National Initiative on Climate Resilient Agriculture

Managing Weather Aberrations
through Real Time Contingency Planning

Annual Report
2013 - 14

AICRPDA - NICRA




All India Coordinated Research Project for Dryland Agriculture

ICAR-Central Research Institute for Dryland Agriculture

Hyderabad - 500 059

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Citation :

Managing Weather Aberrations through Real Time Contingency Planning AICRPDA-NICRA Annual Report, 2013-14, All India Coordinated Research Project for Dryland Agriculture, ICAR-Central Research Institute for Dryland Agriculture, India, p. 241.

Published by

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Preface

In India, rainfed agriculture accounts to 55% of net cultivated area. Rainfed agriculture is more vulnerable to climate change / variability. Therefore, there is a need to demonstrate and disseminate already available climate resilient practices to cope with weather aberration suchas delayed onset of monsoon and seasonal drought. Further, there is also a need to evolve innovative institutional mechanisms for successful adoption, ownership and upscaling of climate change practices.

During 2013-14, the technology demonstration component of National Initiative on Climate Resilient Agriculture (NICRA) is being implemented across 23 network centres of All India Coordinated Research Project for Dryland Agriculture (AICRPDA), both on-station and on-farm, under 4 sub-projects viz., (i) real-time contingency plan implementation, (ii) rainwater management, (iii) efficient energy use and management, and (iv) alternate land use. The focus was on participatory demonstration of location specific climate resilient agricultural technologies / package of practices developed by 23 AICRPDA network Centres (including voluntary centre, IGFRI, Jhansi) in 1430 ha 36 villages representation major rainfed agro-ecologies in 33 districts across 15 states. Major emphasis was given on managing various weather aberrations such as delayed onset of monsoon, seasonal drought and floods.

I compliment Dr G. Ravindra Chary, Principal Scientist (Agronomy) and Dr G.R.Maruthi Sankar, Principal Scientist (Agricultural Statistics) for their efforts in program development, implementation and monitoring. I also appreciate the scientists and staff of AICRPDA and ORP centres for successfully under taking the programme particularly in NICRA villages. This report presents the details on demonstration of real time contingency planning of both on-station and on-farm along with the achievements in other thematic areas. I thank Dr S. Ayyappan, Secretary (DARE) and Director General, ICAR, Dr A.K. Sikka, DDG (NRM), Dr B. Mohan Kumar, ADG (Ag, AF & CC) for providing guidance and support to AICRDA from time to time.

(Ch. Srinivasa Rao)
Project Coordinator (Dryland Research)
AICRPDA

CONTENTS

कार्यकारी सारांश

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना के 23 केंद्रों पर अ.भा.स.बा.कृ.अनु.प.-निक्रा(राष्ट्रीय जलवायु समुत्थान कृषि पहल) कार्यक्रम आयोजित किए जा रहे हैं। निक्रा का प्रौद्योगिकी प्रदर्शन अवयव(टीडीसी), प्रक्षेत्र एवं केंद्र दोनों पर, वर्ष 2013-14 के दौरान इन विषयों पर i) सही समय पर आकस्मिक फसल योजना का कार्यान्वयन ii) वर्षाजल सिंचाई (स्व-स्थाने एवं बहि-स्थाने) तथा बेहतर उपयोग iii) बेहतर ऊर्जा उपयोग एवं प्रबंधन, एवं iv) कार्बन पृथ्थ्करण हेतु वैकल्पिक भूमि उपयोग कार्यान्वित किया गया। वर्षा आधारित प्रौद्योगिकियों के सिद्ध पैकेज पर प्रक्षेत्र प्रदर्शन 15 राज्यों में फैले 26 जिलों के 36 गांवों के 3960 किसानों के कुल 1430.02 हेक्टेयर क्षेत्रफल को शामिल करता है। इसकी मुख्य उपलब्धियां नीचे दी गई हैं।

प्रौद्योगिकी प्रदर्शन(स्व-स्थाने एवं बहि-स्थाने)
सही समय की आकस्मिक योजनाएं

(अ) विलंबित मानसून का आरंभ

- असम, लखिमपुर जिले में चमुआ नारायणपुर गांव के बिस्वानाथ चारियाली पर, गांव में आंतरायिक अकस्मत बाढ़ों के कारण विलंबित रोपण परिस्थितियों के अंतर्गत रंजीत जैसी लोकप्रिय किस्मों की तुलना में बाढ़ सहीष्णु किस्म गीतेश एवं प्रफुल्ला बेहतर सिद्ध हुए। स्थानीय किस्मों की तुलना में गीतेश एवं प्रफुल्ला के उत्पादन में 100 प्रतिशत की वृद्धि हुई।
- इंदौर में, 10 दिनों के विलंबित मानसून के अंतर्गत, 1 ग्राम प्रति किलोग्राम की दर से मॉलिबडेनम से बीज उपचार करने से सोयाबीन(426 किलोग्राम प्रति हेक्टेयर) एवं चना(1141 किलोग्राम प्रति हेक्टेयर) ने 1948 किलोग्राम प्रति हेक्टेयर का सोयाबीन समतुल्य उत्पादन सहित का अधिकतम बीज उत्पादन दिया जबकि 0.1 प्रतिशत मॉलिबडेनम के दो पर्ण छिड़कावों से 1794 किलोग्राम प्रति हेक्टेयर के सोयाबीन समतुल्य उत्पादन सहित 412 किलोग्राम प्रति हेक्टेयर का सोयाबीन एवं 1096 किलोग्राम प्रति हेक्टेयर का चना का उत्पादन प्राप्त हुआ। पंग्री गांव(जिंतूर तालूका, परभनी जिला, महाराष्ट्र) में विलंबित मानसून के अंतर्गत सोयाबीन(एमएयू-853), कुसुंभ(पीबीएनएस-12), चना(आकाश) एवं रबि ज्वार(ज्योति) के उन्नत किस्मों ने 36.7 प्रतिशत तक का अच्छा उत्पादन दिया। अमीनाबाद(तुग्गली मंड़ल,कर्नूल जिला, आंध्र प्रदेश) में 9 दिनों के विलंबित मानसून के अंतर्गत, संरक्षण कूंड़ों को अपनाने से नियंत्रण की तुलना में अधिक निवल प्रतिफल(3591/-रुपए प्रति हेक्टेयर),बी:सी अनुपात(1.2) एवं वर्षाजल उपयोग क्षमता(1.0किलोग्राम प्रतिहेक्टेयर-एमएम) सहित मूंगफली(462 किलोग्राम प्रति हेक्टेयर) के उत्पादन में 17 प्रतिशत सुधार हुआ।
- बंगलोर में, सभी किस्मों में से, अधिकतम वर्षाजल उपयोग क्षमता(8.31 किलोग्राम प्रति हेक्टेयर-एमएम) सहित जब अगस्त के दूसरे पक्ष में बोवाई की गई, तो जीपीयू-66(4000 किलोग्राम प्रित हेक्टेयर) द्वारा अधिक उत्पादन दर्ज किया गया। नियंत्रित प्लाटों(2388 एवं 3475 किलोग्राम प्रति हेक्टेयर) की तुलना में नासे घास लाइव बैरियर वाले प्लोटों में रागी का अनाज एवं भूसी का उत्पादन(2638 एवं 3788 किलोग्राम प्रति हेक्टेयर) अधिक था, इसके बाद खस घास(1925 एवं 2350 किलोग्राम प्रतिहेक्टेयर) का स्थान आता है।

(आ) अगेती मौसमी सूखा

- बल्लोवाल सांकुरी में, अचलपुर गांव(गृहशंकर, होशियारपुर जिला, पंजाब) के अगेती सूखा/शुष्क दौर की परिस्थितियों के अंतर्गत एकल फसल की तुलना में मक्का+उड़द के अंतरासस्ययन ने अधिकतम मक्का समतुल्य उत्पादन(3023 किलोग्राम प्रति हेक्टेयर) एवं जल उपयोग क्षमता(5.29 किलोग्राम प्रति हेक्टेयर-एमएम) दी, इसके बाद मक्का+मूंग अंतरासस्ययन प्रणाली का स्थान था।

(इ) मध्य मौसमी सूखा

- फुलबनी के, बुधानी गांव में अंतरफसल की तुलना में एकल मक्का में मक्का का उत्पादन करीब 5 प्रतिशत अधिक था। जबकि, एकल फसल की तुलना में अंतरासस्ययन प्रणाली से मक्का समतुल्य उत्पादन(3435 किलोग्राम प्रतिहेक्टेयर) साथ ही साथ वर्षाजल उपयोग क्षमता(5.17 किलोग्राम प्रति हेक्टेयर-एमएम) करीब 70 प्रतिशत अधिक था। अरजिया के कोछारिया गांव(सुवाना खंड़, भिलवरत) में, किसानों की प्रक्रिया की तुलना में मक्का में मध्यमौसमी संशोधन के लिए बेहतर प्रक्रियाओं ने 2533 किलोग्राम प्रति हेक्टेयर का अधिकतम अनाज उत्पादन, 30,100/- रुपए का निवल आर्थिक प्रतिफल एवं 3.07 का बी:सी अनुपात दिया जोकि किसानों की प्रक्रिया की तुलना में 14.5 प्रतिशत अधिक था। नागला दूल्हेखान गांव(फजियतपुर खंड़) आग्रा में 16 दिनों की अगेती मानसून के बाद मध्यमौसमी सूखा के अंतर्गत,बाजरा की बेहतर किस्म प्रोग्रो 9450 किस्म ने 86एम88(2040 किलोग्राम प्रति हेक्टेयर) की तुलना में 21461/- रुपए के अधिक निवल प्रतिफल एवं 2.46 का बी:सी अनुपात सहित अधिक बीज उत्पादन(2244 किलोग्राम प्रति हेक्टेयर) दिया। इसी प्रकार, तिल की किस्म प्रगति, आरटी-46(270 किलोग्राम प्रति हेक्टेयर) की तुलना में 295 किलोग्राम प्रति हेक्टेयर अधिक बीज उत्पादन सहित उन्नत सिद्ध हुआ। एसके नगर के कालिमति/धोलिया गांव में अरंड़+मूंग की उन्न्त सस्ययन प्रणाली ने 2.52 किलोग्राम प्रति हेक्टेयर-एमएम वर्षाजल उपयोग क्षमताएवं 5.89 का बी:सी अनुपात सहित 2390 किलोग्राम प्रति हेक्टेयर उत्पादन दिया। 40 दिनों की विलंबित मानसून उसके बाद मध्यमौसमी सूखा के अंतर्गत बीजापुर में, मोठ किस्म केबीएमबी-1 ने स्थानीय किस्म की तुलना में 17.6 प्रतिशत अधिक बीज उत्पादन दिया। इसी प्रकार, कुलथी किस्म जीपीएम-6 ने स्थानीय किस्म की तुलना में 25 प्रतिशत अधिक बीज उत्पादन दिया।
- कोविलपट्टी में, 43.6 एमएम की वर्षा प्राप्त हुई जो साधारण की तुलना में 106.6 एमएम कम है एवं जून, जुलाई तथा अगस्त के दौरान मध्य मौसमी सूखा भी पड़ा। कपास(जैकपॉट), मक्का(एनके 6240) और बाजरा(80 एम 32) के उन्नत किस्मों ने बेहतर निष्पादन दिया जिसके परिणामस्वरूप अधिक उत्पादन एवं वर्षाजल उपयोग क्षमता प्राप्त हुआ। जबकि, नियंत्रण(255 किलोग्राम प्रति हेक्टेयर) की तुलना में मौसमी शुष्क दौरों के प्रशमन के लिए गुलाबी रंग के विकल्पी मेथनोट्राप्स (500 एमएल प्रति हेक्टेयर) के पर्ण छिड़काव ने अधिक बीज कपास(296 किलोग्राम प्रति हेक्टेयर) का उत्पादन दिया जोकि नियंत्रण की तुलना में 16 प्रतिशत अधिक है।
- राजकोट के पाटा मेघापुर गांव में, वर्ग निर्माण एवं गलर विकास स्तर पर 2 प्रतिशत की दर से पोटाशियम नाइट्रेट के पर्ण छिड़काव ने अधिक कपास बीज उत्पादन(2646 किलोग्राम प्रति हेक्टेयर) एवं

निवल प्रतिफल(88650/-रुपए प्रति हेक्टेयर) दर्ज किया जोकि किसानों की प्रक्रिया की तुलना में 18.2 एवं 18.0 प्रतिशत अधिक है।

(ई) आवधिक सूखा

- बिस्वनाथ चरियाली में, लखिमपुर जिला, असम के चमुआ नारायणपुर गांव में आवधिक सूखा परिस्थितियों के अंतर्गत, कम अवधि की चावल की किस्मों में, दिशांग का उत्पादन(4170 किलोग्राम प्रति हेक्टेयर) अधिकतम था। अन्य मध्यम अवधि की किस्मों की तुलना में टीटीबी-404 ने अधिक उत्पादन(5250 किलोग्राम प्रति हेक्टेयर) एवं बी:सी अनुपात(3.15) दर्ज किया। जबकि, लंबी अवधि की किस्मों में, गीतेश ने अधिक उत्पादन(5278 किलोग्राम प्रति हेक्टेयर) दर्ज किया, इसके बाद रंजीत(5418 किलोग्राम प्रतिहेक्टेयर) का स्थान था। किस्म गीतेश में चौंका देनी वाली अतिरिक्त लाभ के कारण मौसम विविधताओं के अधिक अनुकूल है।
- अमीनाबाद गांव(थुगल्ली मंड़ल, कर्नूलजिला, आंध्र प्रदेश) में, कपास में पुष्पण एवं गलर निर्माण के समय ZnSO4(2%), MgSO4, बोरॉक्स(1%) एवं 19-19-19(1%) के छिड़काव से नियंत्रण की तुलना में 9 प्रतिशत अधिक उत्पादन(362 किलोग्राम प्रति हेक्टेयर) एवं अधिक निवल प्रतिफल(8256/- रुपए प्रति हेक्टेयर), बी:सी अनुपात(2.5) एवं वर्षाजल उपयोग क्षमता(0.67 किलोग्राम प्रतिहेक्टेयर प्रति एमएम) प्राप्त हुआ।

वर्षाजल प्रबंधन

स्वस्थाने वर्षाजल प्रबंधन

- अचलपुर गांव(गृहशंकर, होशियारपुर जिला, पंजाब) में, ग्रीष्म जुताई के बाद मक्का की बोवाई ने 24415/- रुपए के निवल आर्थिक प्रतिफल सहित अधिकतम अनाज उत्पादन(3130 किलोग्राम प्रति हेक्टेयर) दिया एवं बिना ग्रीष्म जुताई(2565 किलोग्राम प्रति हेक्टेयर) की तुलना में 22 प्रतिशत उत्पादन दिया। साथ ही, ढलान के विपरीत मक्का की बोवाई ने 2245 किलोग्राम प्रति हेक्टेयर का अनाज उत्पादन दिया जोकि ढलान पर बोए गए मक्का की तुलना में में 5.4 प्रतिशत अधिक था। इसी प्रकार, मक्का में मिट्टी चढ़ाने(हांथों से) से 4267 किलोग्राम प्रति हेक्टेयर का अनाज उत्पादन हुआ जोकि मिट्टी न चढ़ाने के उपचार से 20 प्रतिशत अधिक था।
- थकपाल गांव, जगदलपुर जिला में, खाई के निचले हिस्से को खोदकर एवं जलाक्रांत को रोकने के लिए बांधों का काटकर नाला प्रणाली का निर्माण किया गया।
- अरजिया में, किसानों की प्रक्रिया(2000 किलोग्राम प्रति हेक्टेयर) की तुलना में मक्का में स्व-स्थाने नमी संरक्षण ने 20 प्रतिशत अधिक अनाज उत्पादन(2400 किलोग्राम प्रति हेक्टेयर) दिया।
- आग्रा में, सपाट प्रणाली की तुलना में मेंढ़ एवं कूंड़ प्रणाली से लौकी एवं भिंड़ी का क्रमश: 48.5 एवं 35.2 प्रतिशत अधिक उत्पादन प्राप्त हुआ। नाग्ला दूल्हेखान गांव(फजीयतपुर खंड़, खेरागढ़ तहसील, आग्रा जिला, उत्तर प्रदेश) में, खंड़ित बांधों का निर्माण कर बाजरा की बोवाई करने से उत्पादन में 16.03 प्रतिशत एवं वर्षाजल उपयोग क्षमता में 16 प्रतिशत की वृद्धि हुई।

- हिसार जिले के बालावास एवं बुधशेल्ली गांवों में, दोनों स्थानों पर देसी हल की तुलना में सरसों के लिए डिस्क हैरो से नमी संरक्षण ने अधिक बीज उत्पादन(709 एवं 721 किलोग्राम प्रति हेक्टेयर) एवं निवल प्रतिफल(क्रमश: 4754/-रुपए एवं 5136/- रुपए) दिया।
- चंदनकी गांव(बेचाराजी तालूक, मेहसाना जिला, गुजरात) में, स्थानीय प्रक्रिया(1630 किलोग्राम प्रतिहेक्टेयर) की तुलना में खंड़ मेंढ़ों ने महत्वपूर्ण रूप से अधिकतम बाजरा उत्पादन(1990 किलोग्राम प्रति हेक्टेयर) दर्ज किया।
- कवलगी गांव(बीजापुर जिले के बीजापुर तहसील, कर्नाटक) में, खंड़ मेंढ़ों ने नमी संरक्षण में सहायता की एवं चना तथा सूरजमुखी के उत्पादन में क्रमश: 22.8 और 108 प्रतिशत वृद्धि की।
- नक्कलमुथनपट्टी गांव(कोविलपट्टी तालूका, थूथुकुड़ी जिला, तमिलनाडु), सपाट बोवाई की तुलना में, चौड़ी क्यारी कूड़ों को अपनाने से मृदा नमी में 6 प्रतिशत एवं 12 प्रतिशत उत्पादन (280 किलोग्राम प्रति हेक्टेयर) वृद्धि,14000/- रुपए प्रति हेक्टेयर का समग्र प्रतिफल एवं मूंग(सीओ-6) की वर्षाजल उपयोग क्षमता(1.28 किलोग्राम प्रति हेक्टेयर-एमएम) की वृद्धि हुई।
- अकोला जिला महाराष्ट्रा में, बिना कूंड़ों की तुलना में, कपास में बोवाई के 30 दिनों के बाद कूंड़ों को खोदने से उत्पादन में 15.9 प्रतिशत एवं वर्षाजल उपयोग क्षमता में 16.7 प्रतिशत की वृद्धि हुई। सोयाबीन के मामले में भी इसी प्रकार बोवाई के 30 दिनों के बाद कूंड़ों को खोदने से उत्पादन में 38.5 प्रतिशत एवं वर्षाजल उपयोग क्षमता में 62.3 प्रतिशत की वृद्धि हुई। पंग्री गांव, परभनी में, बिना कूंड़ के 12.1 क्विंटल प्रति हेक्टेयर बीज उत्पादन की तुलना में एकल अरहर में कूंड़ों के खोदने से स्व- स्थाने नमी संरक्षण ने 16.1 क्विंटल प्रति हेक्टेयर का अधिकतम बीज उत्पादन दिया।
- बिस्वनाथ चरियाली के निक्रा गांव चमुआ में, आलू एवं टमाटर दोनों में पलवार के परिणामस्वरूप अधिक उत्पादन एवं निवल प्रतिफल दिया। दो अतिरिक्त सिंचाइयों(16875 किलोग्राम प्रति हेक्टेयर) की तुलना में भूसी पलवार के अंतर्गत आलू के उत्पादन में 81.4 प्रतिशत की वृद्धि हुई।

बहि-स्थाने वर्षाजल प्रबंधन

- अरजिया में, रबि फसलों में, संचित वर्षाजल के पुन:चक्रण के कारण बैंगन की तुलना में 3.18 के बी:सी अनुपात एवं 28.5 प्रतिशत जल की बचत सहित 4547 किलोग्राम प्रति हेक्टेयर का अधिकतम पी पॉड समतुल्य उत्पाद सहित श्रेष्ट हरी धनिया का उत्पादन हुआ। कोचरिया गांव(सुवाना खंड़, भिलवाड़ा) में वर्षाजल संरक्षण एवं पुन:चक्रण की प्रक्रिया को प्रस्तुत किया गया। पारंपरिक प्रक्रिय(18250/-रुपए) की तुलना में कृषि तालाब प्रौद्योगिकी के कारण निवल आर्थिक प्रतिफल(49110/-रुपए) में 69.09 प्रतिशत की वृद्धि हुई।
- बीजापुर में, चना एवं ज्वार के पुष्पण स्तर पर स्प्रिंकलर द्वारा 5 सेंटीमीटर की गहराई तक सिंचाई देने से चना एवं ज्वार में अतिरिक्त उत्पादन क्रमश: 25 एवं 31.4 प्रतिशत हुआ।
- निगनोती गांव(इंदौर जिला, मध्य प्रदेश) में, स्थानीय किस्म की तुलना में प्याज(रेड-3) में अतिरिक्त सिंचाई ने 81500/-रुपए प्रति हेक्टेयर का निवल प्रतिफल एवं 4.3 का बी:सी अनुपात सहित 10650 किलोग्राम प्रति हेक्टेयर का अधिकतम उत्पादन हुआ एवं यह उत्पादन स्थानीय किस्म के उत्पादन की

तुलना में 28.3 प्रतिशत अधिक था। रौरा एवं पटौना खंड़, रीवा(मध्य प्रदेश) में, 20x15x6 मीटर(1800 घन मीटर क्षमता) के आकार का कृषि तालाब का उपयोग अधिक वर्षाजल संरक्षण एवं पुन:चक्रण के लिए किया गया एवं इस संचित जल का उपयोग चना किस्म जेजी-322 के बोवाई पूर्व सिंचाई के रूप में 5 सेंटीमीटर की अतिरिक्त सिंचाई के लिए किया गया। बिना अतिरिक्त सिंचाई की तुलना में अतिरिक्त सिंचाई से उत्पादन में 14.3 प्रतिशत की वृद्धि हुई।

बेहतर ऊर्जा उपयोग का प्रबंधन

- बिस्वनाथ चरियाली के गनकदोलोनी गांव में, यह देखा गया कि यांत्रिकीकरण के स्तर में वृद्धि से धान की खेती में ऊर्जा के उपयोग को 8 से 23 प्रतिशत तक कम किया जा सकता है।
- हरदोइया गांव, फैजाबाद जिला, उत्तर प्रदेश में, बेहतर उपकरणों से धान की किस्म एनडीआर-97 ने बेहतर निष्पादन दिया एवं रोटावेटर से उत्पाद एवं निवेश ऊर्जा अनुपात अधिकतम(9.68:1)) था। एमबी हल+हैरो से अधिकतम बीज उत्पादन(32046 किलोग्राम प्रति हेक्टेयर) था उसके बाद क्रमश: रोटावेटर(29400 किलोग्राम प्रति हेक्टेयर) एवं कल्टिवेटर(2675 किलोग्राम प्रतिहेक्टेयर) का स्थान आता है।
- एस.के. नगर में, अन्य उपकरणों की तुलना में मूंग में रोटो टिल ड्रिल के उपयोग के परिणामस्वरूप 28980/- रुपए प्रति हेक्टेयर का अधिकतम निवल प्रतिफल एवं वर्षाजल उपयोग क्षमता(0.78 किलोग्राम प्रति हेक्टेयर-एमएम) प्राप्त हुआ।
- वारखेड गांव(बरशी तकली तालूका, अकोला जिला, महाराष्ट्र) में, सोयाबीन की मड़ाई के लिए बहुउपयोग थ्रेशर प्रस्तुत किया गया जिससे कटाई के समय में कमी, 33.3 प्रतिशत तक की श्रम लागत एवं फसल की कटाई की लागत में कमी आई।
- पाटा मेघापुर गांव, राजकोट जिला में, रिवर्सबुल हल(ग्रीष्म में) के उपयोग के द्वारा अधिक बीज कपास उत्पादन(2731 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया जोकि किसानों की प्रक्रिया की तुलना में 19.7 प्रतिशत अधिक है।

वैकल्पिक भूमि उपयोग एवं पर्यावरण प्रणालीसेवाएं

- बेंगलोर में, अन्य ओनला आधारित सस्ययन प्रणालियों की तुलना में ओनला+रागी ने 2.16 का बी:सी अनुपात सहित 29831/-रुपए प्रति हेक्टेयर का अधिकतम निवल प्रतिफल दिया, इसके बाद ओनला+लोबिया से 2.07 का बी:सी अनुपात सहित 29548/-रुपए का निवल प्रतिफल दिया। इसी प्रकार सीताफल+चारा मक्का 59633/- रुपए का निवल प्रतिफल एवं 3.09 का बी:सी अनुपात सहित बेहतर था। इंदौर में, 26248/-रुपए के समग्र प्रतिफल सहित ओनला से अधिक फल उत्पादन(1312 किलोग्राम प्रति हेक्टेयर) प्राप्त हुआ, इसके बाद अमरूधा(309 किलोग्राम प्रति हेक्टेयर एवं 6175/-रुपए प्रति हेक्टेयर) एवं फालसा(124 किलोग्राम प्रति हेक्टेयर एवं 7411/-रुपए प्रति हेक्टेयर) का स्थान रहा।
- कोविलपट्टी में, ओनला एवं सीताफल आधारित सस्ययन प्रणालियों में, अन्य अंतर फसलों की तुलना में, क्रमश: 233 एवं 266 किलोग्राम प्रति हेक्टेयर के अधिक बीज उत्पादन सहित मूंग(किस्म सीओ-6) बेहतर सिद्ध हुआ। जबकि, सपोटा आधारित अंतरासस्ययन प्रणाली के मामले में, अन्य अंतर फसलों की तुलना में भिंड़ी 288 किलोग्राम प्रति हेक्टेयर का अधिक उत्पादन दर्ज किया।

निक्रा अनुकूल अनुसंधान

चयनित मृदा मानक क्षेत्रों पर सस्ययन प्रणालियों द्वारा अनुकूलन युक्तियां

वारखेड जलग्रहणक्षेत्र, अकोला जिला, महाराष्ट्र के चयनित मृदा मानक क्षेत्रों पर सस्ययन प्रणालियों द्वारा अनुकूलन युक्तियों पर किए गए अध्ययन में दक्षिण-पश्चिम मानसून(जून-सितंबर) 2013 के दौरान 1265 एमएम वर्षा हुई जो साधारण(666.3 एमएम) की तुलना में 598.7 एमएम अधिक था एवं रबि(अक्तूबर से दिसंबर) के दौरान 210 एमएम वर्षा हुई जो साधारण(66.8 एमएम) की तुलना में 143.2 एमएम अधिक था। 15 जुलाई से 3 अगस्त के दौरान 662 एमएम की अतिरिक्त एवं लगातार वर्षा से सोयाबीन, उड़द, मूंग एवं ज्वार प्रभावित हुआ जोकि वनस्पतिक एवं उत्पादक स्तरों में थे। साधारणतया, मध्य क्षेत्र पर होने वाली गहरी से अति गहरी(vertic Ustochrepts and Typic Haplusterts) काली मृदाओं में एवं जलग्रहण के घाटी तली में उचित नाला व्यवस्था न होने के कारण फसलें काफी प्रभावित होती हैं जिससे उत्पादन में करीब 30 प्रतिशत तक की कमी आती है। जबकि इन फसलों ने जलग्रहण के ऊपरी ऊपरी क्षेत्र में बनने वाली उथली चूनारहित मृदाओं(Typic Ustorthents) में सामान्य से अच्छी नाला परिस्थितियों के कारण अपेक्षाकृत बेहतर निष्पादन दिया। सही समय की आकस्मिक उपाय के रूप में, फसल वालों खेतों से अतिरिक्त जल को बहा दिया गया। गहरी से अति गहरी काली मृदाओं में उत्पादक स्तरों के दौरान लंबी अवधि की फसलों(कपास एवं अरहर) में अंतरासस्ययन प्रणालियों जैसेकि कपास+मूंग(1:1), कपास+मूंग+अरहर(1:1:6):2), सोयाबीन+अरहर(4:2) ने बेहतर मृदा नमी एवं नाला परिस्थितियों के कारण अच्छा ष्पादन दिया। इसके परिणामस्वरूप विशेषकर shallow Typic Ustorthents की तुलना में Veertic Ustochrepts में उत्पादन वृद्धि करीब 26 प्रतिशत तक एवं बेहतर वर्षाजल उपयोग क्षमता 1.44 किलोग्राम प्रतिहेक्टेयर-एमएम तक हुई।

गांव जलवायु जोखिम प्रबंधन समिति(वीसीआरएमसी)

निक्रा के गांवों में गांव जलवायु जोखिम प्रबंधन समिति ने सही समय की आकस्मिक योजनाओं के कार्यान्वयन, वर्षाजल प्रबंधन प्रक्रियाओं, सूखा अभेद्य बनाने, फसल एवं भूमि एवं मृदा आधारित हस्तक्षेपों हेतु कृषि तालाबों/अंत:स्रवण तालाबों द्वारा जल संसाधनों के निर्माण में प्रमुख भूमिका निभाई। इसके अलावा, गांव जलवायु जोखिम प्रबंधन समिति ने कस्टम हायरिंग केंद्रों की स्थापना, उपकरणों को किराए पर देना, किराए आदि की दरों के निर्णय में सहायता की।

कस्टम हायरिंग केंद्र(सीएचएस)

कस्टम हायरिंग केंद्रों ने संसाधनहीन गरीब किसानों को कम लागत पर आवश्यकता आधारित महंगे उपकरणों/मशीनी यंत्रों को किराए पर दिलाने एवं भूमि की तैयार, कम समय में बड़े क्षेत्र में सही एवं सटीक बोवाई एवं अधिक क्षमतायुक्त अन्य कृषि प्राचलों में सहायता की। कस्टम हायरिंग प्रबंधन समिति किराए द्वारा प्राप्त आय को कस्टम हायरिंग केंद्रों की गतिविधियों को चलाने एवं उपकरणों के रख-रखाव पर खर्च किया।

गांव बीज बैंक

चमुआ नारायापुर, लखिमपुर जिला, असम जैसे केंद्रों द्वारा अपनाए गए कुछ निक्रा गांवों में, विभिन्न अवधि की चावल की किस्में जो बाढ़ एवं सूखा जैसे प्रतिकूल मौसम परिस्थितियों के लिए उपयुक्त बीज बैंक की स्थापना का प्रयास किया गया। किसानों को 22 बेहतर किस्मों, 30 से अधिक स्थानीय किस्मों का बीज उत्पादन कार्यक्रम एवं प्रमुख वर्षा आधारित फसलों की बेहतर किस्मों के रख-रखाव पर प्रशिक्षण दिया गया। बीज बैंक में 11 चावल किस्मों का बीज भंड़ारण उपलब्ध है।

चारा बैंक

प्रतिकूल मौसमों के दौरान चारा की कमी को पूरा करने के लिए, निक्रा गांवों में हमने सामुदायिक भूमियों को चारा उत्पादन के अंतर्गत लाया। चारा बैंक से उचित कीमत पर चारा की स्थानीय उपलब्धता से दूध के उत्पादन में वृद्धि एवं पर्यावरण सेवाएं प्रदान करने से किसानों के जीविकोपार्जन में वृद्धि होने की संभावना है। सामुदायिक भूमि को सूखा/बाढ़ के दौरान चारा उत्पादन एवं बेहतर चारा/खाद्य भंड़ारण पद्धतियां, गरीब किसानों को उनकी क्रय सीमा के अंदर चारा की उपलब्धता एवं प्रतिकूल मौसम परिस्थितियों के अंतर्गत पशुओं के लिए बेहतर चारा प्रबंधन प्रदान करता है। ऐसे प्रयासों में, सोलापुर द्वारा निक्रा गांव में फूले जयंत प्रस्तुत किया गया। इसी प्रकार, इंदौर केंद्र द्वारा अपनाए गए निक्रा गांव में स्थानीय बेरसीम की प्रस्तुती, उत्पादन एवं उपलब्धता से दुग्ध उत्पादन की वृद्धि में सहायता मिली। अरजिया केंद्र के निक्रा गांव(कोचरिया गांव) में सामुदायिक चारा बैंक का रखरखाव किया गया।

कृषि सलाह सेवाएं

एक्रीपाम एवं भारतीय मौसम विभाग आदि के सहयोग से निक्रा गांवों में कृषि-सलाहें दी गई। जबकि सभी गांवों में सही समय की आकस्मिक उपायों को कार्यान्वित करने की सलाह दी गई। निक्रा गांवों में श्याम पट(Black board) पर मौसम सूचना का प्रदर्शन एवं कृषि सलाहों के अलावा सही समय की कृषि सलाहों के प्रचार के लिए मोबाइल द्वारा एसएमएस सेवाओं को प्रस्तुत किया गया। 2013-14 के दौरान, राजकोट, बिस्वनाथ चरियाली, बेंगलुरू, सोलापुर एवं इंदौर में किसानों को समय पर कृषि-सलाहें जारी की गई।

मृदा स्वास्थ्य कार्ड

निक्रा गांवों में किसानों को दिए गए मृदा स्वास्थ्य कार्डों को स्थान विशेष के पोषक प्रबंधन, पोषक छिड़कावों एवं मृदा स्वास्थ्य के रख-रखाव के लिए किया जाना है। मृदा स्वास्थ्य कार्डों को बल्लोवाल सांकुरी, बिस्वनाथ चरियाली एवं अनंतपुर केंद्र के किसानों को जारी किया गया।

प्रशिक्षण/क्षेत्रीय दौरे/क्षेत्रीय दिवस

एक्रीपड़ा केंद्रों ने किसान-वैज्ञानिक-पणधारियों से नियमित रूप से बैठकों का आयोजन किया। जिसमें किसानों को किसानों को जलवायु एवं उससे संबंधित क्षेत्रों पर जलवायु विविधता तथा उसके प्रभावों के बारे में सचेत किया एवं बेहतर वर्षा आधारित प्रौद्योगिकियों/श्रेष्ट प्रक्रियाओं पर मानसून पूर्व एवं मानसून में प्रशिक्षण, मौसम प्रतिकूलताओं के दौरान विषयपरक हस्तक्षेपों के निष्पादन के बारे में किसानों एवं पणधारियों को प्रदर्शित करने के

लिए क्षेत्रीय दौरों/क्षेत्रीय दिवसों का आयोजन किया गया। वर्ष के दौरान, विभिन्न एक्रीपडा केंद्रों पर 55 प्रशिक्षणों एवं क्षेत्रीय दिवसों/दौरों का आयोजन किया गया जिससे किसानों सहित 2854 पणधारियों को लाभ हुआ।

संपर्क

निक्रा कार्यक्रम के प्रभावी कार्यान्वयन के लिए, केंद्रों ने राज्य से संबंधित विभागों, कृषि विज्ञान केंद्रों, आत्मा, गैर सरकारी संगठनों, भारतीय कृषि अनुसंधान परिषद के संस्थानों, विभिन्न राज्य/केंद्र सरकार, योजनाएं/कार्यक्रम जैसेकि कृषि तालाब/जल सिंचाई संरचनओं/मध्य प्रदेश एवं छत्तीसगढ़ में मृदा एवं जल संरक्षण कार्यक्रमों से संपर्क स्थापित किया है।

Executive Summary

The AICRPDA – NICRA (National Initiative on Climate Resilient Agriculture) Programme is being implemented at 23 Centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) The Technology Demonstration component (TDC) of NICRA, both on-farm and on-station, was implemented during 2013-14 focusing on i) real time contingency crop plan implementation, ii) rainwater harvesting (*in-situ* and *ex-situ*) and efficient use, iii) efficient energy use and management, and iv) alternate land use for carbon sequestration. The on-farm demonstrations on package of proven rainfed technologies covered a total area of 1430.02 ha in 3960 farmers' fields in 36 villages in 26 districts across 15 states. The salient achievements are summarized below.

