) Students from College of Agriculture, Shimoga
15. M.Sc. (Ag.) students from UAS(D), Raichur

16 Personnel

(As on March 31, 2005

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

Division of Resource Management

Dr. G.R.Korwar	**Principal Scientist (Agronomy) & Head I/c**
Dr. K.D. Sharma	Principal Scientist (S&WCE) (on deputation to NIH, Roorkee)
Dr. U.S.Victor	Principal Scientist (Ag. Meteorology)
Sri N.N.Srivastava	Principal Scientist (Ag. Meteorology)
Sri N.N.Nimbole	Principal Scientist (Agronomy)
Dr. P.K.Mishra	Principal Scientist (S&WCE)
Dr. C.R.Thyagaraj	Principal Scientist (FM&P)
Dr. V.M.Mayande	Principal Scientist (FM&P)
Dr. K.L.Sharma	National Fellow
Dr. Md. Osman*	Senior Scientist (Agronomy)
Dr. G.Rajeswar Rao	Senior Scientist (Forestry)
Dr. Ch. Srinivasa Rao	Senior Scientist (Soil Science)
Dr. G.Pratibha	Senior Scientist (Agronomy)
Dr. K.Srinivas	Senior Scientist (Soil Science)
Er. I.Srinivas	Scientist (Selection Grade) (FM&P)
Dr. K.V.Rao	Scientist (Sr. Scale) (S&WCE)
Dr. B.Sanjeeva Reddy	Scientist (Sr. Scale) (FM&P)
Dr. U.K.Mandal	Scientist (Sr. Scale) (Soil Physics)
Dr. J.V.N.S.Prasad	Scientist (Sr. Scale) (Agronomy)
Er. Ravikanth V. Adake	Scientist (Sr. Scale)(FM&P)
Dr. V.Ramesh	Scientist (Sr. Scale)(Soil Physics)
Sri B. Narsimlu	Technical Officer (T-6)
Sri I. Ramamohan	Technical Officer (T-6)
Sri V. Sree Ramulu	Technical Officer (T-6)
Sri J. B. Ramappa	Technical Officer (T-6)
Sri Ram Kumar	Technical Officer (T-5)
Smt. K. Usha Rani	Technical Officer (T-5)
Sri K Venkanna	Technical Officer (T-5)

Division of Crop Sciences

Dr. G.Subba Reddy	**Principal Scientist & Head I/c.**
Dr. J.V.Rao	Principal Scientist (Agronomy) & Head, Agroforestry Cell
Dr. B.Venkateswarlu	Principal Scientist (Microbiology)
Dr. P.Raghuram Reddy	Principal Scientist (Plant Breeding)
Dr. V.S.Rao	Principal Scientist (Horticulture)
Dr. Y.G.Prasad	Senior Scientist (Entomology)
Dr. S. Desai	Senior Scientist (Plant Pathology)
Dr. N.N.Reddy	Senior Scientist (Horticulture)
Dr. M.Maheswari	Senior Scientist (Plant Physiology)

Dr. S.K.Yadav	Senior Scientist (Biochemistry)
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. S.Venkateswarlu	Senior Scientist (Agronomy)
Dr. G.Jayaram Reddy	Scientist (Sr. Scale) (Agronomy)
Dr. M.Prabhakar	Scientist (Sr. Scale) (Entomology)
Dr. N.Jyothi Lakshmi	Scientist (Sr. Scale) (Plant Physiology)
Smt. P. Anantha Kumari	Technical Officer (T-6)
Sri T. Madhusudhan Swamy	Technical Officer (T-6)
Smt. D. Renuka	Technical Officer (T-6)
Sri Jainender	Technical Officer (T-5)
Sri G. Prem Kumar	Technical Officer (T-5)
Smt. M. Pushpalata	Technical Officer (T-5)