Technology Demonstrations (*both On-station and On-farm)*

Real Time Contingency Planning

a. Delayed onset of monsoon

- At Biswanath Chariali, at Chamua Narayanpur village in Lakhimpur district, Assam the performance of flood tolerant verities Gitesh and Prafulla were better than the popular varieties like Ranjit under delayed transplanting condition due to occurrence of intermittent flash floods in the village. There was 100% increase in the yield of Gitesh and Prafulla as compared to the local cultivars
- At Indore, under delayed onset of monsoon by 10 days, seed treatment with molybdenum @ 1 g/kg gave highest seed yield of soybean (426 kg/ha) and chickpea (1141 kg/ha) with soybean equivalent yield of 1948 kg/ha while 2 foliar sprays of molybdenum @ 0.1% to soybean gave 412 kg/ha and chickpea gave 1096 kg/ha with SEY of 1794 kg/ha. Under delayed onset of monsoon at Pangri village (Jintur Taluka, Parbhani district, Maharashtra), improved varieties of soybean (MAU-81), greengram (BM2002-1), blackgram (BDU-1), pearlmillet (ABPC-4-3), pigeonpea (BSMR-853), safflower (PBNS-12), chickpea (Akash) and *rabi* sorghum (Jyoti) performed better and resulted in yield increase by up to 36.7%. Under delayed onset of monsoon by 9 days at Aminabad village (Thuggali Mandal, Kurnool district, Andhra Pradesh), adoption of conservation furrows resulted in 17% improvement of yield in groundnut (462 kg/ha) with higher net returns (Rs.3591/ha), B:C ratio (1.2) and rainwater use efficiency (1.0 kg/ha-mm) compared to control (396 kg/ha).
- At Bangalore, among all varieties, higher yield was recorded by GPU-66, when sown in 2nd fortnight of August (4000 kg/ha) with maximum RWUE (8.31 kg/ha-mm). Fingermillet grain and straw yield (2638 and 3788 kg/ha) were higher in plots with nase grass live barriers followed by khus grass (1925 and 2350 kg/ha) as compared to control plots (2388 and 3475 kg/ha, respectively).

b. Early season drought

At Ballowal Saunkhri, under early drought/dry spell conditions at Achalpur village (Garhshankar, Hoshiarpur district, Punjab) intercropping of maize + blackgram gave highest MEY (3023 kg/ha) and WUE (5.29 kg/ha-mm) followed by maize + greengram intercropping system than sole crops.

c. Midseason drought

- At Phulbani, Budhadani village maize yield in sole maize was about 5% higher than that of intercrop. However, the maize equivalent yield (3435 kg/ha) as well as rainwater use efficiency (5.17 kg/ha-mm) of intercropping system was about 70% higher over the sole crop. In Kochariya village (Suwana block, Bhilwarat), Arjia, improved practices for midseason correction in maize gave maximum yield of 2533 kg/ha, NMR of Rs.30100/ha and B:C ratio of 3.07 with 14.5% increase over farmers` practice. Under early onset of monsoon by 16 days followed by midseason drought in Nagla Dulhe Khan village (Faziyatpura block) Agra, improved variety of pearl millet. Proagro 9450 variety gave higher seed yield (2244 kg/ha) as compared to 86 M 88 (2040 kg/ha) with higher net returns of Rs.21461/ha and B:C ratio of 2.46. Similarly, sesame variety pragati was superior with higher seed yield of 295 kg/ha as compared to RT-46 (270 kg/ha). At SK Nagar, in Kalimati/Dholiya village, improved cropping system castor + greengram gave 2390 kg/ha at Kalimati with RWUE of 2.52 kg/ha-mm and B:C ratio 5.89. Under delayed onset of monsoon by 40 days followed by midseason drought at Bijapur, mothbean variety KBMB-1 produced 17.6% higher seed yield than local variety. Similarly, horsegram variety GPM 6 produced 25% higher seed yield than local variety.
- At Kovilpatti, a rainfall of 43.6 mm was received which was deficit by 106.6 mm compared to normal (150.2 mm) and also mid-season drought during June, July and August. The improved varieties of cotton (Jackpot), maize (NK 6240) and pearlmillet (80 M 32) performed better and resulted in higher yield and RWUE. Whereas, foliar spray of pink pigmented facultative methanotrophs (500 ml/ha) for mitigation of in-season dry spells recorded higher seed cotton yield (296 kg/ha) than control (255 kg/ha) and was 16% increased over the control.
- At Rajkot, Pata Meghapar village, foliar application of potassium nitrate @ 2% at square formation & boll development stage recorded higher seed cotton yield (2646 kg/ha) and net return (Rs.88650/ha) which were higher by 18.2 and 18.0% compared to farmers' practices.

d. Terminal drought

- At Biswanath chariali, under terminal drought condition at Chamua Narayanpur in Lakhimpur district, Assam, among the short duration rice cultivars, yield of *Dishang* was the maximum (4170 kg/ha). TTB - 404 recorded the higher yield (5250 kg/ha) and B: C ratio (3.15) over other medium duration cultivars. While, in case of long duration varieties, Gitesh recorded higher yield (5278 kg/ha) followed by Ranjit (5418 kg/ha) and variety Gitesh has an additional advantage of staggering ability, thus more resilient to weather variability.
- At Aminabad village (Thuggali Mandal, Kurnool district, Andhra Pradesh), spraying of $ZnSO_4$ (2%), $MgSO_4$, borax (1%) and 19-19-19 (1%) in cotton at the time of flowering and boll formation stage improved yield (362 kg/ha) by 9% and gave higher net returns (Rs.8256/ha), B:C ratio (2.5) and rainwater use efficiency (0.67 kg/ha-mm) over control.

Rainwater Management

***In-situ* rainwater management**

- At Achalpur village (Garhshankar, Hoshiarpur district, Punjab), sowing of maize after summer ploughing gave maximum grain yield (3130 kg/ha) with NMR of Rs 24415/ha and yield was 22% higher in comparison to sowing of maize without summer ploughing (2565 kg/ha). Also, sowing of maize across the slope gave grain yield of 2245 kg/ha which was 5.4% higher over sowing of maize along the slope (2130 kg/ha).Similarly, earthing up (manually) in maize resulted in grain yield of 4267 kg/ha which was 20% higher over no earthing up treatment.
- At Tahkapal village, Jagdalpur district, the drainage system was created by digging the trench in lower side and cutting of bunds to avoid water-logging.
- At Arjia, *in-situ* moisture conservation in maize gave 20% higher grain yield (2400 kg/ha) over farmer`s practice (2000 kg/ha).
- At Agra, bottle gourd and okra produced 48.5 and 35.2% more yield with ridge and furrow system over flat system, respectively. At Nagla Dulhe Khan village (Faziyatpura block, Kheragarh Tehsil, Agra district, Uttar Pradesh), compartmental bunding followed by sowing of pearl millet improved the yield by 16.03% and RWUE by 16%.
- At Balawas and Budhshelly villages in Hisar district, moisture conservation for mustard with disc harrow gave higher seed yield (709 and 721 kg/ha) and net returns (Rs.4754 and Rs. 5136/ha, respectively) as compared to country plough at both locations.
- At Chandanki village (Becharaji taluka, Mehsana district, Gujarat), the compartmental bunding recorded significantly highest pearlmillet yield (1990 kg/ha) as compared to local practice (1630 kg/ha).
- At Kavalagi village (Bijapur Tehsil in Bijapur district, Karnataka), compartmental bunding helped in moisture conservation and increased the yield of chickpea and sunflower to an extent of 22.8 and 108%, respectively.
- At Nakkalamuthanpatti village (Kovilpatti Taluk, Thoothukudi district, Tamil Nadu), adoption of broad bed furrows resulted in 6% higher soil moisture and 12% increased yield (280 kg/ha), gross returns of Rs.14000/ha and rainwater use efficiency (1.28 kg/ha-mm) of greengram (Cv. CO-6) over flat sowing. At Varkhed village (Barshi Takali Taluka,
- Akola district, Maharashtra, opening of furrow at 30 DAS in cotton enhanced yield by 15.9% and RWUE by 16.7% compared to without furrow. Similarly in case of soybean, 38.5% and 62.3% increase in yield and RWUE were recorded with opening of furrow at 30 DAS, respectively. At Pangri village, Parbhani, *in-situ* moisture conservation with opening of furrow in sole pigeonpea gave highest seed yield of 16.1 q/ha compared to seed yield of 12.1 q/ha in without opening of furrow.
- At Biswanath Chariali, in NICRA village Chamua, mulching resulted in higher yield and net returns both in potato and tomato. The yield of the potato under straw mulch was 81.4% higher as compared to that with two supplemental irrigations (16875 kg/ha).

***Ex-situ* rainwater management**

- At Arjia, among rabi crops, green coriander was superior with maximum pea pod equivalent yield of 4547 kg/ha with B:C ratio of 3.18 and water saving by 28.5% over brinjal due to recycling of harvested rainwater. At Kochriya village (Suwana block, Bhilwar), the practice of rainwater harvesting and recycling was introduced. There was an increase of 69.09% in NMR (Rs.49110) due to farm pond technology against traditional practice (Rs.18250).
- At Bijapur, supplementary irrigation of 5 cm depth given through sprinkler at flowering stage of chickpea and sorghum gave an additional yield of 25 and 31.4% in chickpea and sorghum, respectively.
- At Nignoti village (Indore district, Madhya Pradesh), supplemental irrigation in onion (Cv. Red-3) gave maximum yield of 10650 kg/ha with net return of Rs.81500/ha and 4.3 B:C ratio as compared to local cultivar (8300 kg/ha) and the yield was 28.3% more over local cultivar. At Raura and Patauana Block, Rewa (M.P.), a farm pond size of 20 x 15 x 6 m (capacity 1800 m3) was used for efficient rainwater harvesting and recycling for supplementary irrigation of 5 cm as pre-sowing irrigation for chickpea cv. JG-322.The per cent increase in yield over without supplemental irrigation was 14.3%.

Efficient energy use of management

- At Biswanath Chariali, in Ganakdoloni village, it was observed that energy use in paddy cultivation could be reduced by 8 to 23% through increasing the level of mechanization.
- In Hardoiya village, Faizabad district, Uttar Pradesh, paddy variety NDR-97 performed better with improved implement and output-input energy ratio was maximum (9.68:1) with rotavator. The seed yield (32046 kg/ha) was found maximum in MB plough + harrowing followed by rotavator (29400 kg/ha) and cultivator (2675 kg/ha), respectively.
- At SK Nagar, roto till drill use in greengram cultivation resulted in maximum net return of Rs. 28980/ha and RWUE (0.78 kg/ha-mm) over other implements.
- At Varkhed village (Barshi Takali Taluka, Akola district, Maharashtra), use of multipurpose thresher was introduced for threshing of soybean which reduced harvesting time, labour cost by 33.3% and reduced the cost of harvesting.
- At Pata Meghapar village, Rajkot district, primary tillage by using reversible plough (in summer) recorded higher seed cotton yield (2731 kg/ha) which was higher by 19.7% compared to farmer practices.

Alternate land use and eco system services

- At Bangalore, aonla + fingermillet gave maximum net return of Rs.29831/ha with B:C ratio of 2.16 followed by aonla + cowpea with net return of Rs. 29548/ha with B:C ratio of 2.07 as compared to other aonla based cropping systems. Similarly, custard apple + fodder maize was superior with net returns of Rs.59633/ha and B:C ratio of 3.09. At Indore, higher fruit yield was received from aonla (1312 kg/ha) with gross returns of Rs.26248/ha followed by guava (309 kg/ha and Rs.6175/ha) and phalsa (124 kg/ha and Rs.7411/ha).
- At Kovilpatti, in aonla and custard based cropping systems, greengram (Cv. CO-6) was superior with higher seed yield of 233 and 266 kg/ha, respectively over other intercrops. While, in case of sapota based intercropping system, okra recorded higher yield of 288 kg/ha as compared to other intercrops.

NICRA-Strategic Research

Adaptation Strategies through Cropping Systems at Selected Soil Benchmark Sites

In a study on adaptation strategies through cropping systems at selected soil benchmark sites at Warkhed watershed, Akola district, Maharashtra, during south-west monsoon (June-September) 2013, a rainfall of 1265 mm was received which was excess by 598.7 mm compared to normal (666.3 mm) and during *rabi* season, (October to December), a rainfall of 210 mm was received which was excess by 143.2 mm compared to normal (66.8 mm). The excess and continuous rainfall accounting to 662 mm during 15th July to 3rd August affected soybean, blackgram, greengram and sorghum which were at vegetative/reproductive stages. In general, the crops were more affected in deep to very deep black soils (Vertic Ustochrepts and Typic Haplusterts) occurring on the middle sector and valley floor of the watershed due to imperfectly drained conditions which resulted in yield reduction up to 30%. However, these crops performed relatively better due to moderately well to well drained conditions in shallow, non-calcareous soils (Typic Ustorthents) occurring on the upper sector of the watershed. As a real time contingency measure,the excess water was drained out from the crop fields. The long duration crops (cotton and pigeonpea) in intercropping systems *viz*. cotton + greengram (1:1), cotton + greengram + pigeonpea (1:1:6):2), soybean + pigeonpea (4:2) performed better due to ideal soil moisture/drainage conditions during reproductive stages in deep to very deep black soils. This resulted in increased yields up to 26 % and higher rainwater use efficiency (RWUE) up to 1.44 kg/ha-mm, particularly in Vertic Ustochrepts as compared to shallow Typic Ustorthents.

Village Climate Risk Management Committee (VCRMC)

The VCRMCs in NICRA villages played a greater role in implementation of real time contingency plans, rainwater management practices, creation of water assets through farm ponds/ percolation tanks for drought proofing, crop, land and soil based interventions. Further, VCRMCs helped in establishing Custom Hiring Centers, hiring the implements, deciding the hiring rates etc.

Custom Hiring Centre (CHC)

CHCs helped in hiring the need based costly implements/machinery by resource poor farmers at affordable cost and carrying out land preparation, timely and precision sowing covering large area in short time and other agricultural operations with high energy efficiency. A Custom Hiring Management Committee (CHMC) facilitated CHC activities and maintenance of implements from the income generated through hiring. CHCs significantly contributed to alleviate labour shortage during peak demand period.

Village Seed Banks

In some NICRA villages adopted by centres like Chamua Narayapur, Lakhimpur district, Assam, an effort was made to establish a seed bank of the rice varieties of different duration which are suitable for aberrant weather situations like flood and drought. The farmers were trained in seed production progarmme of 22 improved varieties and more than 30 local varieties and maintenance of seed of improved varieties of dominant rainfed crops. The seed stock of 11 rice varieties are available in the seed bank.

Fodder Bank

In order to meet the fodder scarcity during weather aberrations, community lands we brought under fodder production in NICRA villages. Fodder banks are likely to enhance livelihoods of the farmers, increase milk production with locally available fodder at affordable cost, and provide ecosystem services. The community lands provide for fodder production during drought/ flood and improved fodder/ feed storage methods, availability of the fodder within purchase limit of poor farmers, and efficient feed management for livestock during aberrant weather situations. In such efforts, Phule Jayant was introduced in NICRA village by Solapur. Similarly, the introduction, production and availability of berseem locally helped in increased milk production in NICRA village adopted by Indore center. A community fodder bank is maintained in NICRA village (Kochriya village) of Arjia centre.

Agro-advisories

Agro-advisories were given in NICRA villages in collaboration with AICRPAM centers, IMD etc. While real time contingency measures were advised for implementation in all the villages. Besides display of weather information and agro- advisories on black boards in NICRA villages, the SMS service through mobiles was introduced for disseminating real time agro-advisories. During 2013-14, Rajkot, Biswanath Chariali, Bengaluru, Solapur and Indore issued timely agro-advisories to farmers.

Soil Health Cards

Soil health cards given to farmers in NICRA villages are to be used for site-specific nutrient management, nutritional sprays, and for maintaining soil health. Soil health cards were issued by Ballowal Saunkhri, Biswanath Chariali and Anantapur centre to the farmers.

Trainings/Field visits/Field days

The AICPDA centres organized regular farmer-scientists-stakeholder meetings, sensitization of farmers about climate variability and its impact on agriculture and allied sectors and agro advisories, pre and in-season trainings on improved rainfed technologies/ best bet practices, field visits/field days for exposing the farmers and other stakeholders on performance of thematic interventions during weather aberrations. During the year, different AICRPDA centers organized 55 trainings and field days/visits and about 2854 stakeholders including farmers were benefitted.

Linkages

For effective implementation of the NICRA programme, the centres established linkage with state line departments, KVKs, ATMA, NGOs, ICAR Institutes, various sate/central govt. schemes/ programmes like farm pond/water harvesting structures /soil and water conservation programmes in Madhya Pradesh and Chattisgarh.

Introduction

Impacts of climate change on agriculture are being witnessed all over the world, but tropical countries like India are more vulnerable in view of large population depending on agriculture, excessive pressure on natural resources and poor coping mechanism. Various Model predictions indicated that rising temperatures, increased climatic variability and extreme weather events could significantly impact food production and food security in coming years. The projections made up to 2100 for India indicated an overall increase in temperature by 2- 4°C with no substantial change in precipitation.

However, different regions are expected to experience differential change in the amount of rainfall in the coming decade. Besides, changed rainfall patterns, it is predicted that extreme events are likely to increase in the country resulting in more droughts and floods. Rainfed agriculture is considered to be relatively vulnerable to climate variability and change in view of its dependence on only rainfall. People dependent on rainfed agriculture are also less endowed in terms of financial, physical, human and social capital limiting their capacity to adapt to the changing climate. Past five years experience shows that climate variability is already impacting Indian Agriculture. Heat wave during February- March in North India caused an estimated loss of 6 million tonnes of wheat in 2002-03. A decline in production of 60% in rapeseed and 50% in linseed was observed in Himachal Pradesh due to eat wave in March 2004. Pigeonpea crop in area of 7000 ha was damaged in Madhya Pradesh due to frost and cold (Venkateswarlu *etal,* 2011). Similarly, delayed onset of monsoon, mid-season and terminal droughts in rainfed areas are causing huge losses to agriculture and livestock production. Climate change/variability is not only affecting the livelihood of farmers but causing a decline in agricultural Gross Domestic Product (GDP). Another important feature of climate variability is increasing number of extreme events such as cyclones and floods. Recent cyclones in Coastal Andhra Pradesh and Odisha one some examples which vanished the most of the crops leaving nothing left-out situation. Within a span of one year, the country is experiencing severe droughts and floods in the same region posing serious problems to the farmers, agricultural scientists and extension staff. Fall in the yield of staples and consequent shortage of food grain lead to price rise and inflation affecting the poor most. To make the Indian agriculture more climate resilient, besides undertaking research to develop location specific climate resilient agricultural technologies, there is a need to make immediate efforts to transfer the already available agricultural technologies to the farmers' fields especially in more vulnerable regions. At the same time, there is also need to put in place innovative institutional mechanisms at the field level for successful technology adoption and up scaling. In order to deal with climate change in the right earnest, it has been planned to conduct extensive farmer participatory demonstrations of location specific climate resilient agricultural technologies/ package of practices developed by 23 centers of All India Coordinated Research Project for Dryland Agriculture(AICRPDA) under on-station and on-farm conditions under the National Initiative on Climate Resilient Agriculture (NICRA). An important component of AICRPDA-NICRA programme is to test and demonstrate contingency plan prepared by the CRIDA in the field conditions in real time.

AICRPDA At a Glance : The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) was launched in 1970 by the Indian Council of Agricultural Research in IV Plan period, in collaboration with the Government of Canada through Canadian International Development

Agency (CIDA) with Coordinating Cell at Hyderabad, Andhra Pradesh. In 1985, the Project Directorate of AICRPDA was upgraded to the status of an institute i.e. Central Research Institute for Dryland Agriculture (CRIDA) to carry out basic and strategic research while network research under AICRPD Umbrella continued in applied and adaptive research mode. Presently, AICRPDA network has 22 centers and 8 Operational Research Projects (Fig. 1.) viz. 20 centers in State Agricultural Universities, 2 in technical/ other Universities and 3 in ICAR institutes located in 15 states in various agro-ecological settings (Table 1.) The project as several unique features compared to any other AICRP. At each center, location specific research based on natural resource management and socioeconomic status was the hallmark of the programme. Integrated Dryland Development Pilot Projects were started simultaneously and linked with this research network. Introduction of collaborative on-farm participatory research efforts in the Operational Research Project concept goes to the credit of the project. The domain of some centers also includes the tribal dominated districts. The project is supported by 516 staff members (128 scientists and 388 technical, administrative and auxiliary). The research under AICRPDA network centers focuses on location specific problems considering agro ecological characteristics, predominant rainfed production systems and socioeconomic settings with specific emphasis on soil conservation and rainwater management, evaluation of crops/varieties, cropping/farming systems and contingency planning, integrated nutrient management, tillage and farm machinery and alternate land use systems. In the last few years, more focus was given on farming systems, tillage and integrated nutrient management, alternate land use systems for diversification and efficient implements on a template of resource management particularly rainwater management. Off late concerns of climate change and variability issues were addressed through input and energy use efficiency, low carbon economy and environmental services. The on-station research findings generated at the centers were evaluated on farmers' fields in ORP watersheds/ villages. During this process of on farm participatory research, other on-farm trials/demonstrations and Front Line Demonstrations (FLDs) gave impetus for up scaling of rainfed technologies in the recommendation domain of the centers. Over a period of 3 decades, AICRPDA network centers generated location specific technologies for up scaling in the respective agro climatic zones. These technologies basically address rainwater harvesting and reuse for higher resource use efficiency and water productivity, efficient crops/varieties sand cropping systems for higher yield and income, contingency crop planning, integrated nutrient management, bullock/tractor drawn farm implements for efficient tillage/seeding/fertilizer application/ intercultural and other operations with cost effectiveness and timeliness, alternate land use systems for diversification, higher income and resource efficiency. The technology demonstration component of NICRA in AICRPDA network envisages identifying climatic vulnerabilities of agriculture in the selected village in each of the 28 districts based on historical weather data from the nearest weather station, farmers' experiences and perceptions, preparing and implementing adaptation and mitigation strategies following a bottom-up approach. The focus of the program is not only to demonstrate the climate resilient agriculture technologies but also to institutional mechanisms at the village level for implementation of successful adaptation strategies on a sustainable basis. One village or a cluster of villages from each of the 28 selected districts were selected for technology demonstration. The technology demonstration component in the selected districts is being piloted by the respective AICRPDA centers. The emphasis is on managing early, mid-season and terminal drought through crop, soil, water and nutrient based strategies.

Climatic characteristics of the village: After village / cluster of villages selection, each center collected time series climatic/weather data pertaining to the selected village or from the nearby weather station in order to understand the extent of vulnerability of the village's agriculture to climatic variability. The information was collected and analyzed related to the following: (a) Rainfall-annual as well as during *kharif* season (Normal; trend in past 10 years (if any) increase/decrease), (b) Number of rainy days seasonal as well as annual (Overall average, decadal average (1971-80, 1981-90, 1991-2000,2001-09), (c) Intensive rain-spells (above 60 mm per day (Decadal average (1971-80, 1981-90, 1991-2000, 2001-09), (d) Number of dry-spells inpast 10 years (Exceeding 15 days, exceeding 10 days in the *kharif* season as well as in the decades), (e) Other extreme events (Information on damage (number of events decade-wise for whole year), (f) Length of growing season (Changes during past one decade) and (g) Number of floods severely (Completely damaging crop sand livestock, Decade-wise number for the past three the past 3 decades) due to other weather extremities such as frost, heat and cold waves, hail storm, sea inundation of agricultural fields and consequent problems, information if any, on soil degradation due to extreme weather events.

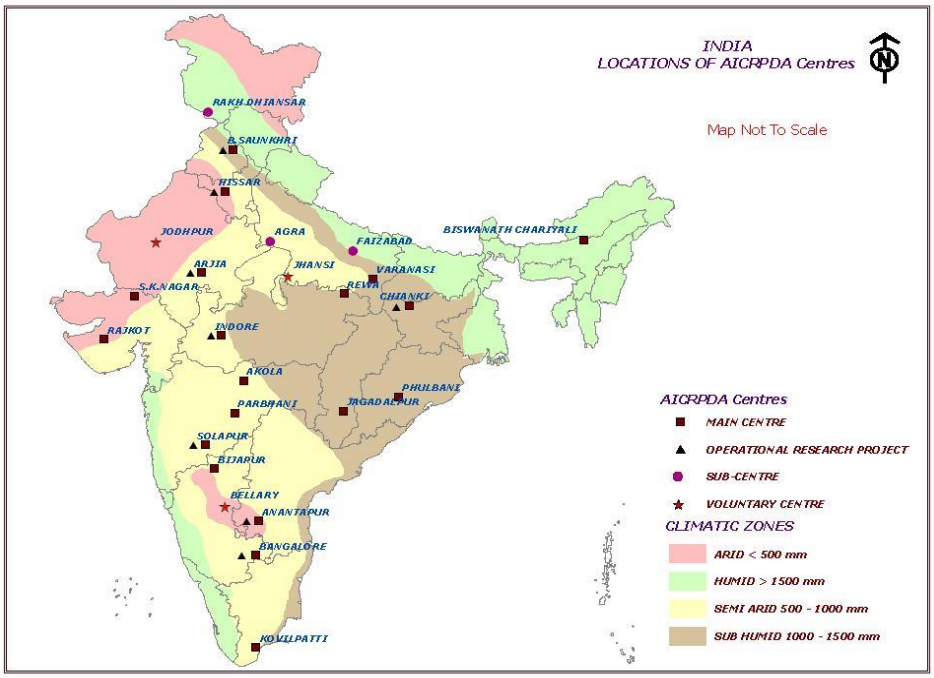


Fig.1. AICRPDA Network Centres – Location map

Participatory Appraisal of NICRA Village: The participatory appraisal of the village was to understand the farming systems, resource situation, constraints and climatic vulnerabilities and to identify opportunities of climate change adaptation and mitigation in the selected village. Every center collect information on land use pattern, area, production and productivity of different agricultural and horticultural crops, livestock composition and production, fishery production, awareness level of farmers about climate change, ground water level and its use, income from agriculture and allied activities, level of risk of crop loss due to climatic variability in the past one decade. This information was collected from the farmers and village key informants. The participatory appraisal was undertaken as follows:

Natural Resource Characterization: To understand as to why the agriculture in the selected village remains vulnerable to climatic change, it was planned to assess the status of natural resources, socio-economic, institutional and infrastructural status and major farming systems. The status of natural resources may cover type, quality, organic matter status and depth of soil and its suitability for different crops, access and level of use of manure (FYM & green) and fertilizers, scope for improving organic matter in soil, access to water-rainwater (if harvested), ground water (open wells and bore wells and whether level is declining) and canal water (timely availability and access); account of major changes in flora and fauna during past one decade and its causes. Such assessment was useful to plan NRM related interventions.

Socio-economic Status Institutional Arrangements: The centers collected the information on land holding structure, level of income, literacy and education of farmers, asset base of farmers, participation in social networks, proportion below poverty line, access to critical inputs to agriculture and marketing opportunity for farm output, access to market information and technical knowledge, level of awareness and skills of farmers, access to different government schemes, existing institutional arrangements like SHGs, commodity groups, user groups and their effectiveness, etc. Based on the social dynamics in the village, different institutional arrangements were planned to implement the project activities.

Major Farming Systems: Farming system based information was collected on land use pattern, extent of irrigation, type of crops and varieties grown, yield levels, level of input use (fertilizer, manure, pesticides, weedicide etc), seed replacement rate in major crops, level of mechanization for different farm activities, system of irrigation (flood, drip, sprinkler), access to farm machines (owned/ custom hiring), access to improved seed, livestock species reared and their yields, incidence of various diseases in the livestock and consequent mortality and changes in cropping/ farming systems during the past one decade. This analysis helped in planning appropriate climatic resilient technological interventions for individual as well as group of farmers.

Constraint Analysis: The team consisting of various disciplines analyzed the constraints related to climatic variability based on secondary weather data, resource situation, farming systems and agricultural yields in the past few years. The major constraints resulting from climatic variability includes; water scarcity, recurrent droughts (early, mid season, terminal), cold wave, heat wave, flood, pest and diseases of crop and livestock, fodder scarcity, poor access to appropriate seeds/planting material and critical inputs and farm machinery (timeliness and cost of access). The constraints were supposed to be analyzed by the multidisciplinary team in a manner so that the actual causes of constraints and points to intervention are identified.

Based on Potential and Constraint Analysis : AICRPDA-NICRA centres : Demonstration of Climate Resilient Technologies each center proposed technological and institutional interventions for enhancing the resilience of farming systems to the climatic variability by involving the major stakeholders such as farmers, researchers, NGOs, officers of the line departments and extension specialists. Based on the detailed analysis of farming systems, resources, constraints, needs of the village, the climatic vulnerability (drought/floods/heat wave/frost/cyclone) and the available technology options from the concerned Regional /Zonal Agricultural Research Stations of the SAU and ICAR institutes and time tested climate resilient farm practices adopted by innovative farmers, the stakeholders in the brainstorming sessions identified the gaps and selected specific interventions

related to each of the four subprojects (i) Real time contingency plan implementation in a participatory mode (ii) Rainwater harvesting *(in-situ and ex-situ)* and efficient use (iii) Efficient energy use and management (iv) Alternate land use. It was planned to saturate the whole village with the identified interventions in order to demonstrate a discernable effect and document the constraints and lessons. Further the preference was given to the interventions targeted/ focused interventions that benefiting larger and resource poor group Interventions which give long-term and sustainable benefits Interventions that address resource conservation and interventions that promote/strengthen village level institutions

The whole village was to be saturated with the climate resilient technologies; however, in the beginning the number of interventions of different types was decided as per the budget available, vulnerability status and cooperation of the farmers. The interventions which require high investment like farm pond were planned for few suitable locations in the village. The *in-situ* moisture conservation and improved agronomic practices, intercropping and new varieties were planned to be taken up for large number of farms in the village. In selection of beneficiaries, the farmers' most vulnerable to climatic variability and small holders were given priority. It was also ensured that the village has control farm/plot/animals for all the implemented interventions in order to assess the impact of interventions in a short period. Every centre was suggested to prepare the activity plan with details of activities along with roles and responsibilities of stakeholders, period and budget for each intervention. The AICRPDA Network centers have been included in the National Initiative on Climate Resilient Agriculture (NICRA) Project of ICAR for taking up demonstration and research activities at various dryland centers in a network mode. The demonstration components of NICRA have been finalized in these centers in a participatory mode. The villages in districts and domain districts of the centers are given in (Table 2) and location of the adopted villages is shown in (Fig. 2). During 2013-14, demonstration of an integrated package of proven rainfed technologies was conducted in selected villages at 23 AICRPDA Centers for adaption of crop production system to climate variability. The demonstrations covered a total area of 1430 ha covering farmers. The trials were conducted in 36 villages in 33 districts. There were four sub-projects, viz., 1) Real Time Contingency Plan Implementation in a participatory mode, 2) Rainwater harvesting *(in-situ and ex-situ)* and efficient use, 3) Efficient energy use and management & 4) Alternate land use / arming systems for carbon sequestration and ecosystem services. The trials were conducted in order to evaluate the performance of improved practices compared to the farmers practice for different rainfed crops of cereals, pulses, oilseeds, vegetables and other commercial crops to cope with current climate variability.

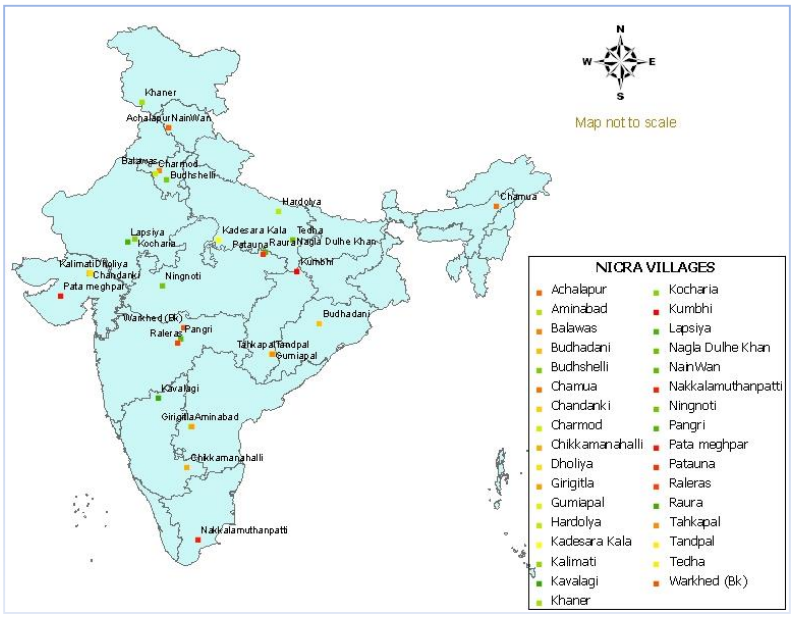


Fig. 2: NICRA-AICRPDA adopted Villages : Location Map

The Programme Implementation - Process The process of implementation of on-station experiments at the AICRPDA centers and on-farm demonstrations in the villages adopted by the centers under NICRA are presented below: The major interventions were implemented both under on-farm and on-station, broadly under four theme areas as follows:

I. Realtime contingency crop plan implementation both on station and on farm in a participatory mode: To sustain the productivity of pearlmillet, cluster bean, sesame under normal are drought conditions. To improve the productivity of mustard, chickpea and wheat under rainfed conditions.

II. Rainwater harvesting (in-situ and ex-situ) and efficient use: Demonstration on efficient in-situ moisture conservation practices to conserve more moisture (ridge and furrow planting, compartmental bundling etc.).Efficient and multiple use of harvested water or enhancing water use efficiency (life saving irrigation, sprinkler irrigation). Ground water recharging through bore well and open well, defunct well.

III. Efficient energy use and management: Introduction of modern machines and to create awareness in the farming community about their use for different crops (establishing custom hiring centre and ensuring services in the village).

IV. Alternate land use for carbon sequestration and eco-system services: To develop alternate land use system / farming system for carbon sequestration and ecosystem Services The package included land configuration, crops or varieties/cropping system, rain water harvesting and recycling, timely operations through custom hiring centre and alternate land use and ecosystem services.