Section of Design and Analysis & KVK

Dr. Y.V.R.Reddy	**Principal Scientist (Ag. Economics) & Head**
Dr. M.S.Prasad	Principal Scientist (Ag. Extension) & OIC, KVK
Dr. C.A.Rama Rao	Senior Scientist (Ag. Economics)
Dr. G.Nirmala	Scientist (Sr. Scale) (Ag. Extension)
Smt. Sreedevi Shankar	Scientist (Food & Nutrition)
Sri M. Chidambara Swamy	Technical Officer (T-9)
Smt. A Sambrajyamma	Technical Officer (T-9)
Sri P. K. Mathod	Technical Officer (T-8)
Sri Pukh Raj Singh	Technical Officer (T-8)
Sri R. Dasaratha Rami Reddy	Technical Officer (T-7)
Sri R. Joseph	Technical Officer (T-7)
Dr Shaik Haffis	Technical Officer (T-6)
Smt. A. Vidyadhari	Technical Officer (T-6)

Section of Transfer of Technology

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

All India Coordinated Research Project for Dryland Agriculture

Dr. K.P.R.Vittal	**Project Coordinator**
Dr. G.R.Maruthi Sankar	Principal Scientist (Ag. Statistics)
Dr. G.Ravindra Chary	Senior Scientist (Agronomy)
Smt. A. Girija	Technical Officer (T-6)
Sri R.V.S.G. Krishnam Raju	Technical Officer (T-6)

All India Coordinated Research Project on Agrometeorology

Dr. G.G.S.N.Rao	**Principal Scientist (Ag. Meteorology) & Project Coordinator i/c**
Dr. Kausalya Ramachandran	National Fellow
Dr. P.Vijaya Kumar	Senior Scientist (Ag. Meteorology)
Sri I. R. Khandgonda	Technical Officer (T-5)

Research Coordination and Management Unit

Dr. I.A.Khan	**Principal Scientist (Genetics)**
Dr. Sreenath Dixit**	Senior Scientist (Ag. Extension)
Dr. S.S.Balloli***	Senior Scientist (Soil Science)

National Agricultural Technology Project Cell

Dr. B.Venkateswarlu	**PPSS**
Sri P. Chandra Sekhar	Technical Officer (T-6)
Smt. P. Lakshminarasama	Technical Officer (T-6)
Sri S.K.C. Bose	Finance & Accounts Officer
Sri G. Lakshminarayana	Asst. Administrative Officer

Library

Dr. P. K. Mishra	**Officer-in-charge**
Sri A. Malla Reddy	Technical Officer (T-6)
Sri I. Syam Prasad	Technical Officer (T-5)

Hayatnagar Research Farm

Dr G. Rajeswar Rao	**Officer-in-charge**
Sri Chandra Mohan Reddy	Technical Officer (T-7)
Sri Ganesh Ramji Hedau	Technical Officer (T-7)
Sri S. Srinivasa Reddy	Technical Officer (T-6)
Sri Y. Venkatesha Reddy	Technical Officer (T-6)

Administration

Sri Ashish Roy	**Senior Administrative Officer**
Sri B.Pandu Reddy	Finance and Accounts Officer
Sri R.K.Shukla	Asst. Administrative Officer
Sri V.Govardhan	Asst. Administrative Officer
Smt. A. Prema Kumari	Asst. Administrative Officer
Sri S.R.Yadav	Asst. Director (OL) and Public Relations Officer

* on sabbatical to ICRISAT from January to December 2005

** on deputation to ICRISAT from October 2004 to September 2005

***on sabbatical to ICRISAT from October 2003 to September 2004

17 Infrastructure Development

17.1 At CRIDA Campus

- Renovation of Agronomy, Plant Pathology, Plant Physiology, Hydrology and Soil Physics laboratories
- Repair and renovation of ARISNET
- Renovation of existing Glass House
- Renovation of farm pond
- Construction of compressor-cum-gas cylinder room
- Strengthening of nurseries at GRF, HRF and CRIDA complex
- Construction of six open top CO_2 chambers for plant growth studies under elevated CO_2 levels and construction of gas cylinder room
- Renovation of A&B type quarters
- Strengthening of TOT Laboratory/Class room
- Laying of GI pipe line for drinking water at CRIDA complex