Table-1: Agro-ecological setting of AICRPDA Network centers

Name of the Centre	SAU/CAR nstitute/ their Hqrs)	Agro-Climatic Zone(NARP)/Agro– Eco sub-region(AESR)	Climate**	Mean Annual Rainfall(mm)	Dominant Soil Type	Major Rainfed Production
Agra (SC)	RBSC, Agra	South–western semiarid zone in Uttar Pradesh(4.1)	Semi-arid (Hot dry)	665	Inceptisols	Pearlmillet
Akola (MC)	PDKV, Akola	Western Vidarbha Zone in Maharashtra (6.3)	Semi-arid (Hot moist)	824	Vertisols	Cotton
Anantapur (MC&ORP)	ANGRAU, Hyderabad	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh (3.0)	Arid (Hot)	544	Alfisols	Groundnut
Arjia (MC&ORP)	MPUAT,Udaipur	Southern zone in Rajasthan(4.2)	Semiarid (Hot dry)	656	Vertisols	Maize
BallowalSaunkhri (MC&ORP)	PAU, Ludhiana	Kandi region in Punjab(9.1)	Sub humid (Hot dry)	1011	Inceptisols	Maize
Bengaluru (MC&ORP)	UAS_Bangaore	Central, eastern and southern dry zone in Karnataka(8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermillet
Bellary (VC)	CSWCRTI,Dehrad	Northern dry zone in Karnataka(3.0)	Arid (Hot)	502	Vertisols	*Rabi* Sorghum
Bijapur (MC)	UAS_D,Dharwad	Northern dry zone in Karnataka(6.1)	Semi-arid (Hot dry)	595	Vertisols	*Rabi* Sorghum
Biswanath Chariyali (MC)	AAU,Jorhat	North-west Plain zone in Assam (15.4)	Per humid (Hot)	1846	Oxisols	Rice
Chianki (MC&ORP)	BAU,Ranchi	Western plateau zone of Jharkhand (4.1)	Semi-arid (Hot dry)	1149	Inceptisols	Rice
Faizabad (SC)	NDUAT,Faizabad	Eastern plain zone in Uttar Pradesh(9.2)	Sub-humid (Hotdry)	1051	Inceptisols	Rice
Hisar (MC&ORP)	CCSHAU,Hisar	South-western dry zone in Haryana(2.3)	Arid (Hyper)	412	Inceptisols	Pearlmillet
Indore (MC&ORP)	RVSKVV,Gwalior	Malwa plateau in Madhya Pradesh(5.2)	Semi-arid (Hot moist)	958	Vertisols	Soybean
Jagadalpur (MC)	IGAU,Raipur	Basthar Plateau zone in Chattisgarh(12.1)	Sub-humid (Hot moist)	1297	Inceptisols	Rice
Jhansi (VC)	IGFRI,Jhansi	Bundhelkhand zone in UttarPradesh(4.4)	Semi-arid (Hot moist)	870	Inceptisols	*Kharif* Sorghum
Jodhpur (VC)	CAZRI,Jodhpur	Arid Western zone of Rajasthan (2.1)	Arid (Hyper)	331	Aridisols	Pearlmillet
Kovilpatti (MC)	TNAU,Coimbatore	Southern zone of Tamil Nadu(8.1)	Semi-arid (Hot dry)	723	Vertisols	Cotton
Parbhani (MC)	MAU,Parbhani	Central Maharastra Plateau Zone in Maharashtra(6.2)	Semi-arid (Ho tmoist)	901	Vertisols	Cotton
Phulbani (MC)	OUAT,Bhubaneswa	Eastern Ghat Zone in Orissa(12.1)	Sub-humid (Hot moist)	1580	Oxisols	Rice
Rajkot (MC)	JAU,Junagarh	North Saurashtra zones in Gujarat (5.1)	Semi-arid (Hot dry)	590	Vertisols	Groundnut
Rakh Dhiansar (SC)	SKUAS_T,Jammu	Low altitude subtropical zone in Jammu and Kashmir(14.2)	Semi-arid (Moist dry)	860	Inceptisols	Maize
Rewa (MC)	JNKVV,Jabalpur	Key more plateau and Satpura Hill zone in Madhya Pradesh(10.3)	Sub-humid (Hot dry)	1088	Vertisols	Soybean
S.K.Nagar (MC)	SDAU,Dantewada	Northern Gujarat in Gujarat(2.3)	Semi-arid/Arid (Hot dry)	670	Entisols	Pearlmillet
Solapur (MC&ORP)	MPKV,Rahuri	Scarcity zone in Maharashtra(6.1)	Semi-arid (Hot dry)	732	Vertisols	*Rabi* Sorghum
Varanasi (MC)	BHU,Varanasi	Eastern Plain and Vindhyan Zone in U.P.(4.3/9.2)	Semi-arid (Hot moist) Sub-humid (Hot dry)	1049	Inceptisols	Rice

MC – Main Centre; SC - Sub Centre; ORP – Operational Research Project

Table – 2: Details of villages under NICRA program

Name of the center	Name of theVillage(s)	District	State	Total cultivated area(ha)	Rainfed area(%)
Agra	Nagla Duleh Khan	Agra	Uttar Pradesh	981	90
Akola	Warkhed, Belura	Akola	Maharashtra	275	92
Anantapur	Aminabad, Girigetla	Kurnool	Andhra Pradesh	167.5	74
Arjia	Kocharia, Mandpiya, Solakakheda, Lapsiya, Tarakakheda	Bhilwara Rajsamand	Rajasthan	540	77
Ballowal Saunkhri	Naiwan, Achalpur	Hosiarpur	Punjab	465.2	84
Bengaluru	Chikkamaranahalli (Chikkamaranahalli colony, Chickaputtyanapalya, Hosapalya, Mudalapalya)	Bengaluru Rural	Karnataka	409.2	90
Bijapur	Kaulagi	Bijapur	Karnataka	1327	98
Biswanath Chariali	Chamua	Lakhlmpur	Assam	133	100
Chianki	Khumbhi-bankheta	Garhwa	Jharkhand	215	70
Faizabad	Hardoiya	Faizabad	Uttar Pradesh	397	35
Hisar	Budhsheli, Charnod, Balawas	Bhiwani	Haryana	2203	77
Indore	Ningnoti	Indore	Madhya Pradesh	248	40
Jagdalpur	Tahakapal, Gumiapal, Pahkapal	Bastar	Chhattisgarh	511.3	98
Jhansi	Kadesara Kala	Lalitpur	Uttar Pradesh	875.1	33
Kovilpatti	Nakkalamuthanpatti, Kalugachalipuram, Muthukrishnapuram	Tuticorin Thoothukkudi	Tamil Nadu	630.7	92
Parbhani	Pangri	Parbhani	Maharashtra	951.1	93
Phulbani	Budhadani	Kandhamal	Orissa	101.2	81
Rajkot	Pata Meghapar	Jamnagar	Gujarat	2793	60
Rakh Dhiansar	Khaner	Rakh Dhiansar	Jammu & Kashmir	55	100
Rewa	Patauna	Rewa	Madhya Pradesh	744	34
SKNagar	Dholia, Kalimati, Chandanki	Banaskantha, Mehasana	Gujarat	1101	68
Solapur	Narotewadi	Solapur	Maharashtra	560.7	80
Varanasi	TerhaSaraya	Mizapur	Uttar Pradesh	290	72

***One village with 4 clusters**

1. Salient Achievements Technology Demonstration

1.1. RICE BASED PRODUCTION SYSTEM

1.1.1. BISWANATH CHARIALI

a. Agro-ecological setting

Biswanath Chariali centre is located in middle Brahmaputra plain eco-sub region (AESR 15.2). The climate is hot humid. Annual normal rainfall is 1990 mm. The length of growing period is 240 to 270 days. Seasonal flooding and water logging is common which demands special selection for normal crop husbandry.

b. On-station experiments

During the year 2013, the onset of monsoon was timely during first week of June. A rainfall of 1088.8 mm was received which was deficit by 93.4 mm compared to normal (1182.2 mm) during south-west monsoon (*kharif*) (Fig.3).

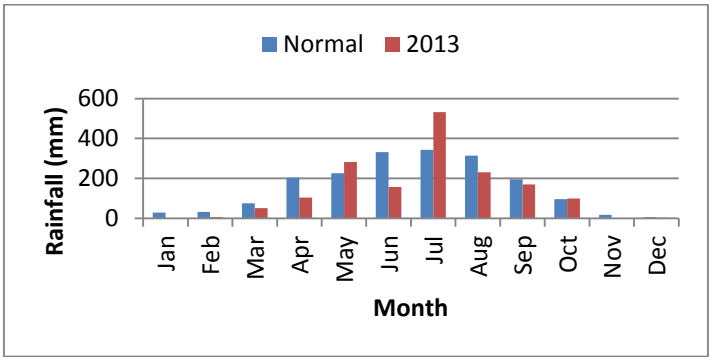


Fig.3: Normal and actual (2013) monthly rainfall at Biswanath Chariali

During north-east monsoon (October - December), 101.8 mm of rainfall was received which was deficit by 18.2 mm compared to normal (120 mm). During summer (March-May), 435.9 mm of rainfall was received which was deficit by 67.8 mm compared to normal (503.7 mm). There were dry spells during 27 to 29 SMW (2-22 July, coinciding with transplanting and tillering stage of rice) and 41-49 SMW (8 October - 9 December, coinciding with sowing/flowering stage of rapeseed, mustard and potato crops).

Development of Dryland Technology Park

The Dryland Technology Park developed at BN College of Agriculture is being maintained and strengthened under NICRA covering an area of 2 ha The major technologies being demonstrated at the Technology Park include farm pond for rainwater harvesting, agri-horticulture, apiary, vermicomposting etc.

Dryland Technology Park

Rainwater harvesting and recycling

The stored water in the farm pond was efficiently utilized for supplemental irrigation in potato. The supplemental irrigation at 25 days (one irrigation), 25 and 60 days (two irrigations) and 25, 60 and 80 days (three irrigations) after planting of potato gave 48.5, 83.2 and 125.9% higher yield over rainfed crop (10050 kg/ha). Similarly, B:C ratio increased from 1.69 to 2.19 under rainfed and three supplemental irrigations (Table-3 & Fig.4).

Table-3: Yield and economics of potato as affected by different levels of irrigation supplied from harvested rainwater

Treatment	Tuber yield (kg/ha)	B:C ratio
Rainfed	10050	1.69
One supplemental irrigation	14870	1.83
Two supplemental irrigations	18400	2.11
Three supplemental irrigations	22710	2.19

Roof top rainwater harvesting

In another trial, the stored water in farm pond was used to provide supplemental irrigations to potato crop during *rabi*, 2013-14. The first and second supplemental irrigations were given at 45 SMW (30 DAS) and 50 SWM (60 DAS), respectively. The depth of each of the irrigation was 6cm m. It was estimated that water collected from the area (224 m^2) was sufficient for providing two irrigations (6cm depth) in potato cultivated in the area of 1840 m^2. Thus, same amount of water may be given to an area of 3680 m^2 if one supplemental irrigation is given to the crop (Fig....).

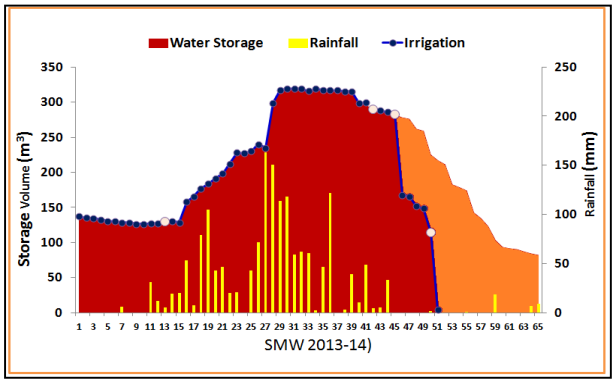


Fig.4: Rainwater (collected from roof top) storage in farm pond at Biswanath Chariali during 2013-14

It was observed that the tuber yield was increased by 136% when two supplemental irrigations were provided as compared to the yield under rainfed condition (5243 kg/ha). Mulching with organic mulches like dry weeds during increased potato yield by 20% over rainfed condition. Similarly, rainwater use efficiency was also increased to 0.52 q/ha-mm grown under mulching as compared to that under rainfed conditions (Table-4).

Table-4: Performance of potato (Cv. Kufri Jyoti) under supplementary irrigations and mulching

Treatment	Tuber yield (kg/ha)	Rainfall received during the crop season (mm)	RWUE (q/ha-mm)	Net return (Rs/ha)	B:C ratio
Two supplemental irrigations	12374	121	1.02	75820	2.04
Mulching	6282		0.52	7867	1.12
Rainfed	5243		0.43	(-) 1575	0.98

c. On-farm experiments

Village profile

The program is being implemented in the village Chamua Narayanpur in Lakhimpur district, Assam. The total cultivated area is 133 ha which is entirely rainfed. The mean annual rainfall is 1987 mm with seasonal rainfall of 1262 mm during *kharif* (June- September). The major soil types are Inceptisols (sandy loam to silty clay loam with pH ranges from 4.65 to 6.38). The major crops during *kharif* are *Sali* rice, sesame, blackgram and green gram and in *rabi* are rapeseed, potato, winter vegetables etc. The numbers of small, marginal, medium and large farmers are 41, 65, 19 and 0, respectively. The ground water table is 6 m.

Climate Vulnerability in general

In general, the climate in this agro-climatic zone is humid. The south-west monsoon contributes 64.5%, northeast monsoon 7.7%, summer 24.8% and winter 3.1% of the total annual average rainfall of 1987 mm. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 30-40% deficit of the average rainfall. The onset (south-west) of monsoon is during 23 SMW (standard meteorological week). Early season drought or normal onset of monsoon followed by 15 to 20 days dry spell and mid-season drought are recurrent. The dry spells or flood during crop season are being experienced for the past 15 years in July, August, September and October at tillering, panicle initiation and reproductive growth stages of *sali* rice. The onset of the monsoon is normal. The maximum/minimum temperature during crop season is increasing (maximum temperature by 0.006^0 C/year and minimum by 0.0194^0 C/year) since the past 50 years. The extreme events like unusual and high intensity rainfall in short span are increasing during *kharif* (June, July, August and September and October) and *rabi* seasons. The area is also experiencing other extreme events like flood, hail storm and thunder storm.

Experienced weather conditions during the year (2013-14)

The rainfall data of Biswanath Chariali centre (being the nearest agromet station) was taken for the analysis of weather conditions during the year 2013 at Chamua Narayanpur village. A rainfall of 1375.3 mm was received which was excess by 95.2 mm compared to normal (1280.1 mm) during *kharif* (Fig.5).

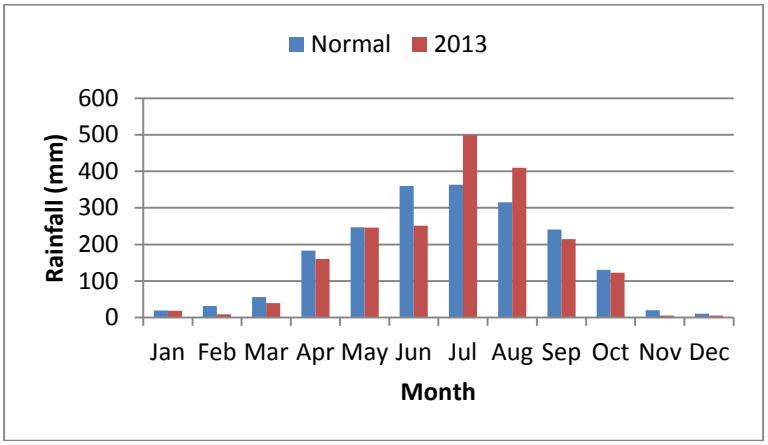


Fig.5: Normal and actual (2013) monthly rainfall at Chamua Narayanpur

During north-east monsoon (October - December), 132.6 mm of rainfall was received which was deficit by 28.5 mm compared to normal (161.1 mm). During summer (March - May), 446.8 mm of rainfall was received which was deficit by 39.7 mm compared to normal (486.5 mm). There were dry spells during 27-29 SMW (2-22 July, coinciding with transplanting and tillering stage of rice) and 41–49 SMW (8 October - 9 December, coinciding with sowing/flowering stage of rapeseed, mustard and potato crops).

Interventions

The major interventions included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring centre and alternate land use and ecosystem services. These interventions covered an area of 17 ha in 180 farmer´s fields.

Real time contingency planning

Under this component, suitable varieties of rice like Luit, Kolong, Dishang, Lachit etc (short duration) and Mohan, Gandhari, Mulagabharu, TTB - 404 (medium duration) of *sali* rice during *kharif* and Jalashree, Jalkunwari, Swarna Sub-1 (submergence tolerance) and Gitesh, Prafulla (having staggering ability) varieties were introduced to cope up with the rainfall variability of the region.

For dry spell during (*kharif*) *sali* rice

Short and medium duration varieties were proved to be better under deficit rainfall conditions during later stages of crop (September 26.1% and October 2.6% deficit than normal) the prevailing condition of midseason and terminal dry-spell. As a it was suggested to cultivate short and medium duration cultivars in the uplands and medium land situations, respectively. However, in case of low land situations, where possibility of deficit of water was rare, long duration cultivars like Ranjit, Moniram and Mahshuri were to be grown.

Among the short duration cultivars, yield of *Dishang* was the maximum (4170 kg/ha). Medium duration varieties have the ability to escape terminal drought and also suitable for growing as second crop in the same field after harvesting rice. TTB-404 recorded the higher yield (5250 kg/ha) and B:C ratio (3.15) over other medium duration cultivars. While, in case of long duration varieties, Gitesh recorded higher yield (5278 kg/ha) followed by Ranjit (5418 kg/ha) and variety Gitesh has an additional advantage of staggering ability, thus more resilient to weather variability (Table-5).

Table-5: Performance of short, medium and long duration varieties of rice

Variety	Duration	Grain yield (kg/ha)	Net return (Rs/ha)	B:C ratio
Luit	Short	2692	12304	1.62
Kolong	Short	2734	12808	1.64
Lachit	Short	3137	17644	1.88
Dishang	Short	4170	30040	2.50
Mohan	Medium	4020	28240	2.41
Mulagabharu	Medium	5047	40564	3.03
TTB-404	Medium	5250	43000	3.15
Ranjit	Long	5418	45016	3.25
Mahsuri	Long	3332	26648	2.33
Gitesh	Long	5278	43336	3.17
Jalkunwari	Long	3612	23344	2.17

Performance of short, medium and long duration rice cultivars

Performance of flood tolerant rice varieties

During 2013, in NICRA village, Ganakdoloni, flash flood occurred for a total period of 36 days viz. 18-27 July (10 days), 07-13 August (7 days), 14-20 August (7 days) and 28 August to 8 Septenber (12 days). Based on the experiences of previous year, flood tolerant varieties Jalashree and Swarna Sub-1 were chosen to cultivate to cope up with intermittent flash floods occurring 4 times during early to late tillering stage of the crop. All other varieties like Mahsuri, Ranjit were damaged completely. However, Jalshree and Swarna Sub -1 withstood the flash flood and gave 2850 and 2531 kg/ha, respectively and though yield was low as compared to normal year, there was 100% benefit compared to other varieties like Ranjit, Mahsuri etc. However, during same year, rice varieties Gitesh and Prafulla with staggered planting ability were introduced in the village for late transplantation after recession of flood. About 65- 70 days old seedlings of Gitesh and Prafulla were transplanted during 14 to 21 September, 2013 after receding water level in the field. The farmers showed reluctance for transplanting after mid of September; however, they were convinced to transplant the old aged seedlings of these varieties after mid of September. The performance of Gitesh and Prafulla were better than the popular varieties like Ranjit under delayed transplanting condition due to occurrence of intermittent flash floods in the village. There was 100% increase in the yield of Gitesh and Prafulla as compared to the local cultivars, however, Gitesh registered higher yield (3102 kg/ha) with B:C ratio of 1.90 as compared to Prafulla (2785 kg/ha) with B:C ratio of 1.74 (Table-6).

Table-6: Performance of flood tolerant rice cultivars during 2013 at Ganakdoloni village

Variety	Grain yield (kg/ha)	Increased in yield (%) as compared to normal varieties	Net return (Rs/ha)	B:C ratio
Jalashree	2850	100	13350	1.74
Swarna sub-1	2531	100	9841	1.55
Gitesh	3102	100	16122	1.90
Prafulla	2785	100	13350	1.74

Performance deep water or floating or *Bao* rice under flooded condition

During 2013, six varieties of rice *viz.*, Kokowa, Tulshi, Rangabao, Dhushuri, Maguri and Ranga Bao deep water rice popularly known as *Bao* rice were introduced. *Bao* rice was sown during April, 2013 and harvested during Nov-Dec, 2013. One additional advantage of *Bao* rice is that 2-3 cuttings of leaves of this rice is possible up to mid September, which can be used as fodder.In-spite of occurrence of 36 days duration of intermittent flash flood from July to September during 2013, all the varieties survived and farmers were able to harvest the crop. Maximum yield was registered by Dhushuri (3000 kg/ha), followed by Bahadur, Maguri, Kokowa, Tulshi and Ranga Bao (1900 Kg/ha). Tulshi is suitable for growing in low lying situation due to its higher elongation ability (Table-7).

Table-7: Performances of rice cultivars during 2013 at Ganakdoloni village

Variety	Plant height (m)	Grain yield (t/ha)	Observations
Kokowa	1.6	2672	3 to 4 cuttings is possible up to 1st week of October
Tulshi	2.5 to 4.6	2400	Maximum elongation ability
Dhushuri	1.9	3000	Having both elongation and submergence ability
Bahadur	1.8	2963	No kneeing ability, having very high elongation ability
Maguri	2.1	2813	Having both elongation and submergence ability
Ranga Bao	2.5 to 3.5	1900	Having both elongation and submergence ability

Performance of *rabi* crops in flood affected areas of Ganakdoloni

During 2013, in 20% area where local and normal varieties like Ranjit, Mahsuri etc. were grown, crop was totally destroyed by intermittent flood. Rapeseed varieties TS-36 and TS-38 were grown in 2 ha of land after flash floods and gave 754 kg/ha yield with net return of Rs. 14300/ha.

Performance of rapeseed (TS -36) after flash flood at Ganakdoloni

Crop diversification

Under crop diversification, 20 crops were introduced to cope with weather variability instead of growing only *Sali* rice (Table.....). Crop diversification was proved to be more resilient to the situations like mid-season and terminal dry spells and water stress during *rabi* season (Table-8). Six farmers were selected for demonstration of crop diversification during 2013. All the farmers earned much higher income from the same soil type and same amount of rainfall from the diversified cropping as compared to monocropping of *Sali* rice (Table....).

Table-8: Performance of crops under crop diversification

Crop	Variety	Yield (kg/ha)	Net income (Rs/ha)	B:C ratio
Turmeric	Local	8481	71387	2.30
Ginger	Local	7141	367725	5.30
Potato	Kufri Pokhraj	14179	40153	2.13
Maize	All Rounder	2252	25126	2.25
Rapeseed	TS-36	894	17775	1.98
	TS-38	1170	28815	2.61
Brinjal	JC-1	10410	71631	3.21
Tomato	MT-3	36730	499221	2.95
Cauliflower	Hybrid	13736	141105	4.46
Broccoli	Hybrid	8333	44000	3.95
French bean	Parvati	15957	262340	11.53
Knolkhol	Hybrid	9687	113616	4.23
Cabbage	Rear Ball, Pride of India	12316	148917	4.60
Radish	Bombay Red	3125	17500	2.26
Ladies finger	Pravani Kranti	11278	199774	8.76
Cow pea	Hybrid	2142	34548	2.82
Broad bean	Local	7500	28750	2.69
Sugarcane	Local	5953	148447	4.37
Pea	Hybrid	2692	25307	2.09
Chili	Hybrid	4666	204264	7.87
Ridge gourd	Local	7504	70769	4.07

Performance of maize cultivars as a new crop during driest period of the year

December to February was the driest period with a rainfall of 10 mm in the NICRA village. Water harvested in the farm ponds could only be used within November and December. As deep rooted crop, maize can be sown in the driest period after harvest of potato and rapeseed in the month of February and March. Generally no crop is grown after harvest of *rabi* crops like potato and rapeseed (February to May) by the farmers of this locality during this period. Maize was introduced in the NICRA village Chamua as resilient crop to be sown during driest period of the year. Maize All-rounder hybrid was cultivated in 1.5 ha area. Some of the farmers harvested the tender cobs as they have good market value. Average number of tender cobs harvested was 84000/ha and grain yield was 56 q/ha with B:C ratio of 7.07 and 5.6, respectively (Table-9).

Table-9: Performance of maize after harvest of potato and rapeseed

Cultivar	Yield (kg/ha)	B:C ratio	RWUE (kg/ha-mm)
Number of tender maize cob			
All Rounder (hybrid)	84000	7.07	265
Grain yield (q/ha)			
All Rounder (hybrid)	56.0	5.6	175

Rainwater harvesting and recycling

During 2013-14, the existing 13 farm ponds in the village were renovated (Fig....) and the stored water was utilized during summer as well as monsoon months. A good amount of rainfall was received during March to May (446.8 mm), which facilitated storing of some amount of rainwater in the farm pond. The rainwater stored during this period was efficiently utilized for sowing *sali* rice in time.

Water stored in farm ponds in the village during the year was efficiently utilized for supplementary irrigation in different stages of potato and rapeseed. The supplemental irrigation gave higher yield of 14179 kg/ha with net returns of Rs.40153/ha in potato; 894 kg/ha with net returns Rs.17775/ha and 1170 kg/ha with net returns of Rs.28815/ha in rapeseed cultivars TS-36 and TS-38, respectively. B:C ratio also increased considerably both in case of potato and rapeseed when crops were grown with supplemental irrigation (Table-10). The rainfall during crop season was 1375 mm.

Table-10: Performance of potato and rapeseed with supplemental irrigation from the harvested rainwater

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Net return (Rs/ha)	B:C ratio
		Supplental irrigation	Without supplental irrigation			
Potato	Pokhraj	14179	9262	85.6	40153	2.13
Rapeseed	TS-36	894	463	107	17775	1.98
	TS 38	1170	-	-	28815	2.61

Performance of potato and rapeseed with supplemental irrigation

***In-situ* water harvesting**

During 2013-14, in NICRA village Chamua, after harvest of rice (short duration variety) potato and tomato were grown in the same field using organic mulches like water hyacinth, rice straw, rice stubbles etc. Mulching resulted in higher yield and net returns both in potato and tomato. In case of potato, labour requirement was reduced by 40% as there was no need to do some operations like earthing up cum weeding and irrigation, which resulted in increased B:C ratio. It was very encouraging that the yield of the potato under straw mulch was 81.4% higher as compared to that with two supplemental irrigations (16875 kg/ha). Tomato yield was increased by 261.8% with mulching with organic mulches over no mulching. Significant increase of net income with very high B:C ratio (10.65) was observed in case of tomato crop grown with mulching as compared to rainfed crop without mulching (Table-11).

Table-11: Performance of potato and tomato with organic mulching

Crop (variety)	Yield (kg/ha)		% increase in yield	Net income (Rs/ha)		B:C ratio	
	With mulching	Without mulching*		With mulching	Without mulching	With mulching	Without mulching
Potato (Kufri Jyoti)	30600	16875	81.4	270525	170925	5.09	2.53
Tomato (MT-3)	36730	10150	261..8	499221	152250	10.65	2.95

Performance of potato with mulching and without mulching

Performance of tomato (MT-3) with mulching and without mulching

Efficient energy use and management

Custom hiring centers were established in the NICRA villages with need based farm implements. The Custom Hiring Centre Management Committee (CHMC) supervised the activities of the custom hiring centres. During the year 2013-14, custom hiring services significantly contributed not only to alleviate the labour shortage during peak demand period, but also helped in crop diversification and increasing cropping intensity. The improved implements were used in the farmers' fields.

In Ganakdoloni village, occurrence of flash flood is common and farmers get very little time for field preparation before or after the flood during *rabi* season. Establishment of custom hiring centre with a power tiller, water lifting pump and seed cum fertilizer drill which helped the farmers immensely for performing timely operations.

Operation wise as well as source wise energy used for cultivation of *Sali* paddy under six levels of energy input *viz.*, Farmers' practice (T_1), use of fertilizer (T_2), use of fertilizer + cultivator + rotavator + water lifting pump-WLP (T_3), use of fertilizer + cultivator + rotavator + WLP + thresher (T_4), use of fertilizer + cultivator + rotavator + WLP + thresher + reaper (T_5) and use of fertilizer + cultivator + rotavator + WLP + thresher + reaper+ Irrigation (T_6) were estimated. It was found that energy requirement for paddy cultivation in different levels of energy input varied from 5630 to 8448 MJ/ha. It was observed that energy used in paddy cultivation could be reduced by 8 to 23% through increasing the level of mechanization (Table-12). Analysis of data revealed that with the increase in the level of mechanization the human and animal hour requirement for paddy cultivation was reduced from 705 to 350 and 352.5 to 22.5 hr/ha, respectively as compared to farmers' practice. Thus mechanization helped in substantial reduction of drudgery of farmers and animals.

Table-12 : Source-wise energy consumption (MJ/ha) in *Sali* paddy cultivation under different levels of energy input

Source of energy	T_1	T_2	T_3	T_4	T_5	T_6
Direct sources						
Human	1482	1526	1118	777	685	716
Animal	3560	3560	1449	227	227	227
Diesel	-	-	1591	1873	1873	2721
Kerosene	-	-	-	-	259	259
Indirect sources						
Machinery	-	-	255	260	265	271
Seed	588	588	588	588	588	588
Fertilizer	-	2774	2774	2774	2774	2774
Total energy input (MJ/ha)	**5630**	**8448**	**7776**	**6499**	**6671**	**7556**

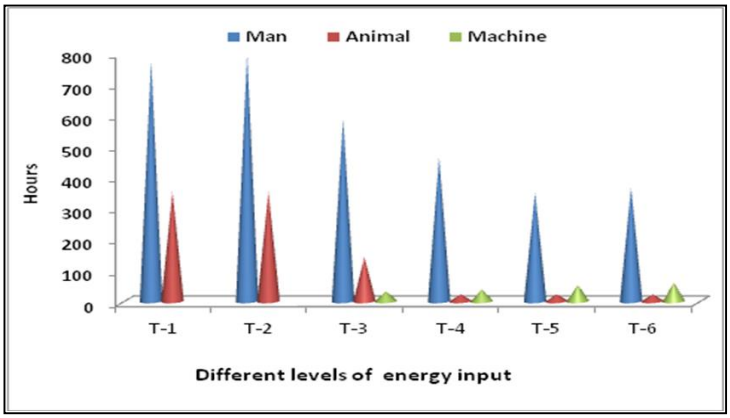


Fig.6: Human, animal and machines hours required for different farm operations in cultivation of *Sali* paddy under different levels of energy input

Energy output, energy use efficiency and energy productivity for different levels of energy input in rice varieties were also calculated. For all the levels of energy input, higher values of energy parameters were observed in long duration variety Ranjit as compared to other two varieties. In case of same rice variety, lowest and highest values of energy parameters were recorded in farmers' practice and T_3 or T_5, respectively (Table-13).

Table-13: Energy inputs, outputs, energy efficiency and energy productivity in cultivation of *Sali* paddy varieties - Ranjit, Basundhara and Luit grown with different levels of energy input

Levels of energy input	Energy input (MJ/ha)	*Sali* paddy varieties								
		Ranjit			*Basundhara*			*Luit*		
		Yield (kg/ha)	Output energy (MJ/ha)	Energy productivity (kg/MJ)	Yield (kg/ha)	Output energy (MJ/ha)	Energy produc-tivity (kg/MJ)	Yield (kg/ha)	Output energy (MJ/ha)	Energy produc-tivity (kg/MJ)
T_1	5630	3752	55154	0.67	2741	40293	0.49	2412	35456	0.43
T_2	8448	5841	85863	0.69	3944	57977	0.47	3412	50156	0.40
T_3	7776	5845	85922	0.75	3925	57698	0.50	3373	49583	0.43
T_4	6499	5787	85069	0.89	3895	57257	0.60	3311	48672	0.51
T_5	6671	-						3405	500054	0.51
T_6	7556				4325	63578	0.57	3661	53817	0.48
Average	7097	5306	78002	0.75	3766	55360	0.53	3230	47478	0.45

Economic analysis was made for all levels of energy use for cultivating different rice cultivars. The B:C ratio in all varieties was minimum in farmers' practice and increased with the level of energy input in all varieties (Table-14). In all varieties the lowest B: C ratio was recorded in farmers' practice. Therefore, economically, farms using higher level of energy input appeared to be in a better position from the viewpoint of both energy use efficiency and benefit-cost ratio than farms with no mechanization and use of fertilizes.

Table-14 : Economic analysis of different levels of energy input used in cultivation of *Sali* paddy varieties

Level of energy input	Cost of Cultivation (Rs/ha)	*Sali* paddy varieties					
		Ranjit		*Basundhara*		*Luit*	
		Net income (Rs/ha)	B:C ratio	Net income (Rs/ha)	B:C ratio	Net income (Rs/ha)	B:C ratio
T_1	22734	11034	1.49	1935	1.09	-1026	0.95
T_2	25504	27065	2.06	9992	1.39	5204	1.20
T_3	21926	30679	2.40	13399	1.61	8431	1.38
T_4	17970	34113	2.90	17085	1.95	11829	1.66
T_5	16958	-	-	-	-	13687	1.81
T_6	18758	-	-	20167	2.08	14191	1.76
Average	20642	25723	2.21	12516	1.62	8719	1.46

Alternate land use and eco-system services

Integrated farming systems involving fish + duck + agri/horticulture, fish +duck +pig, honey bee + duck + diary + vermicompost + agri/horticulture/fodder were demonstrated in farmers' field. Agri-horti and other carbon capturing systems would help in both adaptation and mitigation. Hence these interventions were made to educate farmers that climate change shoul be tackled with both long term and short term strategies. The farmers realized significantly higher yield from the farming systems demonstrated in the village. During 2013, housing facilities for duck (2 units) and pig (one unit) were developed in NICRA village for strengthening and demonstration of duck + fish and duck + fish + pig + agro/horti farming system. Data generated from the farming system "Honey bee + duck + diary + vermicompost + agri/horticulture/fodder" demonstrated in a farmer's field were analyzed and given in Table-15.