17.2 At Hayatnagar Research Farm

- Construction of security room and staff room
- Construction of threshing yard
- Provision of street lights at Phase-III
- Renovation of cold storage room
- Construction of implement shed
- Construction of bullock shed
- Construction of soil testing lab
- Construction of mist chamber
- Strengthening eastern side fencing of Phase-I
- Digging of bore wells in Phase-I and Phse-II and installation of pump sets

17.3 At Gunegal Research Farm

- Construction of two shelter rooms
- Construction of 25000 litre capacity tap water storage tank
- Construction of three toilets

17.4 On-farm

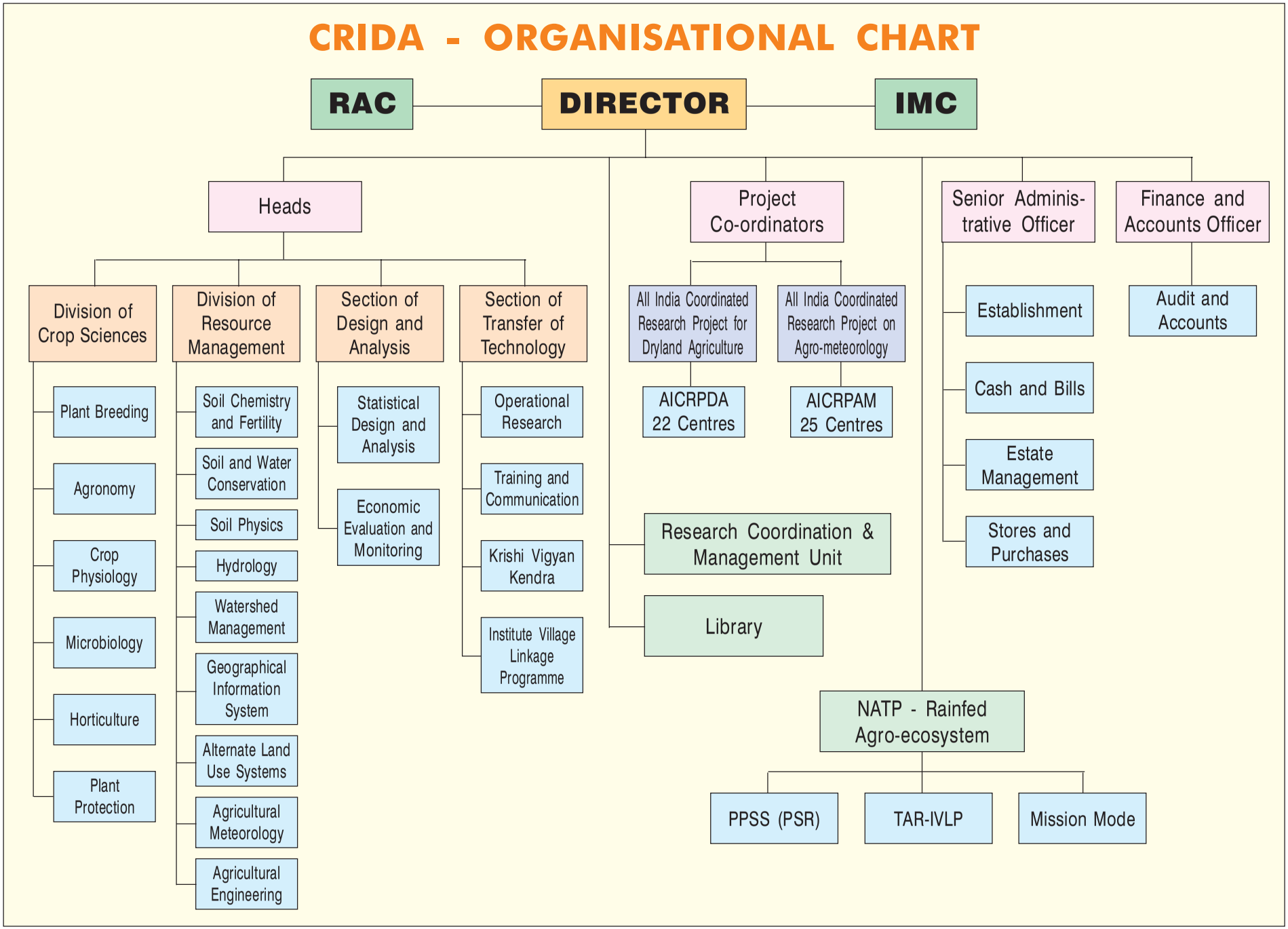
- Construction of vermi-compost shed in Ramanjapur village, Mahabubnagar district, A.P.