Table-15: Demonstration of integrated farming system in NICRA village

Intervention	Area (ha)/No.	Yield (kg)	Income (Rs)	Cost of cultivation (Rs)	Net income (Rs)
Rice (Luit)	0.13333 ha	480	3840	1340	2500
Rice (Mahsuri)	0.13333 ha	680	5440	1340	4100
Rice (Aghoni)	0.01778 ha	387	3096	670	2426
Rapeseed	0.13333 ha	230	9200	1800	7400
Sugarcane	0.00240 ha	1500	52500	20200	32300
Maize (AR)	0.00032 ha	560	11200	789	10411
Ahu rice (Luit)	0.26667 ha	640	4480	1340	3140
Hybrid Napier	0.13333 ha	13040	19560	8400	11100
Dairy (cattle)	5 no	9320 lit	288920	146000	142920
Honey bee	4 hives	48 lit	19200	9200	10000
Duck	40 Nos	40 Nos	16000	4000	12000
Vermicompost	1 tank	2700	13500	3000	10500
Others					5000
Total			446936	198079	253797

Gross income (Rs/ha/yr)	Cost of cultivation (Rs/ha/yr)	Net income (Rs/ha/yr)	B:C ratio
558670	247598	317247	2.26

1.1.2. CHIANKI

a. Agro-ecological setting

Chianki centre is located in Chattisgarh Mahanadi basin (11.0) and western plateau zone in Jharkhand. The climate is hot moist sub-humid. Annual normal rainfall is 1179 mm. The length of growing period is 150-180 days. The annual normal potential evapotranspiration is 1400–1600 mm. In some parts of the region, partial waterlogging in early stages of the crop growth followed by seasonal drought during the rest of the period is observed.

b. On-station experiments

During the year 2013, the onset of monsoon was timely during first week of June. A rainfall of 785.2 mm was received which was deficit by 252.8 mm compared to normal (1038 mm) during south- west monsoon (*kharif*) (Fig.7).

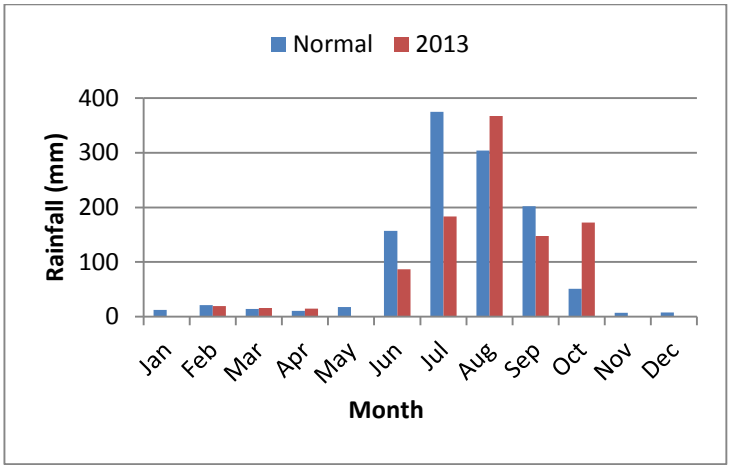


Fig.7: Normal and actual (2013) monthly rainfall at Chianki

During north-east monsoon (October - December), 172 mm of rainfall was received which was excess by 106.1 mm compared to normal (65.9 mm). During summer (March-May), 31 mm of rainfall was received which was deficit by 11.7 mm compared to normal (42.7 mm).

Real time contingency crop planning

Under this component, the improved varieties of rainfed upland rice *viz.*, RR-616-B- 2-75-2, Vandana, BVD-108, BVD-109, BVD-110, BVD-111, BAU-438-6-4, BAU-446-06, BAU-389-02, Anjali and Bakar Dhan (Local) were introduced to cope with deficit rainfall (by 252.8 mm) in allmonths except August during *kharif* 2013.. RR-616-B-2-75-2 recorded mean yield (2662 kg/ha) which was significantly superior with RWUE of 3.16 kg/ha-mm followed by Vandana (2567 kg/ha) with RWUE of 3.05 kg/ha-mm. RR-616-B-275-2, an upland rice variety could be suitable for deficit rainfall conditins (Table-16). BVD-109 gave lowest yield (1632kg/ha) and RWUE (1.94 kg/ha-mm).

Table-16: Evaluation of drought tolerant high yielding varieties of upland rice

Name of entry	Grain yield (kg/ha)	Days to maturity	Plant height (cm)	Panicle length cm)	No. of filled grains/panicle	1000 grain wt.(g)	RWUE (kg/ha-mm)
RR-616-B-2-75-2	2662	94	81.9	23.4	80.3	24.3	3.16
BAU-438-6-4	1806	94	58.8	21.0	75.0	22.4	2.14
BAU-446-06	1874	97	77.6	22.4	103.9	24.2	2.22
BAU-389-02	1794	101	67.9	22.1	114.9	23.7	2.13
Anjali	1789	92	58.8	23.9	86.9	23.4	2.12

Vandana (NC)	2567	94	62.3	23.5	103.1	24.7	3.05
BVD-108	2084	87	72.4	23.9	76.5	22.3	2.47
BVD-109	1632	90	74.7	20.0	75.8	23.0	1.94
BVD-110	2276	95	81.7	22.0	82.7	21.9	2.70
BVD-111©	2006	89	84.0	22.6	97.6	22.7	2.38
Bakar dhan (LC)	2109	91	67.5	16.1	55.3	23.7	2.50
CD (P=0.05)	447						

Similarly, eight entries of medium land transplanted rice were evaluated out of which PHB-71 was significantly superior (5900 kg/ha) with RWUE of 7.30 kg/ha-mm followed by 27-P-31 with marginally lower yield (5640 kg/ha) and RWUE of 6.97 kg/ha-mm. The PHB-71 and 27 -P-31 medium land transplanted rice varieties performed better when the dry spells occurred during 27 to 29 SMW (2-22 July, coinciding with transplanting and tillering stage of rice) compared to other varieties. IR-36 variety gave lowest yield of 4170 kg/ha and RWUE of 5.16 kg/ha-mm (Table-17).

Table-17: Performance of drought tolerant high yielding varieties of rice for medium land situation

Name of entry	Grain yield (kg/ha)	Days to maturity	Plant height (cm)	Panicle length (cm)	No. of filled grains/panicle	1000 grain wt.(g)	RWUE (kg/ha-mm)
Naveen	5130	122	87.1	11.7	26.6	22.7	6.34
Sahabhagi	4270	121	83.0	10.3	26.1	25.0	5.28
PAC 801	5570	113	73.1	13.6	26.3	23.7	6.89
PAC-835	5220	115	74.7	12.8	25.7	23.0	6.45
Arize Tej	5150	128	84.7	13.7	26.3	21.3	6.37
PHB-71	5900	123	80.3	13.0	26.9	24.7	7.30
27-P-31	5640	122	85.9	12.9	25.3	26.3	6.97
IR-36	4170	122	67.3	13.5	25.3	23.3	5.16
CD (P=0.05)	898						

The rainfall of 785.2 mm was received which was deficit by 252.8 mm compared to normal (1038 mm) during south- west monsoon (*kharif*).There were dry spells during 27 to 29 SMW (2-22 July, coinciding with transplanting and tillering stage of rice. Eight varieties of lowland transplanted rice *viz*., MTU-7029, BPT-5204, Rajshree, MTU-1001, Arize-6444, BAU-40805, Samba Masuri and Wita were evaluated. Arize-6444 produced highest yield (7160 kg/ ha) with RWUE of 8.40 kg/ha-mm followed by BAU-40805 (6890 kg/ha) and RWUE (8.08 kg/ha-mm) and Samba mansuri gave lowest yield of (4930 kg/ha) and RWUE (5.79 kg/ha-mm). Arize-6444 and BAU-40805 rice varieties performed better under lowland conditions with deficit rainfall during June (44.7%), July (51%) and September (27%) months in 2013(Table-18).

Table-18: Performance of drought tolerant high yielding varieties of rice under lowland situation

Name of entry	Grain yield (kg/ha)	Days to maturity	Plant height (cm)	Panicle length (cm)	No. of filled grains/panicle	1000 grain wt.(g)	RWUE (kg/ha-mm)
MTU-7029 ©	6170	134	72.3	12.6	22.3	22.7	7.24
Arize-6444	7160	128	87.0	12.9	22.7	25.3	8.40
MTU-1001	5930	134	78.1	14.1	22.5	26.3	6.96
BPT-5204	6480	134	86.1	14.0	20.5	20.0	7.60
Rajashree	6200	134	87.3	12.1	20.5	24.0	7.28
Wita	6710	130	89.3	13.5	22.7	29.3	7.87
Samba Mansuri	4930	130	81.7	13.9	22.1	28.0	5.79
BAU-40805	6890	122	101.3	12.4	22.3	23.5	8.08
CD (P=0.05)	963						

Nine genotypes of maize *viz*., DHM-117, Suwan, Kanchan, BVM-2, HQPM-1, LCY, LCW, MBP-X08 and MBP-708 were evaluated for deficit rainfall conditions. Out of these varieties, HQPM-1 gave significantly higher yield (5040 kg/ha) and RWUE 6.70 kg/ha-mm followed by MBP-X08 (4780 kg/ha) and RWUE of 6.36 kg/ha-mm. BVM-2 gave minimum yield of 3910 kg/ha and RWUE of 5.20 kg/ha-mm in the trial (Table-19).

Table-19: Performance of drought tolerant high yielding varieties/hybrids of maize

Entry	Grain yield q/ha	Days to maturity	Plant height (cm)	Cob length	No. of row/cob	100 Seed wt.(g)	RWUE (kg/ha-mm)
DHM-117	4410	88	204.9	15.1	13.5	28.7	5.86
Suwan	4310	87	211.0	13.3	12.5	17.5	5.73
Kanchan	4710	88	206.7	16.4	13.7	22.2	6.26
BVM-2	3910	88	163.3	15.3	13.2	24.4	5.20
HQPM-1	5040	87	212.7	16.5	13.7	25.3	6.70
LCY	4540	79	229.7	15.7	10.9	25.0	6.04
LCW	4730	85	231.3	18.7	11.9	27.5	6.29
MBP-X08	4780	101	217.0	18.5	13.7	28.0	6.36
MBP-708	4460	90	227.5	16.9	15.1		5.93
CD (P=0.05)	483						

Three improved varieties of pigeonpea *viz.*, IPCH-2671, Asha, Birsa-1 and Local (farmer genotype) were evaluated. Out of these varieties, IPCH-2671 gave significantly higher yield (1616 kg/ha) and RWUE (1.68 kg/ha-mm). Hence, IPCH-2671 variety could be used for sowing to cope with the weather variability including deficit rainfall during *kharif* season (Table-20). The local variety gave minimum yield of 935 kg/ha and RWUE of 0.97 kg/ha-mm.

Table-20: Performance of drought tolerant varieties of pigeonpea

Name of entry	Grain yield (kg/ha)	Days to maturity	Plant height (cm)	No. of Pods/plant	No. of seeds/pod	1000 grain wt.(g)	RWUE (kg/ha-mm)
ICPH-2671	1616	215	238.07	210.53	3.73	10.83	1.68
Birsa Arhar-1	1575	215	217.87	193.73	3.60	10.33	1.63
Asha	1136	217	230.87	175.40	3.73	10.83	1.18
Local	935	234	264.33	140.87	3.60	10.83	0.97
CD (P=0.05)	152						

Four varieties of sesame *viz*., Kanke White, Shekhar and Gujrat Til-4 and C-10 were evaluated for suitability in the sub-zone V. Out of these varieties, Gujrat Til (550 kg/ha) gave significantly higher yield and RWUE 0.73 kg/ha-mm was highly suitable for this region (Table-21). Local (Durga) gave lowest yield of 350 kg/ha and RWUE 0.47 kg/ha-mm.

Table-21: Performance of drought tolerant varieties of sesame

Name of entry	Grain yield (kg/ha)	Days to maturity	Plant height (cm)	No. of capsules/ plant	No. of seeds/ capsule	RWUE (kg/ha-mm)
Kanke White ©	418	98	112.8	28.0	58.8	0.56
Sekhar	477	86	110.4	33.4	58.8	0.63
Gujrat Til-4	550	101	112.4	31.6	54.5	0.73
C-10	430	104	102.4	20.1	53.9	0.57
Local	350	103	123.2	27.5	55.0	0.47
CD (P=0.05)	85					

Five varieties of horsegram *viz*., Birsa Kulthi-1, GHG-19, GHG-13, Madhu (Check) and AK-21were evaluated for their performance under deficit rainfall conditions. Out of these varieties, Madhu gave highest yield (1325 kg/ha) and RWUE 6.63 kg/ha-mm followed by GHG-19 (1289 kg/ ha) and RWUE 6.45 kg/ha-mm. Madhu variety performed better and was found to be highly suitable for this region (Table-22).

Table-22: Performance of high yielding varieties of horsegram for upland situation

Variety	Seed yield (kg/ha)	Days to maturity	Plant height (cm)	No. of pods/plant	No. of seeds/ pod	RWUE (kg/ha-mm)
Birsa Kulthi-1	899	103	35.8	16.5	3.9	4.50
GHG-19	1289	87	34.5	17.0	4.1	6.45
GHG-13	1088	94	32.1	15.5	3.9	5.44
Madhu (Check)	1325	104	34.3	19.9	4.3	6.63
AK-21	1015	97	31.1	15.6	4.3	5.08
CD (P=0.05)	108					

During north-east monsoon (October - December), 172 mm of rainfall was received which was excess by 106.1 mm compared to normal (65.9 mm). However, there was no rainfall during November and December months. Eleven genotypes of niger *viz.*, BN-1, BN-2, BN-3, puja, IVT-11-10, IGP-76, (NC), IGPN-9001, DNC-08-09, JNS-508, JNS-503 and JNS-505 varieties were evaluated. Out of these, IGPN- 9001 gave significantly higher yield (723 kg/ ha) followed by B N - 3 (644 kg/ha). IGPN-9001 variety was found to be more suitable to cope with the rainfall variability of the region (Table-23).

Table-23.: Performance of high yielding varieties of niger for upland situation

Variety	Seed yield (kg/ha)	Days to maturity	Plant height (cm)
BN-1 ©	560	107	57.6
BN-2	577	107	60.7
BN-3	644	108	56.3
Puja	451	109	55.0
IVT-11-10	545	107	67.8
IGP-76 (NC)	540	105	66.4
IGPN-9001	723	108	55.0
DNC-08-09	417	110	54.5
JNS-508	456	111	49.1
JNS-503	373	111	52.6
JNS-505	391	109	63.6
CD (P=0.05)	86		

Similarly, 13 improved varieties of chickpea were evaluated during *rabi* 2013. BAUG-8 was superior with significantly higher yield (1699 kg/ha), followed by BG-3 (LC) (1695 kg/ha) (Table-24). Annegeri gave lowest yield of 895 kg/ha.

Table-24: Performance of different varieties of chickpea

Variety	Seed yield (kg/ha)	Days to maturity	Plant height (cm)	No of primary branches	No of pods/plant
BAUG-8	1699	116	51.8	9.5	92.2
BAUG-11	1605	116	55.2	9.7	87.5
BAUG-15	1355	108	50.7	9.0	99.9
BAUG-16	1561	109	58.6	11.2	83.5
BAUG-10-12	971	109	55.7	9.4	98.8
BAUG-1031	887	111	55.8	8.9	101.7
BAUG-1034	964	109	52.5	10.2	67.6
BAUG-1035	1573	109	49.7	9.5	86.5
BG-3(LC)	1695	108	48.1	10.3	83.3
KAK-2	903	106	50.3	9.2	78.0
KPG-59	1680	101	50.5	10.9	82.6
Annegeri	895	105	56.7	10.3	83.2
Local	1304	116	49.5	10.1	91.8
JG-14	1831	126	54.7	10.9	85.2
CD (P=0.05)	210				

In another trial, 8 varieties of lentil *viz.*, BAUSM-2007, BAUSM-09, BAUSM-2002, Shivani, vardan, pusa bold, Bausm-09-14-7, BAUSM-09-46-05 were evaluated along with local. Out of these, Shivani (806 kg/ha) was superior, followed by BAUSM-09-46-05 (793 kg/ha) (Table-25). The local variety gave minimum yield of 475 kg/ha.

Table-25: Performance of varieties of lentil

Variety	Seed yield (kg/ha)	Days to maturity	Plant height (cm)	No of primary branches	No of secondary branches	No of pods/plant
BAUSM-2007	716	107.0	142.9	3.5	117.0	99.7
BAUSM-09	558	105.7	135.5	4.0	125.0	92.9
BAUSM-2002	753	104.0	133.7	2.7	131.0	113.9
Shivam	806	106.0	151.5	3.7	140.6	99.5
Vardan	509	106.0	145.3	3.3	128.9	119.7
Pusa Bold	649	105.7	147.2	4.1	128.3	111.8
BAUSM-09-14-7	680	104.7	141.0	3.6	121.6	95.1
BAUSM-09-46-05	793	110.3	128.1	2.9	131.8	115.6
Local	475	104.7	131.7	3.8	112.3	127.6
CD (P=0.05)	211					

Pigeonpea based intercropping systems were evaluated for their performance under deficit rainfall conditions (the rainfallwas deficit by 44.7% in June, 51% in July and 27% in September). Maximum pigeonpea equivalent yield was recorded in pigeonpea + okra intercropping system (2891 kg/ha) with RWUE of 2.68 kg/ha-mm which was significantly superior to other intercropping systems. The sole pigeonpea gave yield of 2003 kg/ha with RWUE of 1.86 kg/ha-mm (Table-26).

Table-26: Performance of pigeonpea based intercropping systems

Treatment	Pigeonpea equivalent yield (kg/ha)	RWUE (kg/ha-mm)
Sole Arhar	2003	1.86
Arhar + Maize	2241	2.08
Arhar + Okra	2891	2.68
Arhar + Jowar	1867	1.73
Sole Jowar	527	0.53
Sole okra	2307	2.14
Sole maize	935	0.86
SE(m)	1.39	0.12
CD (P=0.05)	419	38

In an evaluation of different nutrient management practices including foliar spray of urea in chickpea for coping with prolonged dry spells, chickpea cv. JG-14 recorded significantly higher yield (1619 kg/ha) with application of 20:40:20 (N:P:K) kg/ha along with application of 2% urea spray at branching stage and pod initiation stage followed by KPG-59 and F1 + 2% urea spray at branching stage and pod initiation stage which gave the yield of 1533kg/ha and the lowest yield (803 kg/ha) was recorded in KAK-2 with 20:40:20 kg/ha NPK (Table-27).

Table-27: Nutrient management under late sown condition of chickpea

Treatment	Seed yield (kg/ha)	Days to maturity	Plant height (cm)	No of pods/plant	100 seed wt. (g)
V1F1(KPG-59 and 20:40:20 kg/ha NPK)	1314	143.0	42.0	79.1	9.7
V1F2 (KPG-59 and F1 + 2% urea spray at branching)	1372	142.0	43.6	86.9	9.9
V1F3 (KPG-59 and F1 + 2% urea spray at branching stage and pod initiation stages)	1533	144.0	42.8	92.4	10.1

V2F1(JG-14 and 20:40:20 kg/ha NPK)	1328	137	49.0	80.1	11.3
V2 F2 (JG-14 and F1+ 2% urea spray at branching)	1407	139	57.0	89.7	11.6
V2F3 (JG-14 and F1 + 2% urea spray at branching stage and pod initiation stages)	1619	138	58.0	97.2	11.8
V3F1(KAK-2 and 20:40:20 kg/ha NPK)	803	130	52.8	63.5	12.9
V3F2 (KAK-2 and F1 + 2% urea spray at branching)	902	134	51.0	68.3	13.0
V3F3 (KAK-2 and F1 + 2% urea spray at branching)	924	135	52.0	70.8	12.0
CD (P=0.05)	13				

Alternate land use systems

Guava based agri-horti intercropping system under Alternate Land Use (ALU) experiment, Guava+ (Rice + Pigeonpea) showed significant effect and gave highest rice equivalent yield of 71.22 q/ha followed by guava + (Maize + pigeonpea) with the rice equivalent yield of 70.01 q/hq which was statistically at par (Table-28).

Table-28: Performance of guava based agri-horti systems

Treatments	Yield of *kharif* crops (kg/ha)		Rabi 2013-14 chickpea yield (kg/h)a	Rice equivalent yield (kg/ha)
	Sole crop	Intercrop (pigeonpea)		
Guava + (rice – chickpea)	1388	-	945	4538
Guava + (rice + pigeonpea)	1353	1483	-	7122
Guava + (maize – chickpea)	1587	-	862	4811
Guava + (maize + pigeonpea)	1610	1320	-	7101
Guava + (sorghum – chickpea)	1337	-	767	3893
Guava + (sorghum + pigeonpea)	1218	640	-	3707
Guava + (pigeonpea – fallow)	1337	-	-	5198
CD (P=0.05)				755

c. On-farm experiments

Village profile

The program is being implemented in Kumbhi and Bankheta villages in Garhwa district, Jharkhand. The total cultivated area was 215 ha, out of which 150 ha is rainfed. The mean annual rainfall is 1280 mm. The major soil types are sandy loam, clay loam and loam. The major rainfed crops during *kharif* are rice, maize, pigeonpea and sesame and *rabi* crops are chickpea, wheat, lentil, linseed, mustardc. The number of small, marginal, medium and large farmers is 131,69 and 27 respectively. The source of irrigation is harvested rainwater (dam and ahars) covering 30% of cultivated area.

Experienced weather conditions during the year (2013-14)

During the year 2013, the onset of monsoon was timely during first week of June. A rainfall of 763.7 mm was received which was deficit by 228.2 mm compared to normal (992.5 mm) during south- west monsoon (*kharif*) (Fig.8).

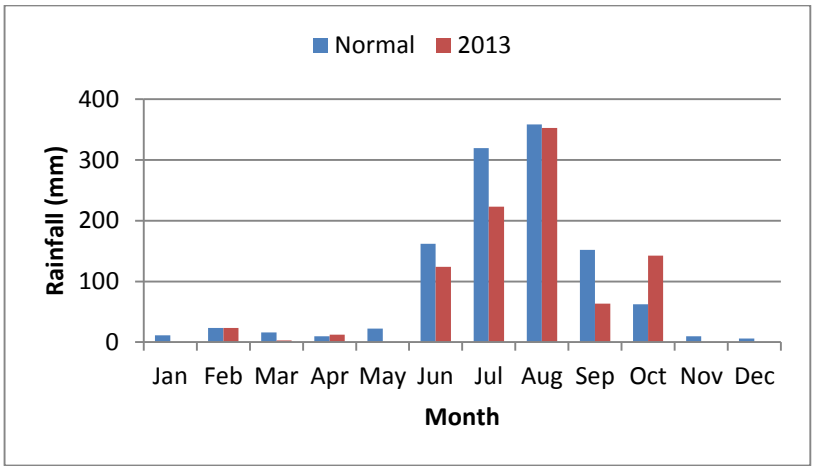


Fig.8: Normal and actual (2013) monthly rainfall at Garhwa

During north-east monsoon (October - December), 142.5 rainfall was received which was excess by 64.9 mm compared to normal (77.6 mm) (Fig.). During summer (March - May), 15.1 rainfall was received which was deficit by 32.9 mm compared to normal (48 mm).

Interventions

Major interventions implemented under on-farm and on-station conditions included real time contingency planning and timely operations through custom hiring center. These interventions covered an area of 55.5 ha in 227 farmers' fields.

Real time contingency planning

The onset of monsoon was timely during first week of June. A rainfall of 763.7 mm was received which was deficit by 228.2 mm compared to normal (992.5 mm) during south- west monsoon (*kharif*). The rainfall was deficit by 23.6% in June, 20.1% in July, 1.6% in August and 58.2% in September. The drought tolerant variety of upland rice (Vandana) was introduced during *kharif* season to cope with the rainfall variability of the region (Table-29). Higher mean yield of 1130 kg/ha was recorded with vandana along with RWUE of 1.59 kg/ha-mm, net returns of Rs. 5234/ha and B:C ratio of 1.37 as compared to local variety (625 kg/ha).

Table-29: Performance of drought tolerant variety of rice (Vandana) under upland situation

Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Vandana	1130	1.59	5234	1.37
Local variety	625	0.87	987	0.74

Similarly, three improved varieties of medium land rice were introduced to cope with the rainfall variability of the region. Higher mean yield of 3627 kg/ha was registered with PAC-801 along with higher net returns (Rs. 32078/ha) and B:C ratio (2.72). Shahbhagi Dhan gave minimum yield of 2400 kg/ha with net returns Rs. 15100/ha, RWUE 3.38 kg/ha-mm and B:C ratio 1.82. (Table-30).

Table-30: Performance of drought tolerant varieties of rice under medium land situation.

Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Naveen	2501	3.52	16514	1.89
Shahbhagi Dhan	2400	3.38	15100	1.82
PAC-801	3627	5.10	32078	2.72

The drought tolerant varieties of lowland rice (Arize-6444) was also demonstrated during *kharif.* Arize-6444 gave grain yield of 4640 kg/ha, RWUE of 6.53 kg/ha-mm and net returns of Rs. 46260/ha with B:C ratio of 3.47.

During north-east monsoon (October - December), 142.5 rainfall was received which was excess by 64.9 mm compared to normal (77.6 mm). The rainfall during October was 129.5% higher compared to normalrainfall of the month. However, there was no rainfall during November and December months. Suitable varieties of rainfed crops viz., maize (BVM-2), pigeonpea (Birsa Arhar-1, Bahar), sorghum (CSV-20) during *kharif* wheat and (K-307, HUW 234), chickpea (KPG-59, JG-14), Mustard (Shivani) and Safflower (A-1) during *rabi* were demonstrated. Maximum net returns of Rs. 29060/ha with B:C ratio of 3.40 were attained by pigeonpea. Among the *rabi* crops, cultivation of wheat (K-307) gave highet net returns (Rs. 2426/ha) and B:C ratio (2.1) compared to other crops (Table-31).

Table-31: Performance of improved varieties of various crops

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Maize	BVM-2	2850	4.97	15950	2.04
Pigeonpea	Birsa Arhar-1	988	1.19	22480	2.86
	Bahar	1176	1.41	29060	3.40
Sorghum	CSV-20	2450	3.45	9550	1.76
Wheat	K-307	3100	11.90	24264	2.10
	HUW234	2341	9.04	13129	1.60
Chickpea	KPG-59	748	2.89	13680	2.09
	JG-14	847	3.27	17133	2.4
Mustard	Shivani	640	2.47	5500	1.52
Safflower	A-1	800	2.95	10000	2.00

Wheat K307

Chickpea JG-14

To cope up with the weather aberrations including deficit rainfall during June, July and September months, pigeonpea (ICPH-2671) + okra (OH-152) intercropping was demonstrated in farmer's fields. Maximum pigeonpea equivalent yield of 1907 kg/ha was recorded in pigeonpea (ICPH-2671) + okra (OH-152) with B:C ratio of 3.12.

Intercropping of pigeonpea (Var. ICPH-2671) + okra (Var. OH-152)

1.1.3. FAIZABAD

a. Agro-ecological setting

Faizabad center is located in northern plain, Rohilkhand, Avadh and south Bihar plains (AESR 9.2) and Eastern plain agro-climatic zone in Utthar pradesh. The climate is hot dry sub-humid. Annual normal potential evapo-transpiration is about 549 mm. Annual normal rainfall is 1054 mm. Length of growing period is 150-180 days. Drought occurs once in ten years.

b. On-station experiments

Experienced weather condition during the year -2013

During the year 2013, the onset of monsoon was timely during first week of June. A rainfall of 1055.1 mm was received which was excess by 140.2 mm compared to normal (914.9 mm) during south- west monsoon (kharif) (Fig.9).

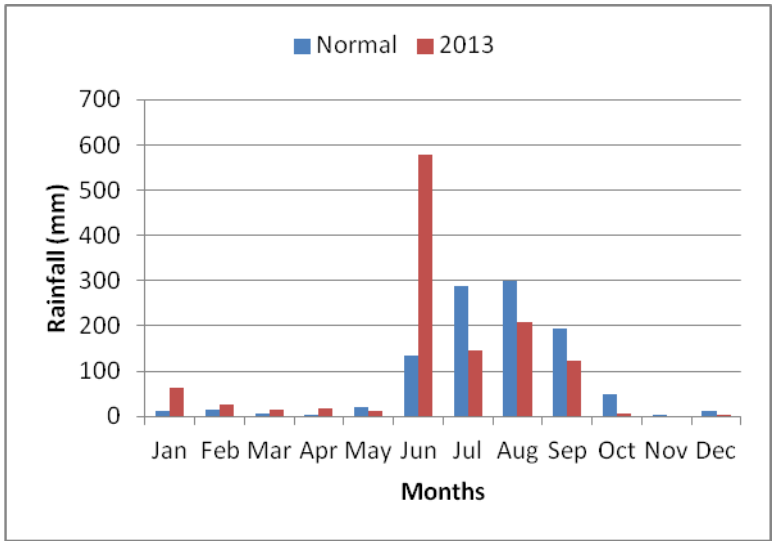


Fig.9: Normal and actual (2013) monthly rainfall at Faizabad

During north-east monsoon (October - December), 7.1 mm rainfall was received which was deficit by 58.5 mm compared to normal (65.6 mm). During summer, 45.5 mm of rainfall was received which was excess by 12.3 mm compared to normal (33.2 mm). There were no dry spells observed in the season.

Real Time Contingency Crop planning

The rainfall of 1055.1 mm was received which was excess by 140.2 mm compared to normal (914.9 mm) during south- west monsoon (kharif). During north-east monsoon (October - December), 7.1 mm rainfall was received which was deficit by 58.5 mm compared to normal (65.6 mm). There were no dry spells observed in the season. Improved varieties of paddy, pigeonpea and chickpea were evaluated. -Different varieties of rice exerted their significant influence on seed yield. 'NDR-97' proved its superiority over rest of the varieties in respect of grain yield (1710 kg/ha) , NMR (Rs.5700/ha) ,B:C ratio of (1.50) and water use efficiency (5.05 kg/ha-mm). An increase of 37.1, 31.9, 32.8 and 24.3% in grain yield was observed, as compared to local variety, with 'NDR-97','Baranideep', 'Suskasamrat' and 'Vandana'respectively. Pigeonpea variety 'NDA-1' (1315kg/ha) closely followed by 'NDA-2' recorded significantly higher than 'Bahar' (1230 kg/ha) and 'MA-13' (1000 kg/ha). An increase of 42, 41, 38 and 23.5% in seed yield was recorded as compared to the local with NDA-1, NDA-2 'Bahar' and 'MA-13', respectively. The highest NMR (Rs. 27450/ha), B:C ratio (3.31) and RWUE (5.19 kg/ha-mm) was recorded with 'NDA-1'. The rainfall in June month was excess by 24% whereas the rainfall during July, August and September months was deficit by 12.3, 48.3 and 43.4 % ,respectively compared to normal rainfall. Chickpea variety 'Pusa-362' being at par with 'Avarodhi', recorded significantly higher seed yield (2000 kg/ha), NMR (Rs. 54200/ha) and B:C ratio (4.43) than 'PG-186' and 'KWR-108'.Highest RWUE of (18.92 kg/mm-ha) and B:C ratio (4.43) was recorded by 'Pusa-362' (Table-32).

Table-32: Performance of improved varieties of rainfed crops

Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B: C ratio
Paddy					
NDR-97	1710	5.05	11400	5700	1.50
Baranideep	1580	4.66	11400	4400	1.38
Suska Samrat	1600	4.72	11400	4600	1.40
Vandana	1420	4.19	11400	2800	1.24
Local	**1075**	**3.17**	**10800**	**(-) 650**	**0.99**
Pigeonpea					
NDA-1	1315	5.19	12000	27450	3.31
NDA-2	1290	5.09	12000	26700	3.22
Bahar	1230	4.86	12000	24900	3.07
MA-13	1000	3.95	12000	18000	2.50
Local	**765**	**3.02**	**11600**	**11350**	**1.98**
Chickpea					
Pusa-362	2000	18.92	15800	54200	4.43
Avarodhi	1840	17.41	15800	48600	4.07
PG-186	1690	15.99	15800	43350	3.74
KWR-108	1500	14.19	15800	36700	3.32
Local	**1175**	**11.12**	**13300**	**27825**	**3.09**

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Faizabad in Hardoiya village, block- Haringtonganj, tehsil-Milkipur in Faizabad district, Uttar Pradesh. The total cultivated area is 397 ha out of which 138 ha is rainfed. The mean annual rainfall is 1040.1 mm with seasonal rainfall of 967.5 mm during *kharif* (June-September). The major soil types are silty loam and silty clay. The major rainfed crops during *kharif* are upland rice, maize, pigeonpea, blackgram, sorghum and pearlmillet and *rabi* crops are chickpea, lentil, mustard, linseed and barley. The numbers of land less, marginal, small and medium farmers are 55, 445 and 155, respectively. The ground water table is 6 meter. The source of irrigation is tube well and ponds covering 65% of cultivated area.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 90%, north-east monsoon contributes 8% and summer contributes 2% of the total annual average rainfall of 1041.1 mm. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon is 15-20% deficit of the average rainfall. The onset (south-west) of monsoon is during 25 SMW. The dry spells during crop season are experienced (for the past 10/15 years) during September at grain setting and maturity stages of the major rainfed crops. The onset of the monsoon has shifted to 25 SMW and with early withdrawal occurring during 39 SMW. The soil moisture status is deficit during growth and flowering stages of major rainfed crops during rabi. The maximum/minimum temperature during kharif season is 39.3 and 25.7oC and during rabi season it was found to be 44.5 and 5.1oC. The extreme events like unusual and high intensity rainfall in short span are decreasing during August and September during kharif and December and January during rabi seasons. The area is also experiencing other extreme events like hail storm, frost, heat wave and cold wave.

Experienced weather conditions during the year (2013-14)

The total rainfall received during 2013-14 was 1197.1 mm in 65 rainy days as against the normal rainfall of 1040.1 mm in 52 rainy days. The highest monthly rainfall of 577.9 mm was recorded during the month of June 2013 followed by 207.7 and 145.1 mm during August and July 2013, respectively. The maximum amount of rainfall received in any single day during 2013-14 was 114.0 mm on 4th June. Out of the total rainfall of 1197.1 mm, 1055.1 mm (88.1%) was received during south-west monsoon (June to September 2013) in 43

rainy days of total rainfall of *kharif* season, 577.9 mm (54.8%) was received during the month of June only, which affected the sowing of paddy, pigeonpea, blackgram, maize, fodder etc. crops. During *rabi* season from (October 2013 to May 2014), the total rainfall received was only 142.0 mm in 15 rainy days. These events impacted the performance of chickpea, lentil and mustard crops adversely (Fig.10).

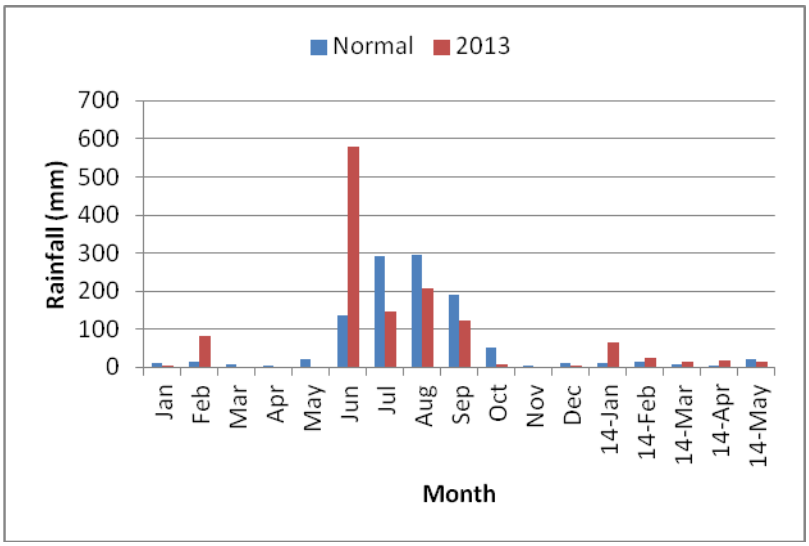


Fig.10: Normal and actual (2013) monthly rainfall at Hardoiya Interventions

The package included crops, varieties and cropping systems. These interventions covered an area of 22 ha in 79 farmers' fields.