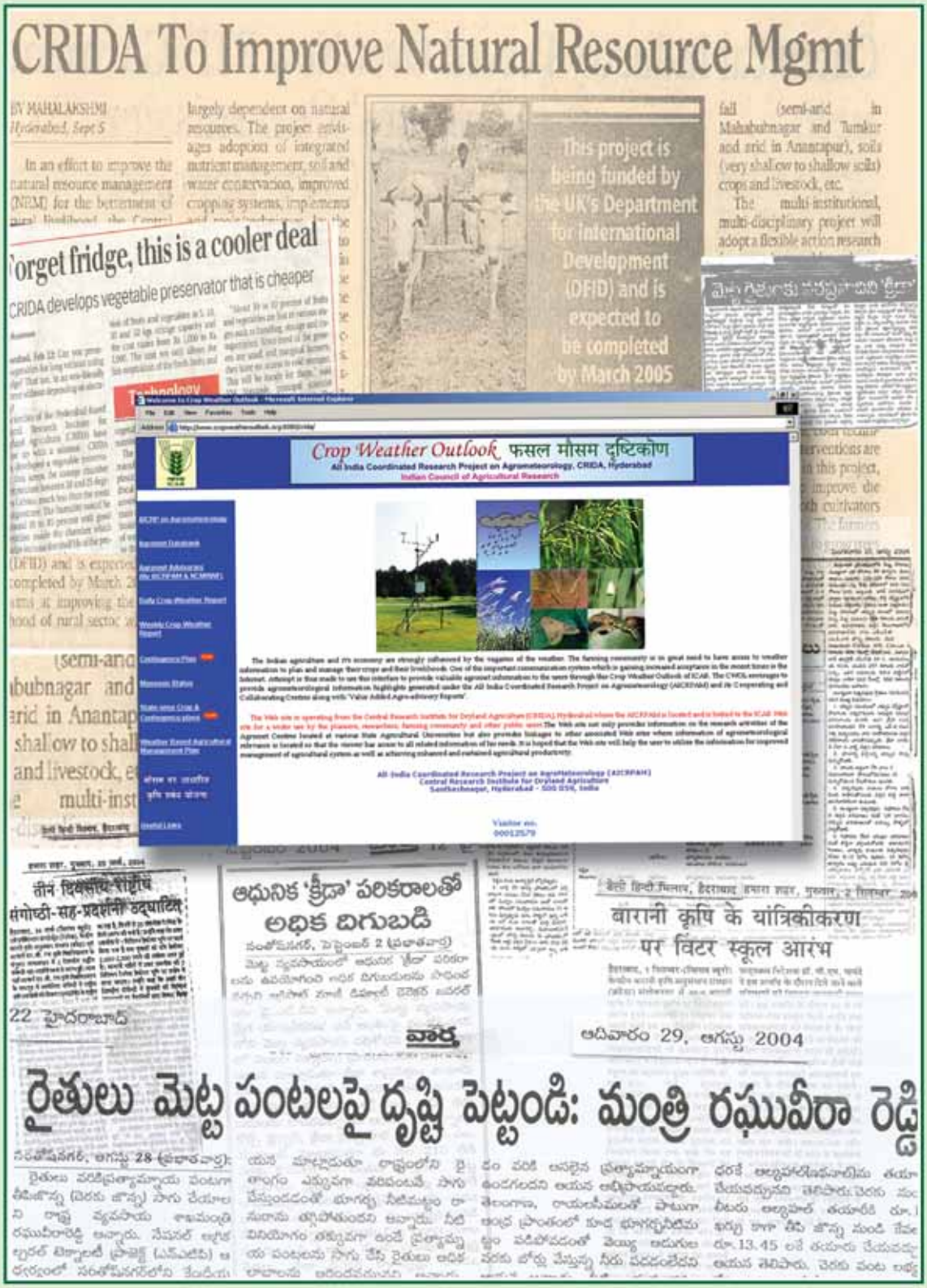
Acronyms

ACIAR	Australian Center for International Agricultural Research
AICRPAM	All India Coordinated Research Project on Agrometeorology
AICRPDA	All India Coordinated Research Project for Dryland Agriculture
ANGRAU	Acharya N.G.Ranga Agricultural University
AP-NL	Andhra Pradesh – Netherlands
AU	Andhra University
CAZRI	Central Arid Zone Research Institute
CCPI	Cooperating Center Principal Investigator
CIAE	Central Institute of Agricultural Engineering
CICR	Central Institute for Cotton Research
cm	Centimeter
CoPI	Co-Principal Investigator
CRRI	Central Rice Research Institute
cv	Cultivar
DAS	Days after sowing
DFID	Department For International Development
DOR	Directorate of Oilseeds Research
DRR	Directorate of Rice Research
DST	Department of Science and Technology
ES	Expert System
FAO	Food and Agriculture Organization
FYM	Farm yard manure
g	Gram
GRF	Gunegal Research Farm
h	Hour
ha	Hectare
HRF	Hayathnagar Research Farm
HQ	Headquarters
IARI	Indian Agricultural Research Institute
IASRI	Indian Agricultural Statistics Research Institute
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IIHR	Indian Institute of Horticultural Research
IISS	Indian Institute of Soil Science
IIT	Indian Institute of Technology
IPE	Institute of Public Enterprise
IVLP	Institute Village Linkage Programme

JNTU	Jawaharlal Nehru Technological University
kg	Kilogram
KVK	Krishi Vigyan Kendra
LAE	Land area equivalent
LAI	Leaf area index
LER	Land equivalent ratio
LGP	Length of growing period
m	Meter
MANAGE	National Institute of Agricultural Extension Management
mm	Millimeter
MPUAT	Maharana Pratap University of Agriculture and Technology
NAARM	National Academy of Agricultural Research Management
NATP	National Agricultural Technology Project
NBAIM	National Bureau of Agriculturally Important Microorganisms
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
NCMRWF	National Center for Medium Range Weather Forecasting
NGO	Non-governmental Organisation
NIANP	National Institute for Animal Nutrition and Physiology
NRCS	National Research Center for Sorghum
NRM	Natural Resource Management
NRSA	National Remote Sensing Agency
NWDPRA	National Watershed Development Program for Rainfed Areas
OU	Osmania University
PI	Principal Investigator
PMC	Project Management Committee
PPIC	Potash and Phosphate Institute of Canada India Programme
RAC	Research Advisory Committee
RH	Relative humidity
Rs	Rupees
RUE	Radiation use efficiency
SAP	Scientific Advisory Panel
SAU	State Agricultural University
SMW	Standard Meteorological Week
SRC	Scientific Research Council
t	Tonne (1000 kg.)
TAR	Technology Assessment and Refinement
TNAU	Tamil Nadu Agricultural University
TTC	Trainers' Training Center
UAS(B)	University of Agricultural Sciences, Bangalore
UAS(D)	University of Agricultural Sciences, Dharwad.

CRIDA - ORGANISATIONAL CHART





केंद्रीय बारानी कृषि अनुसंधान संस्थान

संतोषनगर, हैदराबाद 500 059

Central Research Institute for Dryland Agriculture

Santoshnagar, Hyderabad 500 059

Phone : 040-24530157, 24530161; Fax : 040-24531802, 24535336

Web : http://www.crida.ernet.in; E-mail : root@crida.ernet.in