Real Time Contingency Crop Plan Implementation

Out of total rainfall of *kharif* season, 577.9 mm (54.8%) was received during the month of June only, which affected the sowing of paddy and pigeonpea. Further ,the rainfall during July,August and September months was deficit by 29.4 and 34.9 % compared to normal rainfall. During *rabi* season from October 2013 to May 2014 the total rainfall was received only 142.0 mm in 15 rainy days. These events impacted the performance of chickpea adversely. Different varieties of rice exerted their significant influence on seed yield. 'NDR-97' proved its superiority over rest of the varieties in respect of grain yield (1535 kg/ha), NMR (Rs.3950/ha) ,B:C ratio (1.35) and water use efficiency (4.53 kg/ha-mm). An increase of 12.0, 13.7 and 23.8% in grain yield and 71.7, 88.1 and 295.0% in net return was observed due to 'NDR-97' over 'Baranideep', 'Suskasamrat' and 'Vandana'. Pigeonpea variety 'NDA-2' (1185 kg/ha) closely followed by 'NDA-1' recorded significantly higher seed yield than 'Bahar' (1100 kg/ha) and 'MA-13' (945 kg/ha). An increase of 3.9, 7.2 and 26.0% in seed yield was recorded due to 'NDA-2' over 'NDA-1', 'Bahar' and 'MA-13', respectively. The highest NMR of Rs. 23550/ha was recorded with 'NDA-2', which was 6.1, 12.1 and 44.1% higher than 'NDA-1', 'Bahar' and 'MA-13', respectively. Chickpea variety 'Pusa-362' being at par with 'Avarodhi', recorded significantly higher seed yield (1830 kg/ha), NMR (Rs. 48250/ha) and B:C ratio (4.05) than 'PG-186' and 'KWR-108'. An increase of 4.6, 14.4 and 28.9% in seed yield and 6.29, 20.0 and 42.3% in NMR of 'Pusa-362' was recorded over 'Avarodhi', 'PG-186' and 'KWR-108', respectively (Table-33).

Table-33: Performance of improved varieties of rainfed crops

Variety	Seed yield (kg/ha)	WUE (kg/ha-m)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B: C ratio
Paddy					
NDR-97	1535	4.53	11400	3950	1.35
Baranideep	1370	4.04	11400	2300	1.20
Suska Samrat	1350	3.98	11400	2100	1.18
Vandana	1240	3.66	11400	1000	1.09

Pigeonpea					
NDA-1	1140	4.83	12000	22200	2.85
NDA-2	1185	5.02	12000	23550	2.96
Bahar	1100	4.66	12000	21000	2.75
MA-13	945	4.00	12000	16350	2.36
Chickpea					
Pusa-362	1830	17.41	15800	48250	4.05
Avarodhi	1750	16.65	15800	45450	3.88
PG-186	1600	15.22	15800	40200	3.54
KWR-108	1420	13.51	15800	33900	3.14

Under conditions of excess rainfall in june followed by deficit rainfall in July(50.4), August(29.4) and September (34.9) months, significantly highest pigeonpea yield equivalent (1185 kg/ha) was recorded with pigeonpea, which was 119.4, 149.5 and 199.2 % higher than maize, paddy and fodder crops, respectively. Pigeonpea also secured highest NMR (Rs.23550/ ha) and B:C ratio (2.96). Increase in profit was 380.6, 437.7 and 726.3% higher with pigeonpea over maize, fodder and paddy, respectively. Highest rainwater use efficiency (13.73 kg/mm-ha) was recorded due to maize crop (Table-34).

Table-34: Performance of improved varieties of rainfed crops during *kharif* 2013

Crop	Seed yield (kg/ha)	Pigeonpea yield equivalent (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B: C ratio
Paddy	1425	475	4.21	11400	2850	1.25
Maize	1800	540	13.73	11300	4900	1.43
Pigeonpea	1185	1185	4.68	12000	23550	2.96
Fodder	19800	396	-	7500	4380	1.58
CD (P=0.05)	-	93	-	-	-	-

During *rabi* season (October 2013 to May 2014), the total rainfall received was only 142.0 mm (deficit 11.9%) in 15 rainy days. These events impacted the performance of chickpea, lentil, barley and mustard crops adversely. The data indicated that significantly highest barley yield equivalent was recorded with lentil (5119 kg/ha), which was 9.7, 53.4 and 115.5% higher than chickpea, mustard and barley, respectively. Lentil also gave highest NMR (Rs. 49925/ ha) and B:C ratio (5.34). Highest moisture use efficiency (22.60 kg/mm-ha) was recorded due to barley crop (Table-35).

Table-35: Performance of improved varieties of rainfed crops during *rabi* 2013-14

Crop	Seed yield (kg/ha)	Barley yield equivalent (kg/ha)	MUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NM R (Rs/ha)	B: C ratio
Chickpea	1600	4667	15.22	15700	40300	3.57
Lentil	1755	5119	16.70	11500	49925	5.34
Mustard	1415	3337	21.87	10200	32250	4.16
Barley	2375	2375	22.60	10200	18300	1.79
CD (P=0.05)	-	297.5	-	-	-	-

Evaluation of different Intercropping/ sequence cropping

Different intercropping /sequence cropping systems were evaluated for their performance under deficit rainfall (111.2)conditions**.** Among the various intercropping/ sequence cropping systems, maize + blackgram (1:1) lentil + linseed (4:2) recorded significantly higher pigeonpea yield equivalent (2874 kg/ha), which was 25.0 to 259.2% higher than rest of the cropping sequences. Highest NMR (Rs 55070/ha) was recorded with the same cropping sequence, which was 19.6 to 378.9% higher than rest of the cropping sequences. However, maximum benefit- cost ratio (3.01) was recorded with fodder- chickpea cropping sequence (Table-36).

Table-36: Performance of different intercropping/sequence cropping systems under aberrant rainfall conditions

Treatment	PYE (kg/ha)	Cost of cultivation (Rs/ ha)	NMR ((Rs/ha)	B:C ratio
Blackgram + sesame (1:1) - Fallow	800	12500	11500	1.92
Sorghum (fodder) – chickpea	2298	22900	46040	3.01
Sorghum + blackgram (fodder) - Toria	1640	21850	27350	2.25
Pigeonpea + maize (1: 1)	1701	18500	32530	2.76
Maize + blackgram (1:1) – Lentil + linseed (4:2)	2874	31150	55070	2.77
CD (P-0.05)	95	-	-	-

Efficient Energy Use and Management

During *Kharif* 2013, Paddy variety NDR-97 performed, better with improved implement and output- input energy ratio was maximum (9.68: 1) with rotavator followed by MB plough + harrowing and cultivator ,respectively. The seed yield (3204 kg/ha) was found maximum in MB plough + harrowing followed by rotavator (29400 kg/ha) and cultivator (T_2) (2675 kg/ha), respectively. The B:C ratio was found maximum with MB plough + harrowing compared to other treatments. This showed that deep ploughing with MB plough + 1 harrowing is most suitable for paddy creating good tilth for crop production (Table-37).

Table-37: Evaluation of improved implements in *kharif* paddy

Implement	Grain yield (kg/ha)	Total energy requirement (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
MB Plough + Harrowing	3204	7109	62671	12900	8900	1.68
Cultivator	2675	6316	55254	11400	6800	1.65
Rotavator	2940	6069	58775	12000	8000	1.67

In a similar trial involving maize cultivation, the output- input energy ratio was maximum 8.2:1 with rotavator followed by cultivator and MB plough + harrow ,respectively. The seed yield of maize was also found maximum with rotavator (2719 kg/ha).This could be due to better soil moisture conservation (Table-38).

Table-38: Evaluation of improved implements in *kharif* maize,

Implement	Grain yield (kg/ha)	Total input energy requirement (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivate on (Rs/ha)	NMR (Rs/ha)	B:C ratio
MB Plough + Harrowing	2646	7565.1	59585	12450	3750	1.30
Cultivator	2469	7095.5	55946	11300	3820	1.33
Rotavator	2719	7511.4	61570	11650	5000	1.42

During *rabi* season, the output-input energy ratio was found maximum in T_2 (10.4: 1) followed by T_1 and T_3, respectively. The seed yield of mustard (1500 kg/ha) was found maximum in T_1 followed by T_3 and T_2, respectively. The B:C ratio of 3.78 was found maximum in T_3 followed by T_1 and T_2 (Table-39).

Table-39: Evaluation of improved implements in mustard

Implement	Grain yield (kg/ha)	Total energy requirement (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
MB Plough + Harrowing	22050	7109.9	65175	13500	31500	3.33
Cultivator	18743	5711.1	59368	10800	27450	3.54
Rotavator	21315	6098.8	62878	11500	32000	3.78

In a similar trial in chickpea,the output- input energy ratio was found maximum in T_2 (17.5:1.0) followed by T_3 and T_1. The seed yield of chickpea was found maximum (1700 kg/ha) in T_1 followed by T_3 & T_2 respectively. The B:C ratio was highest (3.65) in T_1 followed by T_3 & T_2, respectively (Table-40).

Table-40: Performance of improved implements in *rabi* crop-Chickpea, Var. Pusa-362

Implement	Grain yield (kg/ha)	Total energy requirement (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
T1:MB Plough + Harrowing	24990	4465.3	55303	16300	43200	3.65
T2: Cultivator	21315	2894.1	56690	15700	35050	3.23
T3: Rotavator	24255	3281.8	55255	16000	41750	3.60

1.1.4. JAGDALPUR

a. Agro-ecological setting

Jagdalpur centre is located in Garjat hills, Dandakarannya and eastern ghats eco-sub-region (AESR 12.1) and Bastar plateau agro-climatic zone in Chattisgarh. The climate is hot moist sub-humid. Annual normal rainfall is 1297 mm. The length of growing period is 180–210 days.

b. On-station experiments

During the year 2013, the onset of monsoon was 18 days earlier (26th May) compared to actual onset of monsoon (second week of June). A rainfall of 1004.4 mm was received which was deficit by 117.1 mm compared to normal (1121.5 mm) (Fig.11), during south-west monsoon (*kharif).* There was initially very high rainfall during June (476.7 mm) which damaged sown crops and sowing of other crops was not possible due to continuous rainfall. Sufficient rainfall was observed around mid August which was enough for maintaining impounding condition of water in rice crop. During north- east monsoon (October - December), 184.3 mm of rainfall was received which was excess by 69.5 mm compared to normal (114.8 mm). The rainfall occurred mainly in the 44th, 45th, 47th, 9th and 10th week of 2013-14, which was insufficient to meet the water requirement of the crops. During summer, 134.1 mm of rainfall was received which was deficit by 12 mm compared to normal (146 mm). There were dry spells during *kharif* season 16th to 22nd June (coinciding with transplanting of rice was delayed) and 21st – 27th August (tillering of rice).

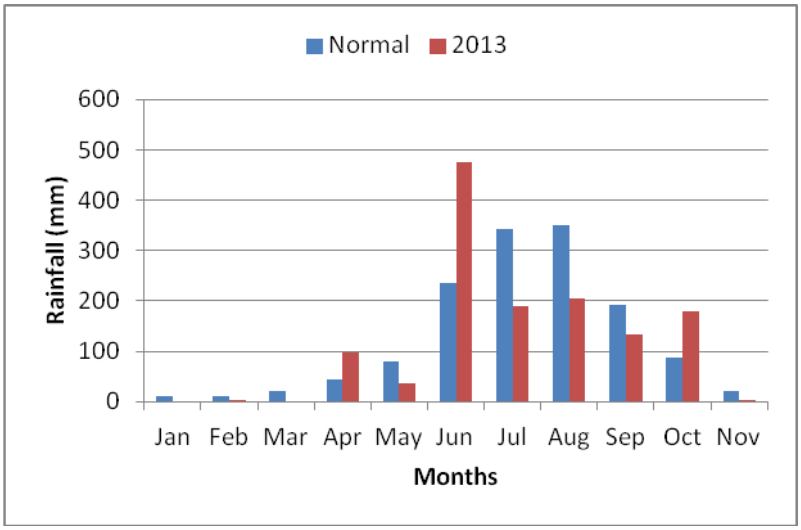


Fig.11: Normal and actual (2013) monthly rainfall at Jagdalpur

Real time contingency crop planning

The onset of monsoon was 18 days earlier (26th May) and a rainfall of 1004.4 mm was received which was deficit by 117.1 mm compared to normal (1121.5 mm), during south-west monsoon (kharif). There was initially very high rainfall during June which damaged sown crops and sowing of other crops was not possible due to continuous rainfall. Among the sorghum based intercropping systems sorghum + okra (1:1) recorded significantly higher sorghum equivalent yield (3455 kg/ha) followed by sorghum + okra (1:2). In case of sole crops, okra recorded significantly highest yield (3305 kg/ha) followed by sorghum (920 kg/ha), but NMR (Rs.18699/ha) and RWUE (0.61 kg/ha-mm) was significantly higher in okra followed by sorghum + okra (1:2). Sorghum + Okra (1:1) recorded highest B:C ratio (2.47) followed by okra sole (2.37) (Table-).

Table-41: Performance of sorghum based intercropping systems under dryland conditions

Treatment	Sorghum equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
Sorghum sole	920	21743	-7943	-0.37	0.66
Sesame sole	557	12479	12586	1.01	0.40
Pigeonpea sole	767	20524	12471	0.61	0.55
Okra sole	3305	30876	18699	0.61	2.37
Sorghum + sesame (1:1)	980	30064	-8269	-0.28	0.70
Sorghum + pigeonpea (1:1)	1260	35427	-5700	-0.16	0.90
Sorghum + okra (1:1)	3455	42329	9496	0.22	2.47
Sorghum + sesame (1:2)	814	25904	-9199	-0.36	0.58
Sorghum + pigeonpea (1:2)	1149	28585	-1737	-0.06	0.82
Sorghum + okra (1:2)	3202	32037	15988	0.50	2.29
CD (P=0.05)	3.12				

Similarly, among maize based intercropping systems, maize equivalent yield was significantly higher in maize + cowpea (1:1) (10062 kg/ha) followed by cowpea sole. B:C ratio was recorded significantly highest in cowpea sole (4.39) followed by maize + cowpea (1:1), whereas, RWUE was significantly highest in maize + cowpea (1:1) (7.21 kg/ha-mm) followed by cowpea sole (6.38 kg/ha-mm) (Table-42).

Table-42: Performance of maize based intercropping system under dryland conditions

Treatment	Maize equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
Maize sole	5343	28989	41008	3.83	1.41
Cowpea sole	8911	16526	72581	6.38	4.39
Pigeonpea sole	550	20524	3126	0.39	0.15
Greengram sole	522	13179	10296	0.37	0.78
Maize + cowpea (1:1)	10062	40008	74496	7.21	1.86
Maize + pigeonpea (1:1)	5338	42674	39866	3.82	0.93
Maize + greengram (1:1)	5071	37777	39185	3.63	1.04
Maize + cowpea (1:2)	8031	34499	57625	5.75	1.67
Maize + pigeonpea (1:2)	4628	35832	30327	3.31	0.85
Maize + greengram (1:2)	4754	33384	33789	3.41	1.01
CD (P=0.05)	6.7				

Sufficient rainfall was recorded (204.7 mm) around mid August which was sufficient for maintaining impounding condition of water in rice crop. However, there were dry spells during 16th to 22nd June (coinciding with transplanting of rice) and 21st to 27th August (tillering of rice). Under real time contingency plan for rice (variety-MTU-1010) in midland situation, the treatment with ZnSO4 spray (twice) recorded highest grain and straw yield (3727 kg/ha and 4826 kg/ha), plant height (72.4 cm), effective tillers (6.2/hill), panicle length (22.5 cm), days to maturity (115), B:C ratio (2.43) and RWUE (3.15 kg/ha-mm). grain yield increased by 13.6% as compared to the control (no spray) (Tables-43 & 44).

Table-43: Effect of foliar spray to cope with dry spells on performance of rice (variety-MTU-1010) in midland situation

Treatment	Plant height (cm)	Effective tillers/hill	Panicle length (cm)	Days to maturity	1000 seed weight (g)
No spray	69.4	4.9	19.7	110	20.8
Urea spray (one)	71.2	5.2	20.2	113	21.2
Urea spray (two)	72.3	5.4	21.6	115	21.8
KNO_3 spray (one)	71.6	5.7	21.5	114	21.5

KNO_3 spray (two)	71.9	5.8	22.2	115	21.6
$ZnSO_4$ spray(one)	72.1	5.8	22.4	113	21.7
$ZnSO_4$ spray (two)	72.4	6.2	22.5	115	22.1

Table-44: Effect of foliar spray In-season dry spells (Real-Time) on performance of rice (variety-MTU-1010) in midland situation

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
No spray	3217	4456	15720	32535	2.07	2.71
Urea spray (one)	3469	4731	16000	36035	2.25	2.93
Urea spray (two)	3512	4739	16280	36400	2.24	2.96
KNO_3 spray (one)	3458	4427	16180	35690	2.21	2.92
KNO_3 spray (two)	3523	4558	16460	36385	2.21	2.97
$ZnSO_4$ spray (one)	3672	4812	16110	38970	2.42	3.10
$ZnSO_4$ spray (two)	3727	4826	16320	39585	2.43	3.15

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA centre, Jagdalpur in Tahkapal, Tandpal and Gumiyapal villages in Tokapal, Tehsil, Bastar district, Chhattisgarh. The total cultivated area is 511.25 ha out of which 500 ha is rainfed. The mean annual rainfall is 1399 mm with seasonal rainfall of 1118.7 mm during *kharif* (June - September). The major soil types are shallow, medium to deep black mixed red and black soils. The major rainfed crops during *kharif* are rice, maize, minor millets, while during *rabi* are vegetables, chikpea, kulthi and niger. The number of marginal, small, medium and large farmers are 61, 269, 86 and 20, respectively. The ground water table is 6 to 15 m depending upon topography and season. The source of irrigation is farm ponds and wells covering 2% of cultivated area.

Climate Vulnerability in General

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 80%, north-east monsoon contributes 8.2%, winter season contributes 1.5% and summer 10.3% of the total annual average rainfall of 1399 mm. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 14% deficit of the average rainfall. The onset (south-west) of monsoon is during 24th SMW. The dry spells are experienced for the past 32 years (5 dry spells in September and 11 dry spells in October) and at panicle initiation and reproductive stages of rice. The normal onset of the monsoon is 12th June (24th SMW) and withdrawal is 25th September (39th SMW). The soil moisture status was deficit during panicle initiation and reproductive stages of major rainfed crops. During past 10 years, the maximum temperature in the *kharif* crop season has decreased by 0.60˚C and by 0.40˚C during rabi season whereas minimum temperature during *kharif* crop season decreasing by 0.7˚C and by 1.8˚C during rabi season. The extreme events like unusual and high intensity rainfall in short span are increasing (30, 32 and 34 SMWs during July-August and 41 and 44 SMWs during October). The area has also been experiencing extreme events like hail storms, floods and cold waves (occasionally). There has been a considerable shift in the rainfall pattern and the quantum of rainfall during SW monsoon (6%) and North-East monsoon season (32%) has increased during last 10 years and sowing window of the dominant rainfed crops delayed from 24th to 25th SWM.

Experienced weather conditions during the year (2013-14)

During the year 2013, in the Tahkapal village, onset of monsoon was early during last week of May i.e May 26th. A rainfall of 978.1 mm was received which was deficit by 143.4 mm compared to normal (1121.5 mm), during south-west monsoon (*kharif).* During north-east monsoon (Oct- Dec), 194.2 mm of rainfall was received which was excess by 79.4 mm compared to normal (114.8 mm). During summer, 106.6 mm of rainfall was received which was deficit by 39.5 mm compared to normal (146.1 mm). There were dry spells during 16th to 22nd July (transplanting of rice was delayed) and 21st to 27th August (tillering of rice) in *kharif* season (Fig.12).

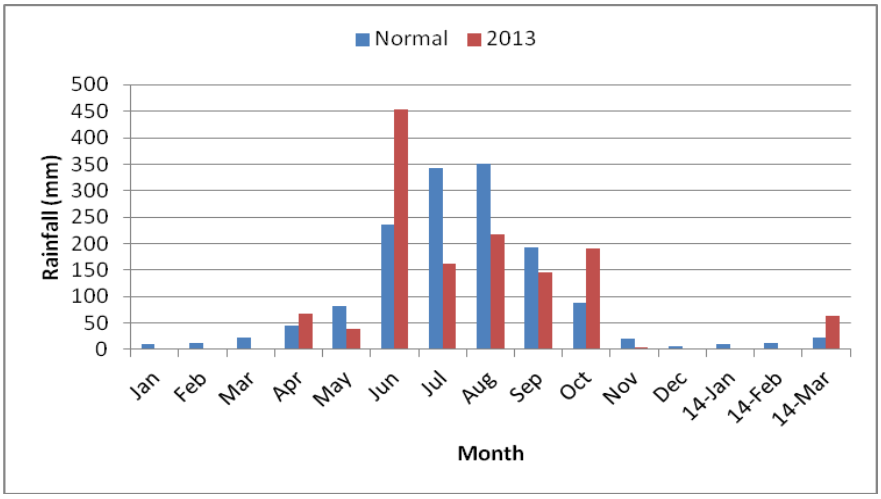


Fig.12: Normal and actual (2013) monthly rainfall at Tahkapal

Interventions

The major interventions included rainwater harvesting and recycling, real time contingency planning and timely operations through custom hiring center. These interventions covered an area of 9.43 ha in 35 farmers' fields.

Real time contingency planning

The onset of monsoon was early during last week of May i.e May 26th. A rainfall of 978.1 mm was received which was deficit by 143.4 mm compared to normal (1121.5 mm), during south-west monsoon (*kharif*). There were dry spells during 16th to 22nd July and 21^{s}t to 27th August (silking of maize) in kharif season. Improved practice of maize cultivation recorded higher grain and straw yield (4350 and 7040 kg/ha), harvest index (0.38), 100 seed weight (38.4), B:C ratio (1.99) and rainwater use efficiency (3.67 kg/ha-mm) as compared to farmers' practice. The percentage of grain and straw yield increased by 33.6 and 22.2%, respectively as compared to farmers' practice (Table-45).

Table-45: Performance of hybrid maize (Dhanya) under rainfed upland situation (pooled over 25 farmers' fields)

Treatment	Grain yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)	100 seed weight (g)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Improved practice	4350	7040	0.38	38.4	21600	42900	1.99	3.67
Farmers' practice	2890	5480	0.35	34.6	15480	27870	1.80	2.44

Framer practice Improved practice

Field view of hybrid maize (variety-Dhanya) under rainfed upland situation

Under upland badi situation, cultivation of vegetable crops viz., chilli, cabbage, cauliflower, okra, cowpea and brinjal was demonstrated. Among all the vegetable crops, chili was superior in terms of net income (Rs.73640/ha) and B:C ratio (2.24), however, highest fruit yield (6273 kg/ha) and RWUE (5.29 kg/ha-mm) was recorded by cabbage with improved practice, the fruit yield increased by 32.4% as compared to farmers practice (Table-46).

Table-46: Performance of vegetable crops under upland badi situation (pooled over 25 farmers' fields)

Crop	Treatment	Fruit yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Chili	Improved practice	4263	32935	73640	2.24	3.60
	Farmers practice	2886	22638	49512	2.19	2.44
Cabbage	Improved practice	6273	34972	40304	1.15	5.29
	Farmers practice	4240	23610	27270	1.16	3.58
Cauliflower	Improved practice	5436	34972	46568	1.33	4.59
	Farmers practice	3812	23610	33570	1.42	3.22
Okra	Improved practice	3574	19840	33770	1.70	3.02
	Farmers practice	2346	13780	21410	1.55	1.98
Cowpea	Improved practice	3358	15180	25116	1.65	2.83
	Farmers practice	2410	12080	16840	1.39	2.03
Brinjal	Improved practice	5067	24808	35996	1.45	4.28
	Farmers practice	3482	17270	24514	1.42	2.94

Chilli

Cabbage

Cauliflower

Cabbage

Cowpea

Okra

Field view of vegetable crops under upland badi situation

The rainfall pattern during *kharif* 2013 indicated that the rainfall was excess by 92.6% in June but was deficit by 52.8% in July, 28.2% is August and 24.3% in September. There were dry spells during 16th to 22nd July (transplanting of rice was delayed) and 21st to 27th August (tillering of rice) in *kharif* season. Under on-farm demonstration on rice (variety-Purnima) under upland situations, foliar spray of $ZnSO_4$ (twice) recorded highest straw yield (4270 kg/ha), 1000 grain wt (21.0), B:C ratio (1.93). However, KNO_3 (twice) recorded highest grain yield (2820 kg/ha), harvest index (0.44), net returns (Rs. 27840/ha) and rainwater use efficiency (2.38 kg/ha-mm). The yield increased by 10.3 and 9.5% with foliar spray of KNO_3 (twice) and $ZnSO_4$ (twice), respectively as compared to the control (no spray) (Table-47).

KNO_3 spray (Two)

Table-47.: Effect of foliar spray treatments on performance of rice (variety-Purnima) under upland situation

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)	Days to maturity (days)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
No spray	2530	3690	0.41	98	13720	24230	1.77	2.14
Urea spray (one)	2680	3770	0.42	103	14000	26200	1.87	2.26
Urea spray (twice)	2730	4010	0.41	106	14280	26670	1.88	2.30
KNO_3 spray (one)	2710	3860	0.41	104	14180	26470	1.86	2.29
KNO_3 spray (twice)	2820	3640	0.44	105	14460	27840	1.92	2.38
$ZnSO_4$ spray (one)	2725	4050	0.40	103	14110	26765	1.90	2.30
$ZnSO_4$ spray (twice)	2796	4270	0.40	106	14320	27620	1.93	2.36

The improved varieties of blackgram (var. Pant U-30) and greengram (var. hum-1) were sown in uplands during August-September in the fields of 20 farmers where finger millet/pigeonpea/maize/vegetable crops were damaged, due to high rainfall in the months of June –July, 2013. In both crops, 40 kg DAP was applied per acre in furrows. Higher NMR of Rs. 21778 and 21410/ha and B:C ratio (2.21 and 2.16) was recorded under both the real time interventions as compared to farmer's practices. However, higher rain water use efficiency (0.74 and 0.70 kg/ha-mm) was recorded under farmer's practice (damaged maize crop) due to higher yield than pulses (Table-48).

Table-48: Performance of crops taken as a real time intervention under upland situation

Treat-ment	Treatment details	Yield (kg/ha)	Cost of Cultivation (Rs/ha)	NMR (Rs/ha)	B:C Ratio	RWUE (kg/ha-mm)
RTI-1	Black gram (var. Pant U-30) DAP was applied @ 40 kg per acre in furrows.	736	9870	21778	2.21	0.74
RTI-2	Green gram (var. hum-1) DAP was applied @ 40 kg per acre in furrows.	696	9910	21410	2.16	0.70
FP-1	Sown crop damaged (fingermillet)	735	8750	2275	0.26	0.74
FP-2	Sown crop damaged (pigeonpea)	422	9110	8890	0.98	0.43
FP-3	Sown crop damaged (maize)	1368	9625	8296	0.86	1.38

Blackgram

Greengram

Horsegram

Performance of blackgram and greengram

Transplanting of pigeonpea (Rajeev lochan) across the slope was done in the fields of three farmers where the normal crop failed due to high rains in the month of June –July, 2013. The seedlings of pigeonpea were prepared in polyethene bags in shaded area. For achieving proper growth, spot application of FYM and DAP was done. Transplanting of pigeonpea (var. Rajeev lochan) as a real time intervention registered higher yield (1000 kg/ha), NMR (Rs.22400/ha), B:C ratio (1.09) and RWUE (0.72 kg/ha-mm) as compared to farmers' practice where affected crop failed and gave negative net return. The yield increased by 60% as compared to direct sowing (Table-49).

Table-49: Performance of pigeonpea (var. Rajeev lochan) as a real time intervention

Intervention	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)
Direct sowing	400	25000	-7800	-0.31	0.29
Transplanting	1000	20600	22400	1.09	0.72

View of transplanted pigeon pea crop

Most of land had remained fallow due to heavy rains in the month of June because none of the crop was sown in this month or the sown crops failed. Hence, the mid season crops niger (var. JNC-9) and horse gram (var. BK-1) were sown in the fields of 20 farmers during 15-20 September (which is the normal sowing time for mid season crops). Niger and horsegram grown as a real time intervention performed better yield with of 500 and 590 kg/ha. Horsegram recorded better yield (590 kg/ha), NMR (Rs.15350/ha), B:C ratio (1.86) and RWUE (0.59 kg/ha-mm) as compared to niger (Table-50).

Table-50.: Performance of midseason crops as a Real Time Intervention

Intervention	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Niger (var. JNS-6)	500	9450	8050	0.85	0.50
Horse gram (var. BK-1) DAP was applied @ 40 kg per acre in furrows	590	8250	15350	1.86	0.59

Horsegram

Niger

Field view of midseason crops

Seedlings of brinjal (var. muktakeshi), Tomato (var. pusa rubi) and Chilli (var. pusa jwala) were prepared by creating artificial drainage conditions in poly shade and transplanting in fallow upland fields and home stead gardens was done covering 15 farmers by maintaining proper drainage during August-September with full package of practices. Among three vegetable crops which were grown as a real time intervention, chilli (var. pusa jwala) performed better in terms of yield (5640 kg/ha), NMR (Rs.32200/ha), B:C ratio (1.33) and RWUE (5.68 kg/ha-mm) as compared to brinjal and tomato (Table-51).

Table-51: Performance of vegetable crops as on real time intervention

Crops	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Brinjal	3250	22540	9960	0.44	3.27
Tomato	3040	21200	3440	0.16	3.06
Chilli	5640	24200	32200	1.33	5.68



View of chilli, tomato and brinjal crops

The sowing of finger millet in uplands was not possible due to heavy rains in June. However, in some places the sowing was done by farmers but due to heavy rains germination was affected. Hence, re-sowing of finger millet (var. GPU-28) was done as an intervention during first week of August in the fields of 10 farmers. Re-sowing of finger millet with recommended dose of fertilizers gave higher yield of 1740 kg/ha with higher NMR (14600 kg/ha), B:C ratio (1.27) and RWUE (1.75 kg/ha-mm). The yield increased by 57.8% as compared to farmers' practice (Table-52).

Table-52: Effect of real time intervention on performance of finger millet (var. GPU-28)

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE kg/ha-mm)
IP : (Re-sowing of fingermillet)	1740	11500	14600	1.27	1.75
FP : (Affected fingermillet)	735	8750	2275	0.26	0.74

Crop condition of re-sown fingermillet

There were dry spells during 16th to 22nd July (transplanting of rice was delayed) and 21st to 27th August (tillering of rice) in *kharif* season. Late sowing (last week of August) of early varieties of rice (MTU-1010) was done through transplanting and *lehi* method (sowing of sprouted seeds) with higher seed rate and higher dose of fertilizer to obtain optimum plant population per unit area as an intervention in the fields of 20 farmers where rice was not sown at proper time due to heavy rains in the months of June-July. For establishing crop, tractor drawn drum seeder was used. Higher yield, net return, B:C ratio and RWUE were recorded under both the real time interventions as compared to farmers practice. Transplanting seems better than lehi in terms of yield (2480 kg/ha), NMR (Rs.20720/ha) and RWUE (2.50 kg/ha-mm). However, B:C ratio (1.26) was higher under *lehi* method. The yield increased by 57.7% and 53.3% with transplanting and *lehi*, respectively as compared to farmers' practice (affected rice crop) (Table-53).

Table-53: Effect of real time intervention on performance of rice (var. MTU-1010)

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE kg/ha-mm)
RTI-1 (transplanting)	2480	16480	20720	1.26	2.50
RTI-2 (Lehi)	2250	13650	20100	1.47	2.27
Farmers' practice (affected rice crop)	1050	10250	5500	0.54	1.06

View of field preparation and crop condition of transplanted rice in midlands

In NICRA village (Tahkapal), dry aerobic seeding of rice is generally practiced in lowland situation in the last week of May to first week of June. The sown crops were damaged due to high rainfall during June (453.6mm) leading to water logging. In this situation, farmers adopted *lehi* practice of rice establishment (pre-germinated rice seeds (var.-MTU-1001) are sown in the puddled field). As an intervention drum seeder was used for sowing within limited time with higher seed rate and fertilizer. The fields were prepared by tractor with cage wheel. The drainage system was created by digging the trench in lower side and cutting of bunds to avoid water logging. Under lowland situation, higher yield (3280 kg/ha), NMR (Rs.32720/ha) B:C ratio (1.99) and RWUE (3.30 kg/ha-mm) were recorded under *lehi* method as a real time intervention as compared to farmers' practice. The yield increased by 61.6% as compared to the farmers practice (affected rice crop) (Table-54).

Table-54: Effect of real time intervention on performance of rice (var. MTU-1001)

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE kg/ha-mm)
RTI (Lehi)	3280	16480	32720	1.99	3.30
FP (Damaged rice crop)	1260	11450	7450	0.65	1.27

View of waterlogged fields in low lying area and rice crop sown by *lehi* method after draining excess water

Other income generating interventions to overcome the adverse effects of climate change and securing livelihood of farmers through convergence

In the previous year it was observed the farmers were not able to grow the crops properly and also due to failure of crops most of the farmers were not getting sufficient income through crop production. Therefore, to enhance the sources of livelihood, it is required to adopt allied enterprises at farm level. In bastar region, fisheries, piggeries, poultry, goatry, dairy, duckery and mushroom cultivation are found suitable enterprises to increase the income of farmers and to overcome the loses due to crop failure. Looking to the present scenario and perception, the following enterprises were started in the selected villages.

Self help groups were formed for establishing different enterprises viz. fish cultivation (10 SHGs), pig farming (4 SHGs), dairying (4 SHGs), poultry (10 SHGs), goat rearing (10 SHGs), mushroom production (4 SHGs), custom hiring and repairing center (3 SHGs) and grain storage (1 SHG).

Fish cultivation in ponds: Twenty Five SHGs were formed for fish cultivation enterprise in the Tandpal, Tahkapal, Gumiyapal villages of Bastar district. Improved fingerlings (rohu/katla/mrigal/common carp and grass carp), feed and other initial inputs were provided to each SHG through convergence. Fingerlings were stocked in the 25 ponds of different sizes.

Fish cultivation in lowland ponds

Pig farming: Four SHGs were formed for pig keeping enterprise in the Tandpal, Tahkapal, Gumiyapal and Badechakwa villages of Bastar district. Pig sheds, 35 nos. of piglets of improved breed (white York shire), feed and other initial inputs were provided to each SHG through convergence.

View of pig farming in NICRA villages

Goat reraring: Four SHGs were formed for goat keeping enterprise in the Tandpal, Tahkapal, Gumiyapal and Badechakwa villages of Bastar district. Goat sheds, 30 nos. of goats of improved breed (Jamunapari), feed and other initial inputs were provided to each SHG**.**

View of goat rearing in NICRA villages

Dairying: Four Self Help Groups were formed for dairying enterprise in the Tandpal, Tahkapal, Gumiyapal and Badechakwa villages of Bastar district and cattle sheds, 7 nos. of improved breed of cows (Gir / Jersey), feed and other initial inputs were provided to each SHG through convergence.

Cattle distribution and awareness camp in NICRA villages

Poultry farming: Four SHGs were formed for poultry farming enterprise in the Tandpal, Tahkapal, Gumiyapal and Badechakwa villages of Bastar district. Poultry sheds, 800 nos. of chicks of improved breed (vanraja / Grampriya), feed and other initial inputs were provided to each SHG through convergence.

View of poultry farming in NICRA villages

Mushroom cultivation: Three SHGs were formed in Tahkapal, Gumiyapal and Tandpal villages for establishing mushroom production enterprises. Production huts, necessary utensils and initial inputs were provided to each SHG. A 7 days training and exposure visits were organized to the beneficiaries at village level.

View of mushroom cultivation in NICRA villages

Custom hiring center: Three custom hiring committees of farmers were formed in the NICRA domain villages and facility of different agricultural implements was provided to them. Initial 7 days training cum exposure visits were organized and tool kits were provided to them.

Sowing of crops by seed drill

Rainwater harvesting *(in situ and ex situ)* and efficient use

Rainwater harvesting and recycling

Due to undulated topography, the uplands of this region suffer from soil erosion. To control the soil erosion and damage of crop, the soil and water conservation measures were adopted. Under these measure, contour and diversion trenches, boulder checks, gabion checks and staggered tranches were constructed in the farmers' fields. For water conservation during the rainy season, ponds were constructed in series from ridge to valley. This conserved water helps during the dry spells when crop suffers from moisture stress. In the fallow and eroded uplands plantation of fruit and multipurpose trees was done to enhance the livelihood of farmers and to provide the fuel and other domestic purposes.

Construction of ponds in series from ridge to valley

View of constructed contour and diversion trenches

View of constructed contour and diversion trenches

Plantation of fruit and multipurpose trees

Efficient use of harvested water by supplemental irrigation to rainfed crops

A farm pond (9.5 x 24 x 1.5 m) with capacity at 342 m^3 was dug for efficient rainwater harvesting and recycling (Fig.). The two existing farm ponds in the village are of size 30 x 30 x 2.5 m and 27 x 24 x 2.5 m were renovated (Fig.). The stored water in the farm ponds during *kharif* 2013 was efficiently utilized for supplementary irrigation/ life saving irrigation of 10 to 15 cm during various stages of the vegetable crops. Chilli (Green long variety) gave maximum net returns of Rs.76565/ha with B:C ratio of 2.32, (while cabbage (pride of India) gave lowest net returns of Rs. 41672/ha with B:C ratio of 1.19 in the trial conducted in Lakshman/Ramu field in Tahakapal village. Similarly, chilli gave maximum net returns of Rs. 67690/ha (B:C ratio of 2.06) while brinjal gave minimum net returns of Rs. 38792/ha (B:C ratio of 1.56) whereas maximum water use efficiency was recorded under tomato crop in the trial conducted in Ramprasad/ Shyamsunder field in Gumiapal village (Tables-55 & 56).

Table-55: Performance of vegetable crops grown using harvested water in farm pond No.1 (Laxman/Ramu)

Crop	Yield (kg/ha)	WUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Tomato	11860	73.6	22658	94880	72222	3.19
Cauliflower	5675	35.2	34972	85125	50153	1.43
Cabbage	6387	39.6	34972	76644	41672	1.19
Chilli	4380	27.2	32935	109500	76565	2.32
Brinjal	5465	33.9	24808	65580	40772	1.64

Farm pond at village Tahakapal and efficient recycling of water for vegetable cultivation

Farm Pond at village Tahakapal in upland farming situation

Table-56 : Effect of supplemental irrigation on vegetable crops (Ramprasad/ Shyamsundar)

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Tomato	Pusa ruby	12144	75.3	22658	74494	3.29
Cauliflower	Pusa JL-80	5830	36.2	34972	52478	1.50
Cabbage	Pride of India	6325	39.2	34972	40928	1.17
Chilli	Japani laungi	4025	25.0	32935	67690	2.06
Brinjal	Green long	5300	32.9	24808	38792	1.56

The water fluctuation data revealed that the water availability was recorded from 35th week (mid August) to 18th week (mid May) in open wells of midland farming situation. This water may be used for growing second crop and third vegetable crop with micro-irrigation system successfully. The water quality analysis of 14 wells showed that the pH and conductivity were in the range of 6.69-7.15 and 0.23-0.42 ds m^{-1}, respectively. No carbonate concentration was recorded however; bicarbonate was recorded in the range of 5.3-16.4 me ql. Ca+ Mg, SAR value, TSS (%) and organic C (%) were in the range of 4.3- 6.3, 0.568-1.523, 114.2-278.7 and 0.02-0.088, respectively. Under this open well, tomato, cauliflower and chilli were grown and among all vegetables, highest yield 10579 kg/ha B: C ratio of 2.74 and water use efficiency (65.7 kg/ha-mm**)** was recorded under tomato crop (Table-57).

Table-57: Adoption of ground water recharge (open wells) and sharing practices at whole village level

Crop	Variety	Yield (kg/ha)	WUE (kg/ha-mm)	Cost of cultivation (Rs /ha)	NMR (Rs/ha)	B:C ratio
Cauliflower (4)	Pusa LJ-80	4908	30.4	34972	38641	1.11
Tomato (2)	Pusa Ruby	10579	65.7	22658	61970	2.74
Chilli (2)	Japani laungi	3700	22.95	32935	59565	1.81

Figures in parentheses indicate number of farmers' fields

Field view of cabbage and tomato

Efficient Energy use and Management

Different seed drills were evaluated for sowing of fingermillet. Among them, sowing with Mahakal dufan seed drill recorded higher grain yield (2350 kg/ha), NMR (Rs.39624/ha) , B: C ratio (5.69), output energy (68871), energy efficiency (5553), energy productivity (0.42 kg/MJ), rain water use efficiency (1.91 kg/ha-mm), lower specific energy (2.37 MJ/kg) and specific cost (Rs.3.00/kg) as compared to Bhoram dev and automatic seed drill. The yield increased by 4.3 and 11.9% with Mahakal dufan seed drill compared to Bhoram dev and automatic seed drill respectively (Table-58).

Table-58: Yield, economics and energy use of finger millet with different seed drills (2011-2014)

Parameter	Bhoramdev seed drill				Automatic seed drill				Mahakal dufan seed drill			
	2011-12	2012-13	2013-14	Mean	2011-12	2012-13	2013-14	Mean	2011-12	2012-13	2013-14	Mean
Yield (kg/ha)	2250	2150	2350	2250	2000	2000	2210	2070	2500	2100	2460	2350
Cost of cultivation (Rs/ha)	3869	8299	8610	6926	4083	8300	8640	7008	3898	8399	8475	6924
NMR (Rs/ha)	19257	45451	50140	38282	16517	41700	46610	34942	21747	44101	53025	39624
B:C ratio	4.97	5.48	5.82	5.42	4.04	5.02	5.39	4.82	5.57	5.25	6.26	5.69
Input energy (MJ/ha)	5483	5558	5624	5555	5483	5596	5644	5574	5503	5575	5580	5553
Output energy	66283	69451	67365	67700	59390	62140	65825	62452	70300	66472	69842	68871
Energy efficiency	12.09	12.50	11.98	12.19	10.83	11.11	11.66	11.20	12.78	11.92	12.52	12.41
Energy productivity (kg/MJ)	0.41	0.39	0.42	0.41	0.36	0.36	0.39	0.37	0.45	0.38	0.44	0.42
Specific energy (MJ/kg)	2.44	2.59	2.39	2.47	2.74	2.80	2.55	2.70	2.20	2.65	2.27	2.37
Specific cost (Rs/kg)	1.72	3.86	3.66	3.08	2.04	4.15	3.91	3.37	1.56	4.00	3.45	3.00
RWUE (kg/ha-mm)	2.02	1.43	1.98	1.81	1.79	1.33	1.87	1.66	2.24	1.40	2.08	1.91

Field view of sowing with different seed drills

In demonstration on sowing of chickpea and pea using tractor drawn seed drills, higher seed yield (914 and 864 kg/ha), NMR (Rs.17250 and 12755/ha), output energy (22127.7 and 23693.5MJ/ha); specific energy (6.39 and 6.76 MJ/kg) and water use efficiency (0.77 and 0.73 kg/ha-mm) of chickpea and pea was recorded under tractor drawn seed cum fertilizer seeding method as compared to farmers practice. B:C ratio of 1.17 with chickpea was higher under tractor drawn seed cum fertilizer drill, where as broadcasting of pea recorded higher B: C ratio (0.98) than tractor drawn seed cum fertilizer drill. In both the crops, energy efficiency (8.55 and 10.56) and energy productivity (0.37 and 0.38 kg/MJ) was higher under broadcasting method. Broadcasting in chickpea and seed drill sowing in pea recorded higher specific cost (Rs.17.05/kg and Rs. 15.22/kg) (Table-59).

Table-59: Yield, economics and energy use of chickpea and pea under different sowing methods

Parameter	Chickpea (var. JG-11)		Pea (var. Vikash)	
	Tractor drawn seed cum fertilizer drill	Broad-casting	Tractor drawn seed cum fertilizer drill	Broad-casting
Grain yield (kg/ha)	914	535	864	543
Cost of cultivation (Rs/ha)	14750	9115	13150	8240
NMR (Rs/ha)	17250	9600	12755	8044
B:C ratio	1.17	1.05	0.97	0.98
Input energy (MJ/ha)	5838.3	1419.0	5838.3	1419.0
Output energy (MJ/ha)	22127.7	12136.3	23693.5	14984.2
Energy efficiency	3.79	8.55	4.06	10.56
Energy productivity (kg/MJ)	0.16	0.37	0.15	0.38
Specific energy (MJ/kg)	6.39	2.65	6.76	2.61
Specific cost (Rs/kg)	16.13	17.05	15.22	15.18
Water use efficiency (kg/ha-mm)	0.77	0.45	0.73	0.46

Field view of sowing of chickpea and pea with tractor drawn seed drill

Mean data of three year study indicates superiority of mechanical transplanting over other two methods in terms of grain yield (3500 kg/ha), NMR (Rs 31914/ha), B:C ratio (2.43), output energy (101419), energy productivity(0.29 kg/MJ), specific energy (3.61MJ/kg) and rain water efficiency (2.82 kg/ha-mm). However, higher energy efficiency and specific cost was found under manual transplanting method. The percentage yields decreased by manual transplanting and direct seeding was 3.4 and 20% (Table-60).

Table-60: Yield, economics and energy use of different planting methods of rice (2011-2014)

Parameter	Planting method											
	Mechanical transplanting				Manual transplanting				Direct seeding			
	2011	2012	2013	Mean	2011	2012	2013	Mean	2011	2012	2013	Mean
Yield (kg/ha)	3340	3360	3810	3500	3200	3300	3650	3380	2610	2970	2830	2800
Straw	3.91	4.02	4.16	4.03	4.00	3.99	4.28	4.09	3.47	3.61	3.9	3.66
Cost of cultivation (Rs/ha)	9910	13700	16216	13275	14100	17755	22335	18063	8425	11120	14466	11337
NMR (Rs/ha)	28213	26596	40934	31914	22425	21845	32415	25562	21366	24520	27984	24623
B:C ratio	2.84	1.94	2.52	2.43	1.59	1.23	1.45	1.42	2.54	2.21	1.93	2.22
Input energy (MJ/ha)	15213	9570	13012	12598	14963	9470	12898	12444	13830	8340	11818	11329
Output energy (MJ/ha)	97539	99205	107512	101419	96624	97956	106681	100420	81403	88398	89983	86595
Energy efficiency	6.41	10.37	8.26	8.35	6.46	10.34	8.27	8.36	5.89	10.60	7.61	8.03
Energy productivity (kg/MJ)	0.22	0.35	0.29	0.29	0.21	0.35	0.28	0.28	0.19	0.36	0.24	0.26
Specific energy (MJ/kg)	4.55	2.85	3.42	3.61	4.68	2.87	3.53	3.69	5.30	2.81	4.18	4.09
Specific cost (Rs/kg)	2.97	4.08	4.26	3.77	4.41	5.38	6.12	5.30	3.23	3.74	5.11	4.03
RWUE (kg/ha-mm)	3.00	2.24	3.22	2.82	2.87	2.20	3.08	2.72	2.34	1.98	2.39	2.24

Different planting methods of rice

Alternate land use / farming systems for carbon sequestration and ecosystem services

Mango, cashew, aonla and guava seedlings were planted in July 2012. Each fruit crop was planted in different blocks. The establishment was successful. These interventions were made to educate farmers that climate change is needed to be tackled both with short-term and long-term strategies. Initial plant height and after one year of plant height was recorded and significantly highest in aonla plant was recorded significantly at par with guava plant and lowest plant height was recorded in mango plant. In case of girth and number of branches, cashew recorded but higher values followed by mango in plant girth and aonla in number of branches. Whereas, survival rate was recorded 98.5 to 99% in all fruit plants. However, canopy was covered numerically maximum in east ward in all the fruit trees, but significantly highest canopy covered in east ward followed by north-ward in aonla (Table-61).

Table-61: Performance of different fruit crops under upland conditions for Bastar region

Treatment	Initial plant height (cm)	Plant height (cm)	Girth (cm)	No. of branches	Sur-vival (%)	Canopy (cm)				
						Dire-ction	Mango	Cashew	Aonla	Guava
Mango	68.25	121.32	8.37	6.88	99%	North	30.88	35.25	59.53	49.23
Cashew	73.5	130.05	10.39	11.64	100%	South	32.67	44.35	47.39	44.58
Aonla	87.5	171.48	8.04	7.80	100%	East	35.07	45.8	69.08	53.44
Guava	85.5	176.56	7.63	6.88	98.5%	West	29.76	39.26	38.98	42.98
CD (P=0.05)	8.27	5.46	0.37	0.679	-	-	NS	NS	14.26	NS

Under *Badi* situations, different crops were cultivated viz., vegetables, pulses and cereals. Among these crops cowpea recorded significantly highest yield (11343 kg/ha) followed by okra (10820 kg/ha). NMR (Rs. 129953/ha) and B:C ratio (4.02) was highest under okra followed by cowpea, whereas cowpea recorded highest water use efficiency (8.64 kg/ha-mm) (Table-62).

Table-62: Performance of different vegetables, pulses and cereals under *Badi* Situations

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	GMR (Rs/ha)	NMR (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
Pigeonpea	795	21502	24080	2578	0.40	0.12
Maize	4667	30370	53566	23196	2.93	0.76
Clusterbean	2585	20072	25850	5778	1.47	0.29
Sorghum	1764	22779	26453	3674	1.47	0.16
Cowpea	11343	21667	90740	69073	8.64	3.19
Okra	10820	32347	162300	129953	6.51	4.02
CD (P=0.05)	9.67	-	-	-	-	-

Evaluation of sorghum varieties/hybrids during kharif 2013, revealed that CSH-16 recorded significantly higher yield (1167 kg/ha) and plant height (2.23 cm) among all the sorghum varieties/hybrids was but at par with CSH-23, CSH-13, SPV-462 and CSV-15 under upland conditions. Gross income was higher with CSH-16 and RWUE was recorded between 0.04 to 0.08 kg/ha-mm (Table-63).

Table-63: Performance of sorghum varieties under upland conditions

Variety / hybrid	Yield (kg/ha)	Plant height (cm)	Gross income (Rs/ha)	RWUE (kg/ha-mm)
CSV-23	600	1.21	9000	0.04
CSV-22-SS	814	1.57	12210	0.06
CSH-23	1127	1.84	16900	0.08
SSV-84	1063	1.47	15950	0.08
SPV-462	892	1.23	13375	0.06
CSH-16	1167	2.23	17500	0.08
CSV-20	828	1.46	12425	0.06
CSV-15	867	1.87	13000	0.06
CSH-13	1100	1.24	16495	0.08
CSV-24-SS	640	0.99	9600	0.05
CVS-27	600	1.81	16450	0.08
CD (P=0.05)	3.09	0.48		

Demonstrations were conducted on different crops in farmers' fields. Among all these crops, blackgram with improved practice gave highest grain yield (850 kg/ha). Blackgram cultivation with improved practices also gave higher NMR (Rs 25250/ha) and B:C ratio (1.94). Transplanted pigeonpea was the next best crop (Table-64).

Table-64: Performance of different crops in NICRA village

Crops	Farmers practices	Improved practices	% yield increase	Cost of ultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Yield (kg/ha)						
Ramtil	120	600	80.0	8000	13000	1.63	0.43
Kodo	150	800	81.3	10000	2000	0.20	0.57
Green gram	115	650	82.3	13017	14933	1.15	0.47
Black gram	120	850	85.9	13000	25250	1.94	0.61
Pigeonpea direct	50	400	87.5	25000	-7800	-0.31	0.29
Pigeonpea transplanted	50	100	50.0	20600	22400	1.09	0.72

Field view of different demonstrations

1.1.5. PHULBANI

a. Agro-ecological setting

Phulbani center is located in Eastern Plateau (Chotanagpur) and Eastern Ghats, Garjat Hills, Dandakarannya and Eastern Ghats (AESR 12.1), and Eastern ghat agro-climatic zone in Odisha. The climate is hot moist sub-humid. Annual normal rainfall is 1378 mm. Annual normal potential evapo- transpiration is 478 mm. Length of growing period is 180-210 days.

b. On-station experiments

Experienced weather condition during the year -2013

During the year 2013, the onset of monsoon was delayed by 6 days during first week of June. A rainfall of 954.6 mm was received which was deficit by 195.9 mm compared to normal (1150.5 mm) during south-west monsoon (kharif). During north-east monsoon (October - December), 370 mm of rainfall was received which was excess by 245.3 mm compared to normal (124.73 mm). During summer, 30 mm of rainfall was received which was deficit by 78.43 mm compared to normal (108.43 mm).There were dry spells during October to November, coinciding with germination and growth of rabi crops (Fig.13).

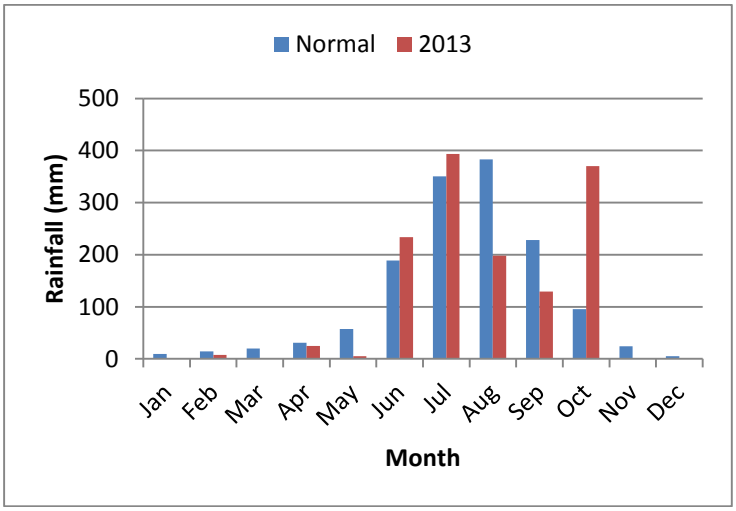


Fig.13: Normal and actual (2013) monthly rainfall at Phulbhani

Real time contingency crop planning

The crops faced dry spells during 2-5 August.(4 days), 14-18 August.(5 days), 22-26 August.(5 days), 30 August.-8 September.(10 days), 10-14 September.(5 days), 23-27 September.(5 days), 4-11 October.(8 days) and 15-20 October (6 days). There were no dry spells during 8th June to 1st August. Rainfall during August was much less than the normal accompanied by 4 short dry spells. Along dry spell of 10 days from 30th August to 8th September coinciding with flowering stage of rice, germination and growth of the *rabi* crop of mustard and other crops affected growth and yield. The rice varieties Vandana and Sahabhagi and Maize + cowpea intercrop were sown in the last week of June, while other crops were sown later. Crop duration varied from 64 days in green gram to 108 days in Sahabhagi (rice). The maximum yield recorded in maize + cowpea intercropping system *i.e* maize equivalent yield (3690 kg/ha) and rainwater use efficiency was the lowest in mustard (0.89 kg/ha-mm) and the highest in maize+ cowpea intercropping system (5.39 kg/ha-mm). The B:C ratio ranged from 1.30 in Sahabhagi to 2.05 in maize + cowpea intercropping system. The results clearly show that cultivation of non-rice crops in rainfed uplands is more advisable in the N-E ghat zone of Odisha (Table).Further,intercropping system (maize +cowpea) performed better and gave higher yield and net returns compared to cultivation of sole crops (Table-65).

Table-65: Performance of crops and cropping systems

Crop	Variety & date of sowing	Crop duration	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Rice	Vandana 25.06.13	90	1675	2.32	12500	4250	1.34
	Sahabhagi 25.06.13	108	1720	2.08	13200	4000	1.30
Greengram	TARM-1 25.09.13	64	350	0.87	9000	5000	1.56
Blackgram	T-9 25.09.13	73	410	1.02	9000	7400	1.82
Mustard	M-27 10.09.13	73	430	0.89	9000	6050	1.67
Sunflower	Jwalamukhi 01.10.13	90	750	2.03	12000	10500	1.88
Maize + Cowpea	Nirmal-51 and Gomti 25.06.13	100	Maize-1890 Cowpea-720 MEY-3690	5.39	18000	18900	2.05

Performance of rice cv. Sahabhagi at AICRPDA, Phulbani

c. On-farm experiments

Village profile

The program is being implemented by in Budhadani village, Phulbani tehsil in Kandhamal district, Odisha. The total cultivated area is 101 ha, out of which 81.96 ha is rainfed. The mean annual rainfall is 1123 mm with seasonal rainfall of 1045 mm during kharif (June-September). The major soil types are red lateritic and brown forest soils. The major rainfed crops during kharif are rice, maize, turmeric ,and greengram, blackgram and vegetables during rabi. The number of small, marginal, medium and large farmers is 29.26%, 51.63%, 19.11%, respectively. The ground water table is 5 m.

Climate vulnerability in general

The climate in this agro-climatic zone is sub- humid. Out of the total annual average rainfall of 1407 mm, south-west monsoon contributes 80%, north-east monsoon contributes 10% and summer rainfall contributes 10%. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 7.2% surplus of the average rainfall. The onset (south-west) of monsoon was during 24 SMW. For the past 15 years, the dry spells during crop season had been experienced during germination to reproductive stages in various rainfed crops. The onset of the monsoon is erratic. The extreme events like unusual and high intensity rainfall in short span are increasing during *kharif* and *rabi* seasons.

Experienced weather conditions during the year (2013-14)

The rainfall data of Phulbani centre (being the nearest agromet station) is taken for the analysis of weather conditions during the year 2013 at Budhadani village. During kharif, 954.6 mm rainfall was received which was deficit by 195.9 mm compared to normal (1150 mm) (Fig.14).

During monsoon, there was well distribution of rainfall from 23rd to 43rd SMW barring few exceptions. Highest weekly rainfall was received during 41st SMW which included phailin on 13th October, but highest number of rainy days per week was observed in 43rd week. There was no rain after 27th October. Absence of rainfall from 28th October, 2013 to 15th February, 2014 affected performance of rabi crops as well as kharif crops like turmeric, pigeonpea, etc. having long maturity duration.

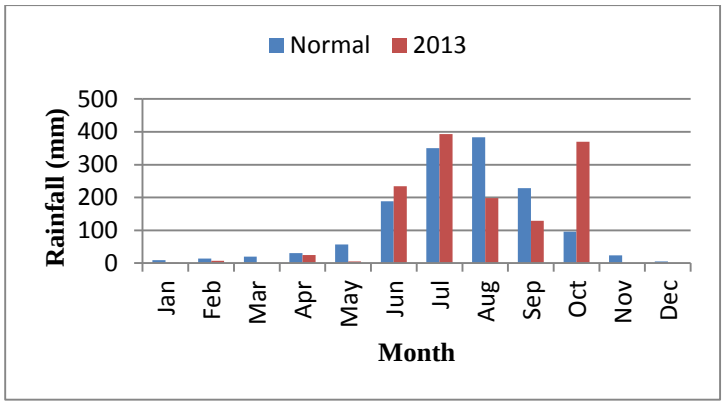


Fig.14: Normal and monthly rainfall at Phulbani

Interventions

The major interventions included real time contingency crop planning and timely operations through custom hiring center. These interventions covered an area of 33 ha in 195 farmers' fields.

Real time contingency planning

The total amount of rainfall received during 2013 was 1363.4 mm, which was 97% of the normal value of 1407 mm. Along dry spell of 10 days occured from 30th August to 8th September coinciding with flowering stage of rice. Heavy rainfall of 143 mm on a single day, i.e. 13th October, 2013 coinciding with maturity / harvesting stage of rice resulted in much loss in productivity. Three rice varieties, Vandana, Sahabhagi and Jhalka were evaluated in the farmers' fields during 2013-14. The mean duration of Vandana, Sahabhagi and Jhalka were found to be 89, 110 and 100 days, respectively. The yield of Vandana in farmers' fields was 1813 kg/ha, with the net return of Rs. 5625/ha. The mean yield and net return of Sahabhagi were found to be 2074 kg/ha and Rs.7541/ha. The average yield of Jhalka was 1483 kg/ha while the net return was Rs.1639 /ha. The B:C ratio of Vandana, Sahabhagi and Jhalka were found to be 1.45, 1.57 and 1.12, respectively. The rainwater use efficiency was found to be highest with Vandana (2.41 kg/ha-mm) followed by Sahabhagi (2.25 kg/ha-mm) and Jhalka (1.84 kg/ha-mm) (Table-66).

Table-66: Performance of drought tolerant short duration rice varieties (Mean of 8 farmers' fields)

Variety	Crop duration	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs./ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio
Vandana	88.9	1813	2.41	12500	18125	5625	1.45
Sahabhagi	109.5	2074	2.25	13200	20741	7541	1.57
Jhalka	101.3	1483	1.84	13200	14829	1629	1.12

Field view of performance of rice varieties

There were dry spells during October to November, coinciding with germination and growth of the rabi wheat. There was no rainfall after 27th October. Absence of rainfall from 28th October, 2013 to 15th February, 2014 affected performance of wheat. The wheat variety sonalika was tested in 10 farmers' fields. The rainfall during crop growing season varied from 297 to 370 mm. The mean yield in different farmers' fields was found to be 2020 kg/ha with net return of Rs.10234/ha and B:C ratio of 1.73 (Table-67).

Table-67: Performance of wheat variety Sonalika (mean of 10 farmers' fields)

Crop duration	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs./ha)	NMR (Rs./ha)	B:C ratio
95.6	2020	6.392	14000	10234	1.73

Field view of performance of wheat variety (Sonalika)

Intercropping systems

The crop duration in sole maize and maize + cowpea intercrop remained almost same. Maize yield in sole maize was about 5% higher than that of intercrop. However, the maize equivalent yield (3435 kg/ha) as well as rainwater use efficiency (5.17 kg/ha-mm) of intercropping system was about 70% higher over the sole crop. Similarly, the B:C ratio of intercropping system was 36% higher over sole maize. This clearly shows that maize + cowpea intercrop was more profitable than sole maize. The crops faced dry spells August to October and a long dry spell of 10 days from 30th August to 8th September affected maize growth and yield (Table-68).

Table-68: Performance of maize + cowpea intercropping system (mean of 17 farmers' fields)

Crop	Variety	Yield (kg/ha)			RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
		Maize	Cowpea	MEY				
Maize + cowpea	Nirmal-51, Gomati	1915	608	3435	5.17	18000	16349	1.91
Sole maize	Nirmal-51	2028		2028	3.07	14500	5783	1.4
% increase/ decrease in intercropping performance over sole maize		-5.57	-	69.35	68.4	24.14	182.71	36.43

Sole maize

Maize + cowpea

Performance of maize + cowpea intercropping system

Contingent crop planning under aberrant weather conditions

The total amount of rainfall received which was 97% of the normal value of 1407 mm.Along dry spell of 10 days from 30th August to 8th September coinciding with flowering stage of rice and germination and growth of *rabi* wheat. Absence of rainfall from 28th October, 2013 to 15th February, 2014 affected performance of wheat crop having long maturity duration. Heavy rainfall of 143 mm on a single day (13th October, 2013) coinciding with maturity / harvesting stage of rice resulted much loss in productivity. Eight crops (rice varieties Vandana and Sahabhagi), green gram, black gram, mustard, wheat, sunflower, potato and field pea) and one intercropping system (maize + cowpea) were tested in the farmers' fields of Budhadani village. Lowest rainfall during cropping system was received by potato (167 mm) followed by wheat (319 mm) for which irrigations were given during critical growth stages. The average crop duration varied from 65 days in green gram to 100 days in rice (mean of Vandana & Sahabhagi). Except green gram and black gram, all other crops and cropping systems exhibited higher net return than rice. The maximum yield was recorded in maize + cowpea (4140 kg/ha) However, the B:C ratio of green gram and black gram was superior to rice. Highest net return of Rs.74930 was recorded by in potato while the B:C ratio was highest with field pea (2.90) (Table-69).

Table-69: Performance of crops and cropping systems

Crop	Crop duration	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Rice	100	1869	2.27	12967	5718	1.44
Maize + cowpea	83	MEY=4140	6.23	18000	23392	2.30
Green gram	65	356	0.91	9000	5233	1.58
Black gram	71	346	0.89	9000	4853	1.54
Potato	96	7662	51.03	40000	74930	2.87
Field pea	75	1242	3.66	12000	25270	2.90
Sunflower	92	719	2.18	12000	9563	1.80
Wheat	96	2020	6.39	14000	10234	1.73
Mustard	76	531	1.09	9000	9576	2.06

Green gram

Black gram

Potato

Mustard

Field pea

Rice

Performance of crops and cropping systems under aberrant weather conditions

Efficient energy use and management

Farmers are gradually using improved implements in addition to their conventional tools and implements. Among all the implements, Power tiller was used by maximum number of farmers and generated higher revenue through custom hiring (Rs.3290) (Table-70).

Table-70: Improved implements available at custom hiring centre used by NICRA farmers

Implement	No. of farmers (implements hired)	Revenue (Rupees)
Power tiller	14	3290
Paddy thresher	17	900
Paddy winnower	13	240
Rice reaper	11	780
Water pump	-	-
MB plough	-	-
Weeder	-	-
Sprayer	5	-

Farmer using sprayer for plant protection

Farmer using power tiller for secondary tillage

Alternate land use system

The farmers reared chicks for selling eggs and chicken. The Banaraja breed was found to benefit the farming community better than the local poultry breeds due to their better laying capacity and good growth. The obstacle for vermicomposting was unavailability of required species of earthworm and less interest among farmers.

Poultry breed - Banaraja

Chicks distributed to farmers

1.1.6. VARANASI

a. Agro-ecological setting

Varanasi center is located in Northern Plain, Rohilkhand, Avadh and south Bihar Plains (AESR 9.2) and Eastern plateau and vindhyan zone in Uttar Pradesh. The climate is hot dry sub-humid. Annual normal potential evapo-transpiration is 577 mm. Annual normal rainfall is 1078 mm. Length of growing period is 150-180 days. Drought occurs once in six years.

b. On-station experiments

During 2013, the onset of monsoon was timely during 2nd week of June i.e 16th June. A rainfall of 746.3 mm was received which was deficit by 198.2 mm compared to normal (944.5 mm) (Fig.15), during south-west monsoon (*kharif).* During north-east monsoon (October - December), 135.5 mm of rainfall was received which was excess by 74.6 mm compared to normal (60.9 mm). During summer, 19.8 mm of rainfall was received which was deficit by 12.5 mm compared to normal (32.3 mm). There were 3 dry spells during *kharif season* coinciding with 15- 25 July, 05- 20 September and 22 - to 29 September.

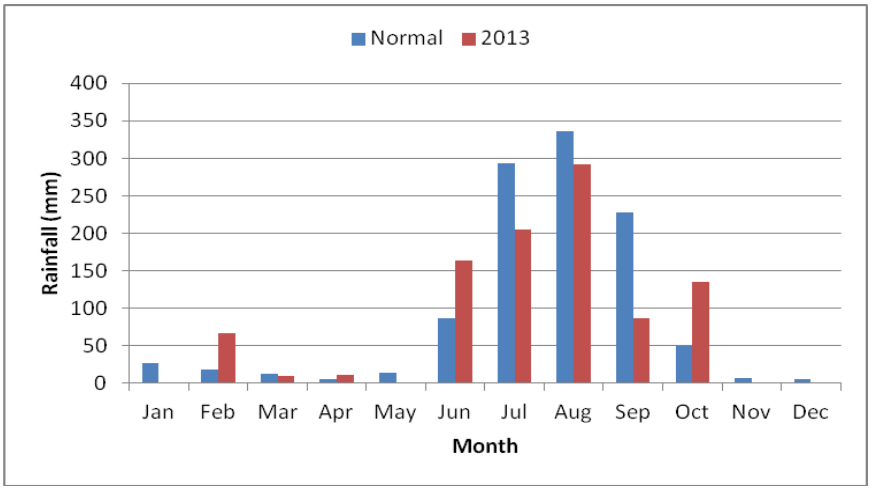


Fig.15: Normal and actual (2013) monthly rainfall at Varanasi

On-station experiments : Nil

On-farm experiments

Village profile

The program is being implemented in Terha Saraya Village, Mirzapur Dist., Uttar Pradesh. The total cultivated area is 290 ha out of which 210 ha is rainfed. The mean annual rainfall is 1191 mm with seasonal rainfall of 948 mm during *kharif* (June-September). The major soil types are sandy loam and loamy sand. The major rainfed crops during *kharif* are rice, maize, pearlmillet, greengram, pigeonpea, and wheat, chickpea, sesame, pea and linseed during *rabi*. The numbers of small, marginal, medium and large farmers are 0, 45, 85, and 120, respectively. The irrigated area is 15-25% of cultivated area.

Climate Vulnerability in General

The climate in this agro-climatic zone is semi-arid to sub-humid. Out of the total annual average rainfall of 1191 mm, the south-west monsoon contributes 80%, north-east monsoon contributes 15% and summer rainfall contributes 5%. Mirzapur district of Uttar Pradesh experienced intra-seasonal variability of rainfall (intermittent dry spells in standing crop), extreme events (flash floods, heat wave and cold wave) and unseasonal rains. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 25 to 50% deficit of the average

rainfall. The onset (south-west) of monsoon was during 26 SMW. For the last 15 years, the dry spells during crop season were experienced in July, August and September and at flowering and grain filling stages of the major rainfed crops. The onset of the monsoon had been early compared to the normal. The extreme events like unusual and high intensity rainfall in short span have been increasing during *kharif* and *rabi* seasons.

Experienced weather conditions during the year (2013-14)

The rainfall data of Varanasi centre (being the nearest agromet station) was taken for the analysis of weather conditions during the year 2013 at Pahari village. A rainfall of 735.6 mm was received which was deficit by 208.9 mm compared to normal (944 mm) (Fig.16), during south-west monsoon (*kharif).* During north-east monsoon (October - December), 138.7 mm of rainfall was received which was excess by 77.8 mm compared to normal (60.9 mm). In summer (March-May) 20 mm rainfall received which was 12.3 mm deficit as compared to the normal (32.3mm). There were dry spells during 27th June to 5th July and 26th August to 6th September in the *kharif* season.

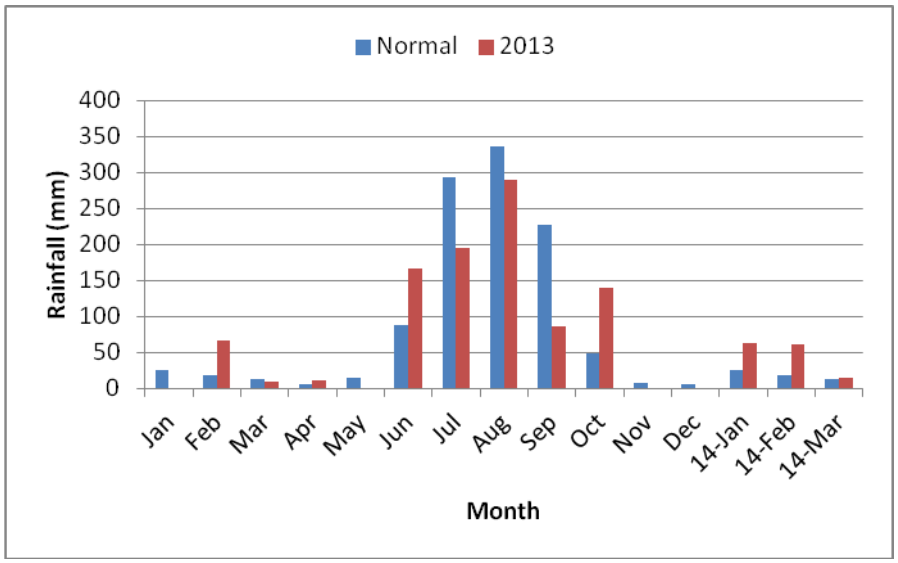


Fig.16: Normal and actual (2013) monthly rainfall at Pahari

Real time contingency plan implementation

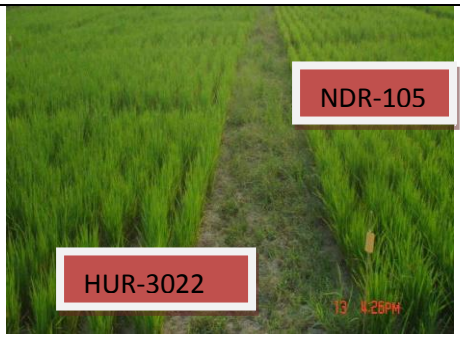
There were dry spell during 27th June to 5th July and 26th August to 6th September in the kharif season. Different varieties of rainfed rice, maize, pigeonpea and sesame during *kharif* and chickpea, lentil, field pea, mustard and linseed during rabi were demonstrated (Table-71). Among the *kharif* crops rice variety NDR-97 recorded higher mean seed yield (2433 kg/ha) but higher NMR (Rs. 58538/ha) and B:C ratio (3.79) was recorded in pigeonpea variety Malvia Chamatkar (M-13) with the mean seed yield of 1768 kg/ha. In rabi crops, chickpea gave higher seed yield as compared to other crops, among the chickpea varieties Abrodhi+ improved technique recorded higher seed yield (1832 kg/ha), NMR (Rs 39982/ha) and B:C ratio (4.11) with RWUE of 13.25. The percentage of seed yield increased by 31.9 as compared to control (Local + Local technique).

Table-71: Performance of different crops in NICRA village

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	NMR (Rs/ha)	B:C ratio
Rice	NDR-97	2433	3.86	21122	2.41
	NDR-105	2163	3.43	17511	2.17
	HUR-3022	1775	2.82	11727	1.78
Maize	Shweta	2158	4.39	18472	2.32
	Local	1784	3.63	13483	1.96
Sesame	GT-1+improved technique	571	0.88	26275	4.29
	GT-1 + Farmers' practice	508	0.78	23480	3.81

	Local variety + Farmers' practice	388	0.59	15250	2.91
	Local variety + Local technique	328	0.50	13650	3.28
Pigeonpea	Bahar	1490	1.94	46038	3.19
	NDA-1	1571	2.04	49713	3.37
	Malvia Chamatkar (M-13)	1768	2.30	58538	3.79
	Local	1043	1.36	25938	2.24
Chickpea	Abrodhi+improved technique	1832	13.25	39982	4.11
	Abrodhi + Farmers' practice	1612	11.65	33162	3.62
	Local + improved technique	1507	10.89	29907	3.38
	Local + Farmers' practice	1247	9.02	21847	2.80
Pea	MUPD-15	1807	13.06	40337	30.52
	Local	1221	9.28	22405	2.40
Lentil	HUL-57	1139	8.23	21039	2.45
	PL-406	1078	7.81	19198	2.32
	Local	669	4.83	7133	1.49
Mustard	Varunaa (T-59)	1047	7.57	33199	2.24
	Local	783	5.66	130.91.67	2.09
Linseed	Garima	823	6.00	20933	2.47
	Local	587	4.25	11618	1.97

Rice



Local variety of maize

Improved maize variety (Shweta)

GT-1 + improved technique of sesame

Local variety + improved technique of sesame

Local chickpea variety

Abrodhi +improved practice of chickpea

Field pea (MUPD-15)

Local variety of field pea

Lentil (HUL-57)

Local lentil variety

Pigeonpea (Malviya Chamatkar)

Mustard (Varuna)

Maize-mustard, maize-linseed and rice-linseed sequence cropping systems were introduced under real time rainfall situation to cope with the climate variability. The rainfall during Kharif 2013 was deficit by 22% with two dry spells of abot 10 days each during 27 June-05 July and 26 August 6 September.However,during *rabi* season. The rainfall was excess by 128% compared to normal rainfall. The highest NMR of Rs 39671/ha and B:C ratio of 2.55 were attained under maize-mustard sequence cropping system compared to other treatments (Table-72).

Table-72: Performance of component crops in cropping system demonstrated in NICRA village

Cropping system	Component crop	Yield (kg/ha)	RWUE (kg/ha-mm)	NMR (Rs/ha)	B:C ratio
Maize-Mustard	Maize	2158	4.39	18472	2.32
	Mustard	1047	7.57	21199	2.77
Maize-Linseed	Maize	2158	4.49	18472	2.32
	Linseed	829	6	20929	2.47
Rice-Linseed	Rice	2433	3.36	21122	2.19
	Linseed	587	4.25	11678	1.97

Demonstrations on ridge-furrow method of pigeonpea plantings were conducted at 12 farmers' fields, for efficient moisture conservation and coping with dry spells during crop season. Ridge-furrow method of planting not only enhanced productivity but also facilitated runoff modulation towards enhanced *in-situ* moisture conservation and improved drainage. All the three varieties of pigeonpea i.e. Bahar, NDA-1 and Chamatkar (M-13) fared well on ridges with higher net return and cost benefit ratio compared to broadcasting on flat land. Among the varieties, M-13 with ridge-furrows gave highest seed yield (1933 kg/ha) NMR (Rs.66963/ha), B:C ratio (3.04) and RWUE of 2.51 kg/ha-mm (Table-73).

Table-73: Performance of pigeonpea varieties as influenced by land configuration (12 farmers)

Verity	No. of farmers	Sowing method	Yield (kg/ha)	RWUE (kg/ha-mm)	NMR (Rs/ha)	B:C ratio
Bahar	04	Broadcasting	1205	1.57	38225	2.39
	04	Ridge furrows	1689	2.2	56016	2.55
NDA-1	04	Broadcasting	1260	1.64	40700	2.71
	04	Ridge furrows	1808	2.35	61338	2.79
M-13	04	Broadcasting	1321	1.72	43456	2.72
	04	Ridge furrows	1933	2.51	66963	3.04

Ridge-furrow planting of pigeonpea

Rainwater harvesting and efficient use

High intensity short duration rainfall is common in Vindhyan region which provide an opportunity to harvest excess runoff in farm pond. A farm pond size of 60.5 x 42 x 5 m (capacity 12420 m^3) was dug for efficient rainwater harvesting and recycling. The existing farm pond in the village of size 80 x 69 x 2.25 m was renovated (Fig.). The total water harvesting capacities of these two ponds were increased from15840 m^3 to 12420 m^3. The stored water in the farm pond during this year was efficiently utilized for supplementary irrigation of 3 cm during critical stages of the crop. The rainfall received during the year (894.3 mm) helped in maximum hydraulic load capacity. Supplementary irrigation was provided using this harvested water which helped in enhancing the yield and monetary returns of

chickpea (Avarodhi) and mustard (T-59). The ground water table near the farm pond was increased by about 0.5 m (Tables 74 & 75).

Table-74: Rainwater harvesting in the farm ponds

Weekly data	Depth of water in a pond (mm)	Evaporation (mm)	Seepage loss (mm)
Farm pond 1	4000		
1st week (SMW 40)	3924.8	3.6 (25.2)	50
2nd week	3855.5	2.9 (20.3)	49
3rd week	3783.2	2.9 (20.3)	52
4th week	3715.0	2.6 (18.2)	50
5th week	3644.6	2.2 (15.4)	55
6th week	3581.2	2.2 (15.4)	48
Farm pond 2	2000		
1st week (SMW 40)	1926.8	3.6 (25.2)	48
2nd week	1860.5	2.9 (20.3)	46
3rd week	1797.2	2.9 (20.3)	43
4th week	1740.0	2.6 (18.2)	39
5th week	1684.6	2.2 (15.4)	40
6th week	1634.2	2.2 (15.4)	35

Table-75: Performance of *rabi* crops with supplemental irrigation

Crop	Rainfall (mm) from sowing to harvest	Water used for critical irrigation	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Chickpea (Abrodhi)	76.4	3 cm	1428	17.88	13867	31840	2.27
	76.4	No irrigation	650	8.51	12000	62000	0.52
Mustard (T-59)	76.4	3cm	870	10.96	12600	11760	0.93
	76.4	3 cm	1260	15.29	13200	22080	1.67

Efficient energy use and management

As per demand of the farmers', the improved implements like ridger seeder, harrow and thresher gave higher output energy and seed yield compared to normal implements. Energy input and output for different crops and cropping system were influenced by using the improved mechanical units. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period (Table-76).

Table-76: Energy management with improved implements in rainfed crops during *rabi* season

Crop	Variety	Total energy equivalent (MJ/ha)		Output-input ratio
		Total energy input (MJ)	Total energy output (MJ)	
Varietal trial				
Paddy	NDR-97	10791	85152	7.89
	NDR-105	10791	75688	7.01
	HUR-3022	10791	62140	5.76
Maize	Shweta	10466	75542	7.22
	Local	10466	62452	5.97

Sesame	GT-1+ improved technique	10240	35989	3.51
	GT-1 + Farmers' practice	8316	32004	3.85
	Local variety + Improved technique	10240	24413	2.38
	Local variety + + Farmers' practice	8316	20633	2.48
Pigeonpea	Bahar	7947	72996	9.19
	NDA-1	7947	76998	9.69
	Malvia Chamatkar (M-13)	7947	86608	10.90
	Local	7647	51110	6.68
Chickpea	Abrodhi + improved technique	7544	89752	11.90
	Abrodhi + Farmers' practice	6974	78972	11.32
	Local + improved technique	7544	73827	9.79
	Local + Farmers' practice	6974	61087	8.76
Pea	MUPD-15	5572	88533	15.89
	Local	5572	59813	10.74
Lentil	HUL-57	5572	55798	10.01
	PL-406	5572	52818	9.48
	Local	5572	32758	5.88
Mustard	Varunaa (T-59)	8315	65961	7.93
	Local	8316	49350	5.93
Linseed	Garima	8034	51843	6.45
	Local	8034	37002	4.61
Intercropping				
Chickpea sole		6974	89752	12.87
Mustard sole		7053	51583	7.31
Chickpea + mustard (3:1)		7699	97083	12.61
Linseed sole		8034	43877	5.46
Chickpea + linseed (2:1)		7699	90515	11.76

Alternate land use & eco-system services

Agro-forestry, Agri-horti and other biological carbon capture systems help in both adaptation and mitigation. Aonla and guava based agri-horti system already planted in previous years at RGSC Barkachha showed potential in terms of efficient use of marginal lands (Table-77). Among the systems, Aonla+ sesame recorded higher net monitory returns (Rs.58600/ha) and B:C ratio (3.91).

Table-77: Performance of aonla and guava based agri-horti systems

Agri-horti system	Crop area (ha)	Yield (kg/ha)		Cost of cultivation(Rs/ha)	NMR (Rs/ha)	B:C ratio
		Fruit	Crop			
Aonla + sesame	0.25	2600	160	15000	58600	3.91
Guava + perarlmillet (Forage)	0.15	3750	6000	14600	46900	3.21

Guava and Aonla based Agri-horti systems

1.2. MAIZE BASED PRODUCTION SYSTEM

1.2.1. ARJIA

a. Agro-ecological setting

Arjia is located in north Gujarat plain (inclusion of Aravalli range and east Rajasthan Uplands) hot dry semiarid eco-sub region (AESR 4.2) and Southern zone in Rajasthan. Normal annual rainfall is 658 mm. Annual potential evapo-transpiration is 1681 mm. Length of growing period is 90-120 days.

b. On-station experiments

During the year 2013, the onset of monsoon was delayed by 8 days (first week of July). A rainfall of 747.2 mm was received which was excess by 132.7 mm compared to normal (614.5 mm) (Fig.17), during south-west monsoon (*kharif).* During north-east monsoon (October - December), 26.8 mm of rainfall was received which was excess by 6.6 mm compared to normal (20.2 mm). During summer (March- May), 5.4 mm of rainfall was received which was deficit by 9.7 mm compared to normal (15.1 mm).

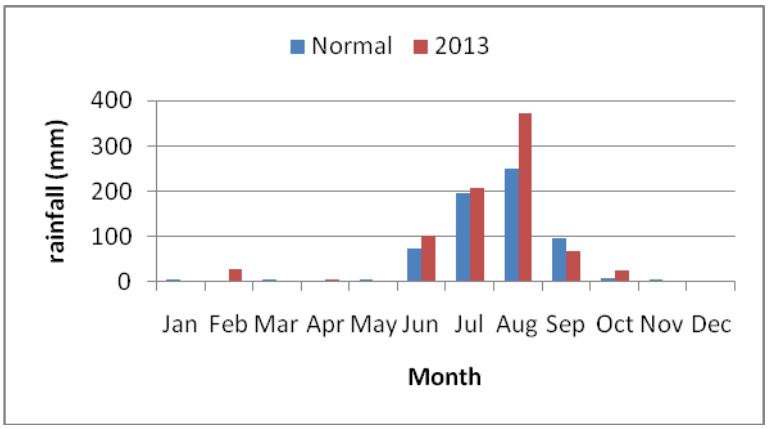


Fig.17: Normal and actual (2013) monthly rainfall at Arjia

Real time contingency plan implementation in a participatory mode

Different varieties and intercropping systems were evaluated under real rainfall situation. The rainfall received during this year was higher (806.6 mm) than average rainfall (657.7) and with uneven distribution. During the rainy season of 2013, wet spell occurred just after crop sowing from 28 July to 25 August (total 24 rainy days), thus all interculture operations like hoeing, weeding, top dressing of fertilizers, earthing etc. could not be done timely and crops were also affected adversely. Further, from 25th August to 21st September (28 days), dry spells period occurred. This period was most critical for all crops from production point of view and crops were adversely affected. The maize could not set grain and other crop yield levels were also very low (Table-78) Among different crops, groundnut (sole) produced higher pod yield (35 kg/ha) and maize equivalent yield (MEY) (919 kg/ha) followed by sole blackgram with MEY of 741 kg/ha.

Table-78: Evaluation of suitable crops and cropping systems under real rainfall situations

Treatment	Plant height (cm)	100/1000 seed wt.	Grain yield (kg/ha)	MEY (kg/ha)	Biological yield (kg/ha)
Sole maize	152.0	-	-	-	1426
Maize + blackgram (2:2)					
Sole blackgram	74.6	39.27	234	741	745
Sole greengram	82.6	26.58	75	250	410
Sole cluster bean	92.5	28.34	150	525	570
Sole sorghum (dual purpose)	201.4	-	-	-	2760

Sole sesame	86.2	-	-	-	325
Sole horsegram (AK42)	75.5	29.34	104	364	415
Sole horsegram (AK-21)	82.6	31.61	125	438	470
Sole groundnut	73.5	39.67	315	919	630
Groundnut + sesame (6:2)					
Sesame	86.4	-	-	-	-
Maize (Navjot)	147.0	-	-	-	1420
Maize (PM-3)	152.4	-	-	-	1330

Effect of agronomical practices and chemical spray on productivity of maize under real rainfall situations

During the rainy season of 2013, wet spell occurred just after crop sowing from 28 July to 25 August (total 24 rainy days). Further, from 25th August to 21st September (28 days) dry spells period occurred. Under these conditions, different mid-season corrections were evaluated to cope with dry spells. However, all the treatments failed to produce any grain yield of maize. Zinc sulphate @ 0.5% spray increased stover yield of 25.8% as compared to control (Table-79).

Table-79: Effect of agronomical practices and chemical spray on productivity on maize

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)
Control (Normal practice s)	-	1265
Reduce 25% Plant population	-	1130
Soil Stirring one time during drought	-	1340
Thio-urea spray 2%	-	1300
Soluble NPK Spray 2%	-	1350
Zinc sulphate 0.5%	-	1410

Rainwater management

Catchment-storage-command relationship for enhancing water productivity in a micro-watershed

During the year 2013, 806.8 mm rainfall was recorded out of which 747.72 mm (92.6%) was recorded during rainy season and 26.8 mm was recorded in post-monsoon season. The rainfall-runoff study indicated that the highest runoff (1022.26 cum) was recorded during the month of August (Table), which was 84.2% of total runoff produced during the year (2013). However, average runoff was recorded as 33.5% of total runoff producing rainfall (331.4 mm). Results further revealed that increase in monthly rainfall gave increased runoff (Table-80).

Table-80: Runoff from the small agricultural watershed

Month	Rainfall (mm)		Runoff (m^3)	% runoff of monthly rainfall	% runoff producing rainfall
	Monthly	Runoff producing rainfall			
June	101.3	-	0	0	0
July	205.9	66.7	191.34	4.67	14.4
August	370.9	264.7	1022.26	13.85	19.4
September	69.2	0	0	0	0
October	26.8	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
Total	774.0	331.4	1213.60	18.5	33.85

The harvested rainwater was used for cultivation of *rabi* vegetables through drip and surface irrigation methods. Among different *rabi* vegetables, coriander recorded the highest pea pod equivalent yield 4547 kg/ha with B:C ratio (3.18) and water saving by 28.5% over brinjal. The highest water productivity was recorded with coriander green. Drip irrigation method saved the water by 35% with increased pea pod equivalent yield by 11.3% (Table-81).

Table-81: Productivity and economics of *rabi* crops as influenced by recycling of harvested rainwater through different methods

Crop	Pea pod equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	NET RETURN(Rs/ha)	B:C ratio
	Pod	Stover			
Coriander green	4547	-	21745	69195	3.18
Pea	3421	6307	20234	66600	2.79
Brinjal	3844	-	22988	53972	2.35
CD (P=0.05)	236.35	-	-	-	-
Surface irrigation	3936	-	23286	55614	2.39
Drip irrigation	4378	-	19806	67755	3.42
S.EM±	19.12	-	-	-	-
CD (P=0.05)	95.7	-	-	-	-

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA centre, Arjia in Kochariya village, Suwana block, Bhilwara Tehsil, district and in Lapsiya village, Railmagra block and Rajsamand district, Rajasthan. The total cultivated area is 287 and 253 ha out of which 220 and 197 ha are rainfed at Kochariya and Lapsiya villages, respectively. The mean annual rainfall is 657.7 mm and 512.9 mm with seasonal rainfall of 603 mm and 474 mm during *kharif* (June- September) at Kochariya and Lapsiya villages, respectively. The major soil types are sandy loam and sandy clay loam at Kochariya and sandy loam at Lapsiya village. The major rainfed crops during *kharif* are maize, blackgram and groundnut at Kochariya while sorghum, maize, blackgram at Lapsiya and during *rabi* are wheat, barley and mustard in both the villages. The ground water table is 210 m and 250 m at Kochariya and Lapsiya, respectively. The source of irrigation is dug well and tube well covering 23.9 and 22.13% of cultivated area at village Kochariya and Lapsiya, respectively.

Climate vulnerability in general

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 657.7 mm, the south-west monsoon contributes 93.1%, north-east monsoon contributes 3.7% and summer contributes 3.2%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 17.8% deficit of the average rainfall. The onset (south-west) of monsoon was during 26 SMW. The dry spells during crop season were experienced for the past 15 years. They occurred in September and at reproductive stages of the major rainfed crops. The soil moisture status was deficit during reproductive stages of major rainfed crops. The maximum and minimum temperature during kharif crop growing season revealed an increase of 1.17˚C in maximum temperature and decrease of 0.79˚C as compared to their respective normal for the past 20 years. During rabi, there was a decrease of 0.96˚C in maximum temperature as compared to normal for the past 20 years. The extreme events like unusual and high intensity rainfall in short span were increasing during August. The area has been experiencing drought during kharif and frost during rabi. There has been considerable shift in rainfall pattern which resulted to change in climate from dry sub-humid to semi-arid and sowing window has been shifted by almost one week to 25 SMW for the dominant rainfed crops.

Experienced weather conditions during 2013-14

During 2013, in Kochariya village, onset of monsoon was delayed by 10 days i.e., first week of July. A rainfall of 512.3 mm was received which was deficit by 102.2 mm compared to normal (614.5 mm) (Fig.), during south-west monsoon (kharif). During north-east monsoon (October- December), 16 mm rainfall was received which was deficit by 4.2 mm compared to normal (20.2 mm). During summer (March - May), no rainfall was received which was deficit by 15.1 mm compared to normal (15.1 mm).

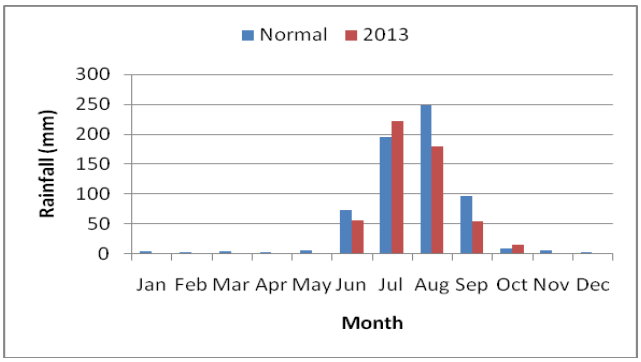


Fig.18: Normal and actual (2013) monthly rainfall at Kocharia

During 2013, in Lapsiya village, onset of monsoon was delayed by 10 days i.e., first week of July. A rainfall of 312 mm was received which was deficit by 161 mm compared to normal (473 mm) (Fig.), during south-west monsoon (*kharif).* During north-east monsoon (October- December), 10 mm rainfall was received which was deficit by 4.3 mm compared to normal (14.3 mm). During summer (March - May), no rainfall was received which was deficit by 22.5 mm compared to normal (22.5 mm).

Interventions

The major interventions implemented include land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 119 ha in 396 farmers' fields.

Real time contingency plan implementation in a participatory mode

At Kochariya, the onset of monsoon was delayed by 10 days i.e., first week of July. A rainfall of 512.3 mm was received which was deficit by 102.2 mm compared to normal (614.5 mm) during south-west monsoon (*kharif*). The rainfall was deficit by 68.9% in August and 42.1% in September adversely affecting the crops. At Kochariya, out of 4 varieties of maize in six farmers' fields, PM-3 recorded maximum yield of 2333 kg/ha and 2547 kg/ha of mean over 3 years with an increase of 25% over local variety and higher NET RETURNof Rs. 27192/ha, B:C ratio of 3.15 and RWUE of 5.56 kg/ha-mm under early monsoon condition (26th June) and around 20% deficit rainfall situation (Table-82). Similarly, in Lapsiya village, variety PM-3 performed better with 813 kg/ha of grain yield and 1597 kg/ha of mean yield over 3 years with 30.8% increase over local variety. It also recorded higher net return of Rs. 4492/ha, B:C ratio of 1.38 and RWUE of 2.72 kg/ha-mm under delayed onset of monsoon and severe drought (37% deficit rainfall) condition (Table-82).

Table-82: Yield and economics of maize varieties at Kochariya and Lapsiya villages

Village	Variety	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C Ratio
		Grain	Mean grain (3 years)	Stover					
Kochariya	PM-3	2333	2547	3583	39	5.56	12642	27192	3.15
	PEHM-2	2210	2389	3250	41	5.27	12000	25440	3.12
	Navjot	2100	2100	3083	41	5.00	12042	23525	2.95
	Local	1750	2010	2783	39	4.17	11725	18342	2.56
Lapsiya	PM-3	813	1597	2525	24.33	2.72	11933	4492	1.38
	PEHM-2	750	1496	2267	24.88	2.51	11583	3450	1.30
	Navjot	700	700	2133	24.72	2.34	11567	2500	1.22
	Local	563	1236	1875	23.17	1.88	11200	425	1.04

In a farmer's field at Kochariya, Pratap 1430 variety of sorghum gave maximum yield of 2250 kg/ha and 2539 kg/ha of mean over 3 years with an increase of 28.9% over local and higher net return of Rs 28150/ha, B:C ratio of 3.23 and RWUE of 4.41 kg/ha-mm under early monsoon condition (26th June) and around 20% deficit rainfall situation (Table-83). Under delayed onset of monsoon and severe drought (37% deficit rainfall) condition at Lapsiya village, sorghum variety Pratap 1430 gave maximum yield of 1321 kg/ha and 1602 kg/ha of mean over 3 years with higher net return of Rs. 14736/ha, B:C ratio of 2.25 and RWUE of 4.42 kg/ha-mm (Table-83).

Table-83: Yield and economics of sorghum varieties at Kochariya and Lapsiya villages

Village	Variety	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover					
Kochariya	CSV-15	1850	2235	5900	23.87	4.41	12600	22500	2.79
	CSV-17	1700	1878	4200	28.81	4.05	12600	16600	2.32
	Pratap 1430	2250	2539	6400	26.01	5.36	12600	28150	3.23
	Local	1600	1708	3600	30.77	3.81	12600	14000	2.11
Lapsiya	CSV-15	1300	1499	4779	21.39	4.35	11693	14554	2.25
	CSV-17	1171	1438	2521	31.73	3.92	11550	7639	1.66
	Pratap-1430	1321	1602	4786	21.64	4.42	11764	14736	2.25
	local	907	1116	2881	23.97	3.03	11486	5696	1.50

Out of 4 varieties of blackgram, T-9 proved to be best with 375 kg/ha of yield and 463 kg/ha of mean over 3 years with 30.7 % increase in yield over local variety under early monsoon condition (26th June) and around 20% deficit rainfall situation of Kochariya (Table-84). At Lapsiya under delayed onset of monsoon and severe drought (37% deficit rainfall) condition in 3 farmers' fieldss, out of 3 blachgram varieties, T-9 recorded maximum grain yield of 168 kg/ha and 289 kg/ha of mean over 3 years with 29.8% increase over local variety (Table-84).

Table-84: Yield and economics of blackgram varieties at Kochariya and Lapsiya villages

Village	Variety	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
		Seed	Mean seed (3 yrs)	Stover					
Kochariya	T-9	375	463	600	38.46	0.89	14250	75	1.01
	TAU-1	350	399	583	37.50	0.79	14583	-1167	0.92
	TAU- 2	290	427	500	34.21	0.62	14237	-4137	0.71
	local	260	279	-	-	-	-	-	-
Lapsiya	T-9	168	289	325	34.10	0.56	11300	-4596	0.59
	TAU-1	133	127	317	29.72	0.45	11150	-5692	0.49
	local	118	234	317	27.24	0.40	11217	-6283	0.44

In a groundnut varietal trial with 3 varieties in 3 farmers' fieldss under early monsoon condition (26th June) and around 20% deficit rainfall situation in Kochariya, TG -37A recorded maximum pod yield of 1200 kg/ha and 1917 kg/ha of mean yield over 3 years, net return of Rs. 41680/ha , B:C ratio of 3.45 and the increase in yield was 4.2% (Table-85). At Lapsiya under delayed onset of monsoon and severe drought (37% deficit rainfall) condition, in a groundnut varietal trial of 4 varieties at 2 farmers' fields , TG 37 A gave maximum yield of 663 kg/ha, 1465 kg/ha of mean yield over 3 years, net return of Rs.19763/ha and B:C ratio of 2.44 compared to local variety with 450 kg/ha, Rs.10750/ha and 1.83, respectively. The increase in yield was 32.1% (Table-85).

Table-85: Yield and economics of groundnut varieties at and Lapsiya villages

Village	Variety	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return(Rs/ha)	B:C ratio
		Pod	Mean pod	Stover					
Kochariya	TG-37A	1200	1917	1560	43.48	2.86	17000	41680	3.45
	TAG-24	1150	1796	1495	43.48	2.74	16367	39868	3.44
	Local	967	967	1317	42.29	2.30	17303	30147	2.75
Lapsiya	TPG 41	500	1100	1225	28.91	1.67	14150	12025	1.85
	TG 37A	663	1465	1175	36.06	2.22	13575	19763	2.46
	TAG 24	633	1375	1275	33.16	2.12	13950	18338	2.31
	Local	450	450	1175	27.61	1.51	13025	10750	1.83

Evaluation of intercropping/sequence cropping systems

Different intercropping systems were demonstrated in farmers' fields as an insurance against rainfall variability. At Kochariya, the improved practice of maize + blackgram 2:2 intercropping system at 6 farmers' fields gave 2723 kg/ha of maize equivalent yield which was 17.1% increase over farmers' practice (2365 kg/ha) and the net return of Rs.32723/ha and B:C ratio of 3.41 (Table-86). At Lapsiya, improved practice of maize + blackgram (2:2) gave higher maize equivalent yield of 1088 kg/ha with 20.8% increase over farmers practice of mixed cropping system, and 1387 kg/ha of mean equivalent yield over 3 years, net return of Rs.10073/ha and B:C ratio of 1.88 (Table-86).

Table-86: Yield and economics of maize + blackgram (2:2) intercropping at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)				Maize equivalent yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return(Rs/ha)	B:C Ratio
		Seed		Stover							
		Maize	Black-gram	Maize	Black-gram	Seed	Mean (3 yrs)				
Kochariya	Improved practice	2350	149	3692	324	2723	2851	6.49	13592	32723	3.41
	Farmers' practice	1877	118	2892	230	2173	2365	5.18	13025	23748	2.82
Lapsiya	Improved practice	808	112	2833	263	1088	1387	3.64	11475	10073	1.88
	Farmers' practice	596	80	1942	196	796	1137	2.66	10967	4548	1.42

At Kochariya in 5 farmers' fields, improved practice of groundnut + sesame (6:2) recorded maximum yield of groundnut equivalent (1326 kg/ha, 1497 kg/ha of mean over 3 years, net return of Rs.46925/ha and B:C ratio of 3.57 with an increase of 14.5% over farmers practice of mixed cropping with 1134 kg/ha, 1155 kg/ha of mean over years, net return of Rs 38153/ha and B:C ratio of 3.18 (Table-87). At Lapsiya village with 6 farmers, improved practice of groundnut + sesame (6:2) intercropping system gave 23.8% increase in groundnut equivalent yield (529 kg/ha), 679 kg/ha of mean equivalent yield over 3 years, higher net return of Rs.13838/ha and B:C ratio of 1.98 over farmers' practice with pod yield of 403 kg/ha and 530 kg/ha of mean over 3 years, net return of Rs. 7848/ha and B:C ratio of 1.56 (Table-87).

Table-87: Yield and economics of groundnut + sesame (6:2) intercropping at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)				Groundnut equivalent yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C Ratio
		Seed		Stover							
		Ground-nut	Sesame	Ground-nut	Sesame	Seed	Mean (3 yrs)				
Kochariya	Improved practice	1178	74	1820	180	1326	1497	3.16	18250	46925	3.57
	Farmers' practice	1018	58	1550	130	1134	1155	2.70	17560	38153	3.18
Lapsiya	Improved practice	375	77	1380	250	529	679	1.77	14170	13838	1.98
	Farmers' practice	285	59	1180	210	403	530	1.35	13880	7848	1.56

The improved practice of sorghum + greengram (2:1) intercropping gave 21.6% increase in sorghum equivalent yield at 2 farmers' fields in Kochariya village with a equivalent yield of 2759 kg/ha and 2819 kg/ha of mean over 3 years, net return of Rs 30288/ha and B:C ratio of 3.16 over farmers' practice of mixed cropping (sorghum equivalent of 2164 kg/ha) (Table-88). At Lapsiya at 5 farmers' fields, improved practice of sorghum + greengram (2:1) intercropping recorded maximum equivalent yield of 1941 kg/ha, net return of Rs.27145/ha and B:C ratio of 3.39 with 26.5% increase in equivalent yield over farmers practice with equivalent yield of 1427 kg/ha, net return of Rs.16695/ha and B:C ratio of 2.49 (Table-88).

Table-88: Yield and economics of sorghum + greengram (2:1) intercropping at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)				Sorghum equivalent yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C Ratio
		Seed		Stover							
		Sorghum	Green-gram	Sorghum	Green-gram	Seed	Mean (3 yrs)				
Kochariya	Improved practice	2125	155	5250	335	2759	2819	6.58	14025	30288	3.16
	Farmers' practice	1775	95	4000	230	2164	2139	5.16	13225	21150	2.60
Lapsiya	Improved practice	1450	120	5740	1130	1941	6870	6.49	11380	27145	3.39
	Farmers' practice	1100	80	4020	850	1427	4870	4.77	11180	16695	2.49

Rainfall: 299.0 mm

The rainfall of 312 mm was received which was deficit by 161 mm compared to normal (473 mm), during south-west monsoon (*kharif).* During north-east monsoon (October- December), 10 mm rainfall was received which was deficit by 4.3 mm compared to normal (14.3 mm). At Lapsiya at 5 farmers' fieldss, improved practice of blackgram + sesame (2:2) intercropping system gave an equivalent yield of 554 kg/ha, 465 kg/ha of mean equivalent. yield over 3 years, net return of Rs. 12678/ha and B:C ratio of 2.33 and the increase in yield was 35.6% over farmers practice of mixed cropping with equivalent yield of 357 kg/ha, 328 kg/ha of mean over 3 years, net return of Rs.512/ha and B:C ratio of 1.56 (Table-89).

Table-89: Yield and economics of blackgram+ sesame (2:2) intercropping at Lapsiya village

Treatment	Yield (kg/ha)				Blackgram equivalent yield		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Seed		Stover							
	Black gram	Sesame	Black gram	Sesame	Seed	Mean (3 yrs)				
Improved practice	335	85	1070	225	554	465	1.85	9510	12678	2.33
Farmers' practice	190	65	650	160	357	328	1.19	9090	5124	1.56

The improved production technologies of different crops were demonstrated in both Kochariya and Lapsiya villages. At Kochariya in 3 farmers' fields, improved practices in maize gave maximum yield of 2533 kg/ha, mean yield over 3 years 2447 kg/ha, net return of Rs.30100/ha and B:C ratio of 3.07 with 14.5% increase over farmers' practice (2133 kg/ha, 2093 kg/ha, Rs. 24233/ha and 2.77, respectively) (Table-90). Similarly, the improved practice for in maize at Lapsiya in 4 farmers' fields gave grain yield of 843 kg/ha with increase of 24.3% over farmers practices (638 kg/ha) and 1503 kg/ha of mean over 3 years, net return of Rs.6333/ha and B:C ratio of 1.56 (Table-90).

Table-90: Yield and economics of maize as influenced by improved practices

Village	Treatment	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return(Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover					
Kochariya	Improved practice	2533	2447	4600	35.51	6.04	14567	30100	3.07
	Farmers' practice	2133	2093	4050	34.49	5.08	13733	24233	2.77
Lapsiya	Improved practice	843	1503	2900	22.51	2.82	11263	6333	1.56
	Farmers' practice	638	1176	2438	20.71	2.13	10713	3088	1.29

The improved in sorghum at Kochariya in 4 farmers' fields recorded maximum yield of 2231 kg/ha with increase of 15.5% over farmers practice (1886 kg/ha). The improved practices gave net return of Rs. 25631/ha and B:C ratio of 2.83 (Table-91). At Lapsiya in 5 farmers' fields, improved practices in sorghum (1350 kg/ha) performed better with 29.6% increase in grain yield over farmers practice (950 kg/ha). Improved practices gave net return of Rs. 17365/ha and B:C ratio of 2.64, while farmers' practice gave net return of Rs. 11620 and 2.19 (Table-91).

Table-91: Yield and economics sorghum crop as influenced by improved practices

Villages	Treatment	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return(Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover					
Kochariya	Improved practice	2231	2277	6025	27.03	5.32	13975	25631	2.83
	Farmers' practice	1886	1956	5385	25.90	4.50	13485	20726	2.54
Lapsiya	Improved practice	1350	1709	5250	20.47	4.52	10610	17365	2.64
	Farmers' practice	950	1295	4360	17.88	3.18	9730	11620	2.19

At Lapsiya in 4 farmers' fields, improved practices in blackgram gave seed yield of 288 kg/ha (35.8% increase over farmers practice with 185 kg/ha), 318 kg/ha of mean over 3 years, net return of Rs. 513/ha and B:C ratio of 1.05 (Table-92). The rainfall was deficit by 68.9% in August and 42.1% in September adversely affecting the crop. Similarly**,** improved practices in greengram at Lapsiya in 3 farmers' fields gave 270 kg/ha of yield with 33.3% increase over farmers' practice (180 kg/ha), 293 kg/ha of mean yield over 3 years, net return of Rs. 3883/ha and B:C ratio of 1.41 (Table-92).

Table-92: Yield and economics of blackgram and greengram at Lapsiya village

Crop	Treatment	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Mean seed (3 yrs)	Stover					
Blackgram	Improved practice	288	318	475	37.66	0.96	10738	513	1.05
	Farmers' practice	185	215	319	36.76	0.62	10188	-2916	0.71
Greegram	Improved practice	270	293	467	36.66	0.90	9433	3883	1.41
	Farmers' practice	180	202	342	34.51	0.60	9083	-129	0.99

Evaluation of agro advisory services in different crops

Agro-advisories were issued to farmers during *kharif* season for performing of different farm operations. An on farm trial on effect of agro advisory services on maize yield were conducted at four farmers' fields of village Kochariya with plot size of 0.2 ha each. Improved practices with agro advisory services gave 24.05% higher grain yield (2450 kg/ha) over farmers' practice (1975 kg/ha). The results revealed that improved practices gave higher net returnof Rs. 28638/ha and B:C ratio of 3.04 (Table-93). Similarly, in two farmers' fields of village Lapsiya, improved practices with agro advisory services gave 29.63% higher grain yield (875 kg /ha) over farmers' practice (675 kg/ha). The results revealed that improved practice s gave higher net return of Rs. 6775/ha and B:C ratio 1.60 (Table-93).

Table-93: Yield and economics of maize as influenced by agro-advisory based improved practices

Village	Treatment	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover					
Kochariya	Improved practice	2450	2445	4175	36.97	5.84	14013	28638	3.04
	Farmers' practice	1975	1971	3775	34.35	4.71	13500	21700	2.61
Lapsiya	Improved practice	875	1726	2950	22.88	2.93	11375	6775	1.60
	Farmers' practice	675	1400	2525	21.10	2.26	10825	3675	1.34

An on farm on trial effect of agro advisory services on yield of sorghum were conducted at four farmers' fields of village Kochariya with plot size of 0.2 ha each. Improved practices with agro advisory services gave 27.48% higher grain yield (2375 kg/ha) over farmer practice (1863 kg/ha), 2428 kg/ha of mean over 3 years, net return of Rs 26775/ha and B:C ratio of 2.82 (Table-94). At Lapsiya, improved practices of agro advisory services gave 29.35% higher grain yield (1410 kg/ha) over farmers' practice (1090 kg/ha), 1688 kg/ha of mean yield over 3 years with a higher net return of Rs. 18190/ha and B:C ratio of 2.61 (Table-94).

Table-94: Yield and economics of sorghum as influenced by agro-advisory based improved practices

Villages	Treatment	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover					
Kochariya	Improved practice	2375	2428	6150	27.86	5.66	14725	26775	2.82
	Farmers' practice	1863	1966	5750	24.47	4.44	14115	20748	2.47
Lapsiya	Improved practice	1410	1688	5580	20.17	4.72	11270	18190	2.61
	Farmers' practice	1090	1337	4630	19.04	3.65	10700	12865	2.20

An on farm trial on effect of agro advisory services on groundnut yield were conducted at one farmers' field of village Kochariya. Improved practice with agro advisory services gave 29.41% higher grain yield 1100 kg/ha over farmers' practice (850 kg/ha), 1250 kg/ha of mean yield over 3 years, higher net return of Rs. 36500/ha and B:C ratio of 3.00 (Table-95). In village Lapsiya, improved practice of agro advisory services gave 66.67% higher grain yield (375 kg/ha) over farmers' practice (225 kg/ha), 1063 kg/ha of mean over 3 years, net return of Rs. 5825/ha and B:C ratio of 1.40 (Table-95).

Table-95: Yield and economics of groundnut under agro advisory based improved practices

Village	Treatment	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Seed	Mean seed (3 yrs)	Stover					
Kochariya	Improved practice	1100	1250	1750	38.60	2.62	18250	36500	3.00
	Farmers' practice	850	1063	1280	39.91	2.03	17360	24730	2.42
Lapsiya	Improved practice	375	1063	1150	24.59	1.25	14500	5825	1.40
	Farmers' practice	225	838	900	20.00	0.75	12500	325	1.03

Real time contingency plan implementation in a participatory mode during *rabi* 2013-14

Evaluation of varieties of wheat at different locations

During north-east monsoon (October- December),16 mm rainfall was received in Kochariya village which was deficit by 4.2 mm compared to normal (20.2 mm). Further, the entire rainfall(16 mm) occurred during October while no rainfall was received during November and December months. An on farm trial on different varieties of wheat were conducted at seven farmers' fields of village Kochariya. The results revealed that improved variety Raj 4037 gave 16.24% higher grain yield (4364 kg/ha) over the local cultivars (3754 kg/ha) and mean over 3 years (4568 kg/ha). Raj 4037 variety also gave highest net return(Rs 58364/ha) and B:C ratio of 3.17 of compared to local cultivars (Table-96). During north-east monsoon (October- December), only10 mm rainfall was received in Lapsiya village which was deficit by 4.3 mm compared to normal (14.23mm). Improved variety of wheat i.e. Raj 4037 gave 17.12 per cent higher grain yield (4275 kg/ha) over the local cultivars (3650 kg/ha), 4507 kg/ha of mean over 3 years and Raj 4037 variety also gave highest net return of (Rs 56150/ ha) and B:C ratio 3.23 in compared to local cultivar (Table-96).

Table-96: Yield and economics of wheat varieties at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)			Harvest index (%)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover				
Kochariya	Raj 4037	4364	4568	6600	39.80	26900	58364	3.17
	Local	3754	3888	5650	39.92	25275	47981	2.90
Lapsiya	Raj 4037	4275	4507	5750	42.64	25225	56150	3.23
	Local	3650	3774	5000	42.20	24250	45500	2.88

Different varieties of mustard were demonstrated at six farmers' fields of village Kochariya with plot size of 0.2 ha each. The results revealed that improved variety of mustard i.e. Laxmi gave 31.56% higher seed yield (1267 kg/ha) over the local cultivar (963 kg/ha). Laxmi variety also gave highest NET RETURN(Rs 24350/ha) and B:C ratio (2.67) compared to local cultivar (Rs. 15187/ha), B:C ratio of 2.03 (Table-97). Similarly, in three farmers' fields of village Lapsiya, improved variety of mustard i.e. Laxmi gave 14.36% higher seed yield (1258 kg/ha) over the local cultivar (1100 kg/ha). Laxmi variety also gave highest net return of Rs 24025/ha and B:C ratio (2.63) compared to local cultivar (Rs. 2023 /ha, B:C ratio 2.48) (Table-97).

Table-97: Yield and economics of mustard varieties at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)		Harvest index (%)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover				
Kochariya	Laxmi	1267	2300	35.51	14683	24350	2.67
	Local	963	2083	31.62	14833	15187	2.03
Lapsiya	Laxmi	1258	2300	35.37	14767	24025	2.63
	Local	1100	2067	34.73	13733	20233	2.48

An on farm trial on different varieties of taramira were conducted at six farmers' fields of village Kochariya with plot size of 0.2 ha each. The results revealed that improved variety of taramira i.e. RTM-2002 gave 37.51% higher seed yield (1093 kg/ha) over the local cultivar (683 kg/ha). RTM-2002 variety also gave highest net return(Rs 22950 /ha) and B:C ratio (2.91) followed by RTM-314 (Rs 18617/ha, B:C ratio 5.53) compared to local cultivar (Table-98). In Lapsiya village, improved variety of taramira i.e. RTM-2002 gave 37.51% higher seed yield (1225 kg/ha) over the local cultivar (775 kg/ha). RTM-2002 variety also gave highest net return of (Rs 28725/ha) and B:C ratio (3.46) followed by RTM-314 (Rs 25250/ha, B:C ratio (3.11) compared to local cultivar (Table-98).

Table-98 : Yield and economics of taramira varieties at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)		Harvest index (%)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover				
Kochariya	RTM-314	958	2017	32.21	12150	18617	2.53
	RTM-2002	1093	2192	33.26	12017	22950	2.91
	Local	683	1725	28.38	10900	11300	2.04
Lapsiya	RTM-314	1125	2350	32.37	11975	25250	3.11
	RTM-2002	1225	2450	33.33	11700	28725	3.46
	Local	775	1800	30.04	10450	15375	2.47

During north-east monsoon (October- December), 16 mm rainfall was received which was deficit by 4.2 mm compared to normal (20.2 mm). During summer (March - May), no rainfall was received. An on farm assessment of the effect of zinc sulphate application for mid season correction in wheat was conducted at five farmers' fields of village Kochariya plot size of 0.2 ha each. The results revealed that application of zinc sulphate on wheat gave 21.66 per cent higher grain yield (4386 kg/ha) over the control (3605 kg/ha) and 4596 kg/ha of mean yield over 3 years. Application of zinc sulphate on wheat also gave highest net return of Rs 59004/ ha and B:C ratio (3.24) compared to control (Rs 44909/ha, B:C ratio 2.78) (Table-99). Similarly, at three farmers' fields of village Lapsiya, plot size of 0.2 ha each. zinc sulphate application recorded 16.63 per cent higher grain yield (4230 kg/ha) over the control (3658 kg/ha). Application of zinc sulphate on wheat also gave highest net return of Rs 58150/ha and B:C ratio of 3.45 compared to control (Rs. 46175/ha and B:C ratio 3.02) (Table-99).

Table-99: Yield and economics of application of zinc sulphate on wheat at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)			Harvest index (%)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover				
Kochariya	Zinc sulphate	4386	4596	6560	40.07	26460	59004	3.24
	Control	3605	3791	5340	40.30	25180	44909	2.78
Lapsiya	Zinc sulphate	4230	4453	6133	40.82	23700	58150	3.45
	Control	3658	3795	4733	43.59	22900	46175	3.02

An on farm trial on effect of different chemicals on wheat was conducted at four farmers' fields of village Kochariya with plot size of 0.2 ha each. The results revealed that spray of thiourea @ 0.5% on wheat gave 21.02% higher grain yield (4593 kg/ha) over the control (3795 kg/ha) and 4555 kg/ha of mean over 3 years. Spray of

thiourea @ 0.5% on wheat also gave highest net return of Rs 62363/ha and B:C ratio of 3.30 followed by spray of KCl @ 0.1% (Rs 59225/ ha) and B:C ratio of 3.27) compared to control (Rs 48825/ ha, B:C ratio 2.93) (Table-100). Similarly, at three farmers' fields of village Lapsiya, spray of thiourea @ 0.5% gave 17.91% higher grain yield (4383 kg/ha) over the control (3717 kg/ha). Spray of thiourea @ 0.5% also gave highest net return (Rs 58150/ha) and B:C ratio (3.22) followed by spray of KCl @ 0.1% (Rs 53700/ha, B:C ratio 3.10, spray of Kaolin @ 0.5% (Rs 51617/ha, B:C ratio 3.03) compared to control (Rs 46733/ ha, B:C ratio 2.97) (Table-100).

Table-100: Effect of different chemicals on grain yield and economics of wheat at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)			Harvest index (%)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover				
Kochariya	Thiourea @ 0.5%	4593	4555	6875	40.05	27150	62363	3.30
	KCl @ 0.1%	4375	4384	6575	39.96	26125	59225	3.27
	Kaolin @ 5%	4338	4261	6650	39.48	26175	58838	3.25
	Control	3795	3683	5750	39.76	25350	48825	2.93
Lapsiya	Thiourea @ 0.5%	4383	4580	6200	41.42	26200	58150	3.22
	KCl @ 0.1%	4200	4328	5433	43.60	25600	53700	3.10
	Kaolin @ 5%	4083	4146	5267	43.68	25433	51617	3.03
	Control	3717	3703	4900	43.14	23717	46733	2.97

Demonstrations were conducted on improved practices of different rabi crops for coping with rainfall variability (no rainfall during November and December months) in both Kochariya and Lapsiya villages. An on farm trial on mustard was conducted at seven farmers' fields of village Kochariya with plot size of 0.2 ha each The improved practices in mustard gave 17.62% higher seed yield (1201 kg/ ha) over the farmer practice (1021 kg/ha) and 1241 kg/ha of mean over 3 years. Improved practices in mustard also gave highest net return of Rs. 26045/ha and B:C ratio of 2.77 compared to farmers' practice (Rs. 19966/ha and B:C ratio 2.36) (Table-101). During 2013 north-east monsoon (October- December), 10 mm rainfall was received which was deficit by 4.3 mm compared to normal (14.3 mm). During summer (March - May), no rainfall was received which was deficit by 22.5 mm compared to normal (22.5 mm).An on farm trial on mid season correction in mustard were conducted at five farmers' fields of village Lapsiya plot size of 0.2 ha each. The improved practice of mid season correction in mustard gave 18.91 per cent higher grain yield (1320 kg/ha) over the farmer practice (1110 kg/ha) and 1314 kg/ha of mean yield over 3 years. Improved practice in mustard also gave highest net return of (Rs. 26480/ha and B:C ratio 2.86 in comparison to farmer practice (Rs. 21330/ ha and B:C ratio 2.65 (Table-101).

Table-101: Yield and economics of mustard at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)			Harvest index (%)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Mean grain (3 yrs)	Stover				
Kochariya	Improved practice	1201	1241	2329	34.02	14743	26045	2.77
	Farmers' practice	1021	1017	2003	33.78	14743	19966	2.36
Lapsiya	Improved practice	1320	1314	2460	34.91	14260	26480	2.86
	Farmers' practice	1110	1068	2060	35.01	12920	21330	2.65

In an on-farm assessment for suitability of gram + mustard (4:1) inter-cropping system at Kochariya in 3 farmers' fields, maximum grain yield of 1480 kg/ha of gram and 60 kg/ha of mustard was recorded under improved practice, with net return of Rs. 56535/ha and B:C ratio of 4.84 in gram + mustard (4:1) intercropping system. The mixed cropping of gram + mustard gave a gram yield of 1077 kg/ha, mustard yield of 35 kg/ha, net return of Rs. 37675/ha and B:C ratio of 3.72. The improved intercropping system of gram + mustard (4:1) gave 27.61% higher gram equivalent yield over mixed cropping (Table-102). In an on-farm assessment for suitability of

inter-cropping system at Lapsiya, maximum seed yield of 1473 kg/ha of gram and 75 kg/ha of mustard under improved practice, with net return of Rs. 56760/ha and B:C ratio of 4.85 were attained in gram + mustard (4:1) intercropping system. The mixed cropping of gram + mustard gave a gram yield of 990 kg/ha, mustard yield of 45 kg/ha, net return of Rs. 34193/ha and B:C ratio of 3.48. The improved intercropping system of gram + mustard (4:1) gave 33.01% higher gram equivalent yield to mixed cropping (Table-102).

Table-102: Yield and economics of gram + mustard (4:1) intercropping at Kochariya and Lapsiya villages

Village	System	Yield (kg/ha) (Grain)		Yield (kg/ha) (Stover)		Gram equivalent Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
		Gram	Mustard	Gram	Mustard	Grain	Stover			
Kochariya	Improved practice	1480	60	1550	140	1521	1585	14705	56535	4.84
	Farmers' practice	1077	35	1300	80	1101	1320	13840	37675	3.72
Lapsiya	Improved practice	1473	75	1825	170	1524	1868	14730	56760	4.85
	Farmers' practice	990	45	1250	105	1021	1276	13798	34193	3.48

Rainwater harvesting (*in situ and ex situ*) and its efficient use

***In-situ* moisture conservation in maize at different locations**

An on farm demonstration on *in-situ* moisture conservation in maize was conducted at three farmers' fields of village Kochariya with plot size of 0.2 ha each. The *in-situ* moisture conservation in maize gave 20% higher grain yield (2400 kg/ha) over the farmers' practice (2000 kg/ha) and 2636 kg/ha of mean over 3 years. *In-situ* moisture conservation also gave highest net return of Rs 28350/ha and B:C ratio 3.10 over farmers' practice (Rs 23483/ha and B:C ratio 2.88) (Table-103).

Table-103: Yield and economics of *in-situ* moisture conservation practices at Kochariya village (3 farmers)

Treatment	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Grain	Mean grain (3 yrs)	Stover					
Improved practice	2400	2636	4133	36.74	5.72	13517	28350	3.10
Farmers' practice	2000	2198	3983	33.41	4.77	12483	23483	2.88

An on farm demonstration on *in-situ* moisture conservation in sorghum was conducted at four farmers' fields of village Lapsiya with plot size of 0.2 ha each. The *in-situ* moisture conservation gave 26.67% higher grain yield (1425 kg/ha) over the farmers' practice (1125 kg/ha) and 1604 kg/ha of mean yield over 3 years. *In-situ* moisture conservation also gave highest net return of Rs 20225/ha and B:C ratio 3.08 over farmers' practice (Rs 14238/ha, B:C ratio 2.53) (Table-104).

Table-104: Yield and economics of sorghum as influenced by *in-situ* moisture conservation practices at Lapsiya village (4 farmers)

Treatment	Yield (kg/ha)			Harvest index (%)	RWUE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Grain	Mean grain (3 yrs)	Stover					
Improved practice	1425	1604	5700	20.02	4.77	9700	20225	3.08
Farmers' practice	1125	1375	4475	20.10	3.76	9325	14238	2.53

a) Rainwater harvesting structure – *Kuchha* farm pond

Dugout farm ponds have been constructed having capacity 1242 CUM (Size: top-18x30m, bottom-12x24m, depth 3m) at farmer's field at village Kochriya during the year 2012. The catchment area of the pond is 55 ha and it has a command area of 1.75 ha. An on farm trial on rainwater harvesting and recycling was conducted at village Kochriya and there was an increase of 69.09 % in net return (Rs 49110) due to farm pond technology against traditional practice (Rs.18250) during the year 2013-14 (Table -105).

Table-105: Yield and economics of rainwater harvesting and recycling with *Kuccha* farm pond

Particular	Improved/present production technologies	Traditional/past production practices
Crop (ha)	Maize + black gram (2:2)-0.5, Groundnut + sesame (6:2) - 0.375, Cluster bean -0.5, Mustard- 0.6, Barley- 0.2, Gram-0.1	Maize +blackgram (Mixed) -1
Productivity (kg)	1275 (110), 350 (45), 275, 1150, 540,120	1950+80
Maize equivalent yield (kg)	7186.4	2150
Additional cost (Rs)	9000	-
Cost of production (Rs)	42500	11850
Net income (Rs)	49110	18250

b) Rainwater harvesting structure – *Pucca* farm pond

A dugout farm pond has been constructed having capacity of 240 CUM (Size: top-11.6x12 m, bottom-4.2x 4.5 m, depth 3m) at farmer's field at village Bagatpura during the year 2012 with cement concrete lining (1:4:8) of 5.0 cm thickness. The catchment area of the pond is 5 ha and it has a command area of 0.75 ha. An on farm trial on rainwater harvesting and recycling was conducted at village Bagatpura and there was an increase of 144% in net return (Rs 44563) due to farm pond technology against traditional practice (Rs. 18250) during the year 2013-14 (Table-106)..

Table-106 : Yield and economics of rainwater harvesting and recycling with *Pucca* farm pond

Particulars	Improved / present production technologies	Traditional / past production practices
Crop (ha)	Maize + black gram (2:2)-0.4 Groundnut + sesame (6:2) - 0.2	Sorghum-0.6
Productivity (kg)	1350 (220), 225 (40)	650
Maize equivalent yield (kg)	1900, 305	650
Additional cost (Rs)	8000	-
Cost of production (Rs)	11100	11850
Net income (Rs)	44563	18250

c) Rainwater harvesting structure – *NADI*

A *nadi* has been renovated (deepened the existing nadi (size 111375 cum) and modified the outlet for improving the recycling of harvested water) in the year 2011-12 for harvesting the rainwater of at village Mandpiya, Panchayat Kochriya, P.S. Suwana, Dist. Bhilwara-Rajasthan. After having such an assured water source, cropping plan has been changed and Chickpea was taken in *rabi* 2013 and higher net return of Rs. 264500 was recorded due to renovation of *nadi* with a B:C ratio of 1.80 (Table-107).

Table-107 :Yield and economics of rainwater harvesting and recycling at NADI

Area (ha)	Yield (kg/ha)		Harvest index (%)	Harvested water applied	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Seed	Stover					
12.0	12500	24000	34.25	5 cm	147000	264500	1.80

Efficient energy use and management

A custom hiring centre was established in one of the NICRA village (Kochariya) to improve the timeliness and precision in different farm operations is a participatory mode. The improved implements *viz.*; Reversible disc plough, MB plough, Chiesel plough, cultivator, Rota-til-drill, intercropping seed drill, Multi crop seed drill, Two

row seed drill, Hand seed drill, Arjia wheel hoe, Single row power weeder (four stroke) , Single row power weeder (two stroke), three row power weeder, Battery operated power sprayer, duster and Chaff Cutter (Electric) were provided to farmers on a nominal hiring charges. The custom hiring centre was used by 186 farmers in 82.9 ha area during the year 2013-14 (Table-108).

The farmers of the village have appreciated the effectiveness of the custom hiring centre for creating awareness about improved implements and improving the availability of implements thereby improving the precision and timeliness in farm operation. The farmers from the nearby village also used to come to Kochariya village to see the new implements and they have also demanded for such scheme from their political leaders.

Table-108: Details of implements used under customer hiring centre

Type of machinery/ equipments used	Number of equipments	Type of farm operation	Number of farmers/ area covered (ha)	Diesel consumption (lit/hr/operation)
Reversible disc plough	One	Primary tillage	12, 6.5 ha	3.3
Intercropping seed drill	One	Sowing	30,5.7 ha	1.2
Cultivator	One	Secondary tillage	40,13.9	2.8
Chiesel plough	One	In-situ moisture conservation	4,0.9	3.2
Cell type seed drill (TD)	One	Sowing of groundnut and all crops	24,9.8 ha	1.2
Two row seed drill	three	Sowing	11,9 ha	1.25 ha/day/bullock power
Single row power weeder (Four stroke)	One	Interculture	5,6.2 ha	0.5
Single row power weeder (Two stroke)	One	Interculture	3, 4.6 ha	0.65
Three row power weeder	One	Interculture	7, 14.4 ha	0.7
Battery operated power sprayer	Three	Spraying	45,10.2 ha	8 hrs per charging
Duster	One	Dusting	6,2	Manual
		Total	186, 82.9	

Alternate land use / Integrated farming system for carbon sequestration and ecosystem services

Establishment of Silvipastoral system

The major components of the model consist of forage (*Cenchrus setgerus –CAZRI-76*) and perennial tree components. *In-situ* rainwater management (contour trenches at 8 m interval) has been taken as a critical input to stabilize the yields. An on-farm demonstration on improved silvi-pasture model on non-arable land was conducted with full package of practice. The area of each demonstration was 1.2 ha. Improved grasses with rainwater conservation practices performed better and gave highest dry grass yield (6900 kg/ha) as compared to local grass (2200 kg/ha) during the very second year of establishment. The improved practice gave net return of Rs. 27600/ha and B:C ratio (6.90) compared to farmers' practice (Table-109).

Table-109 : Yield and economics of silvipastoral system

Grass	Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Cenchrus setigerus	Improved practice	6900	3000	27600	6.90
Local grass*	Farmers' practice	2200	3000	2200	1.73

*yield of grass is benchmark yield

Establishment of horti-pastoral system

A horti-pastoral system has been developed by adopting improved trench planting system for ber plantation and grass seeding of *Cenchrus setigerus* between trenches. The survival per cent of ber plants was recoded to be 92 per cent, the yield of the ber was negligible due to second year of plantation

Integrated farming system

Improved Murrah breed of buffalo was introduced in the Kocharia village (three farmers) and one improved breed of Murrah he-buffalo was introduced to change the present breed of buffalo in the NICRA village. The average milk yield ranged from12-16 litres/day with 24-30% higher milk yield compared to local breed.

Biogas plants

Eight farmers have been selected to construct biogas plant for improving the quality of manure and to lower down the carbon emission in NICRA villages. The work has been completed and all the biogas plants are working satisfactorily. Farmers appreciated the working facility with biogas plants and use the biogas for lighting lamp also. Further, they have appreciated the outcome i.e. quality of slurry which was much superior to their local system of composting. Even farmers have decided to drill this bio gas slurry instead of spreading as common practice.

1.2.2. BALLOWAL SAUNKHRI

a. Agro-ecological setting

Ballowal Saunkhri is located in Kandi zone in Punjab. Annual average rainfall is 1012 mm. Annual potential evapo-transpiration is 739 mm.

b. On-station experiments

The annual rainfall recorded during the year 2013-14 was 1177.3 mm, which was 7.6% more than the normal annual rainfall of 1081 (mean of 25 years) recorded at this Research station. Out of this total rainfall, 53.81% (633.5 mm) was received during the monsoon period between July-September.

Total rainfall (1177.3 mm) received during the year (May 2013-April 2014) was less than total pan evaporation (1342.1 mm) which accounted for 87.7% of the total evaporation. During monsoon months (July-September), total precipitation (633.5 mm) was 189.33% of the evaporation (334.6 mm) during the same period. In case of pos- monsoon period (October 2013-April 2014), evaporation (574 mm) was 2.64 times that of precipitation (271.6 mm) during the same period (Fig-19).

Dry spells: During Kharif season two dry spells were recorded, first dry spell of 18 days duration occurred at early stage of the crop from 21st July to 8th August and crop suffered second spell of 11 days dry spell at later stages from 16th to 27th September.

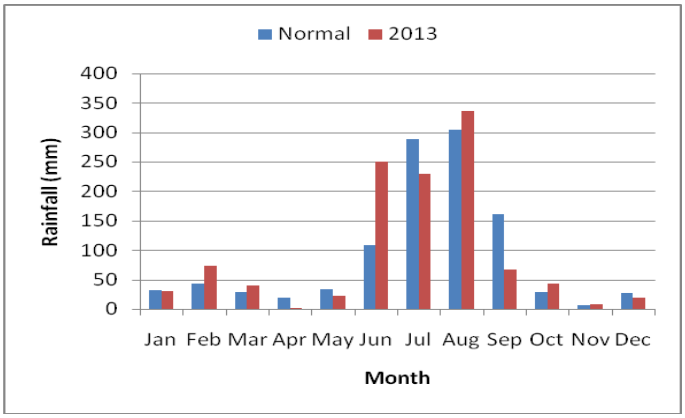


Fig.19: Normal and actual (2013) monthly rainfall at Ballowal Saunkhri

Real time contingency planning

Evaluation of improved varieties of *kharif* crops

Despite dry spells during *Kharif* season, first dry spell of 18 days duration occurred at early stage of the crop from 21st July to 8th August and crop suffered second spell of 11 days at later stages from 16th to 27th September, introduction of maize hybrid PMH 2 gave maximum yield of 3389 kg/ha with net return of Rs 28,543/ha and B:C ratio (2.01) which was 45% higher over local (1856 kg/ha) and 33% over JH 3459 (2767 kg/ha) and in case of mash, Mash 114 gave highest seed yield (783 kg/ ha), net returns (Rs.17798/ha) and B:C ratio (1.83) over Mash 338 and local cultivars (Table-110).

Table-110: Yield and economics of improved and local varieties of maize and blackgram

Crop	Variety	Rain fall (mm)	Yield (kg/ha)	Harvest Index	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Maize	JH 3459	610	2767	0.33	4.54	27864	19319	1.69
	PMH 2	610	3389	0.36	5.56	28348	28543	2.01
	Local	610	1856	0.28	3.04	25564	6976	1.27
	Mean	610	2671	0.32	4.38	27259	18279	1.66
Mash	Mash 338	641	608	0.16	0.95	20940	9460	1.45
	Mash 114	641	783	0.18	1.22	21352	17798	1.83
	Local	641	100	0.12	0.16	19742	-14742	0.25
	Mean	641	497	0.15	0.78	20678	4172	1.18

Evaluation of improved varieties of *rabi* crops

In case of post monsoon period (October 2013-April 2014). In an evaluation of improved varieties of *rabi* crops, PBW 644 variety of wheat gave highest grain yield 3236 kg/ha with net returns of Rs 38174/ha and B:C ratio of 2.61 and in case of raya PBR 97 gave maximum seed yield (1556 kg/ha), net return (Rs 30,714/ha) and B:C ratio (2.92) which was 49.8% higher over local cultivar (seed yield 1039 kg/ha, net return of Rs 15204/ha and B:C ratio of 1.95). In chickpea, PBG 5 gave maximum yield of 1703 kg/ha with B:C ratio of 3.14 followed by PBG 1 with yield 1328 kg/ha and B:C ratio of 2.45, which was 45 and 13% higher over the local cultivar. in taramira, TMLC 2 gave seed yield of 458 kg/ha with NMR of Rs 3648/ha and B:C ratio of 1.36, which was 73% higher over the local cultivar (yield 264 kg/ha, net return of Rs. 2172/ha and B:C ratio of 0.78. Similarly in Lentil, LL 699 gave maximum yield of 1247 kg/ha with NMR of Rs 34989/ha and B:C ratio of 2.66, which was 218% higher over the local cultivar (yield 392 kg/ha, net return Rs. 3486/ha and B:C ratio 0.83) (Table-111).

Table-111: Yield and economics of improved and local varieties wheat, raya, chickpea, taramira and lentil

Crop	Variety	Rain fall (mm)	Yield (kg/ha)	Straw yield (kg/ha)	Harvest Index	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Wheat	**PBW 175**	192	3167	4361	0.42	23547	36055	2.53
	PBW 644	192	3236	4611	0.41	23647	38174	2.61
	Wheat local	189	2833	5306	0.35	23201	35032	2.51
Mean		191	3079	4759	0.39	23465	36420	2.55
Raya	**PBR 97**	189	1556	4383	0.26	15966	30714	2.92
	Raya local	189	1039	4047	0.20	15966	15204	1.95
Mean		189	1298	4215	0	15966	22959	2.44
Chickpea	**PBG-1**	191	1328	3325	0.29	21662	31458	2.45
	PBG-5	191	1703	3006	0.36	21662	46458	3.14
	Gram local	189	1175	3425	0.26	21662	25338	2.17
Mean		190	1402	3252	0	21662	34418	2.59
Taramira	**TMLC**	189	458	3886	0.11	10092	3648	1.36
	Taramira local	175	264	2722	0.09	10092	-2172	0.78
Mean		182	361	3304	0.10	10092	738	1.07
Lentil	**LL 699**	189	1247	3097	0.29	21126	34989	2.66
	Local lentil	185	392	2333	0.11	21126	-3486	0.83
Mean		187	819	2715	0.20	21126	15751	1.75

Evaluation of improved intercropping systems

The Kandi region is characterised by erratic distribution of rainfall, delayed onset and an early withdrawal of monsoon, moisture stress caused by dry spell and light textured soils with poor water retention capacity. Maize crop is highly susceptible to water stress, under such conditions it gives low yield and sometimes fails totally. Crops like green gram and blackgram that are tolerant to moisture stress may be grown as intercrosp in maize crop under

rainfed condition to provide insurance against complete crop failure. During *Kharif* season two dry spells were recorded, first dry spell of 18 days duration occurred at early stage of the crop from 21st July to 8th August and crop suffered second spell of 11 days at later stages from 16th to 27th September. Intercropping of maize + blackgram gave highest maize equivalent yield (MEY) (3023 kg/ha) and WUE (5.29 kg/ha-mm) with net return of Rs. 20752/ha and B:C ratio of 1.71 followed by maize + greengram intercropping system than sole crops. During *rabi* season intercropping of chickpea + raya gave highest wheat equivalent yield (WEY) of 3959 kg/ha, net return (Rs. 36693/ha) and B:C ratio (2.62) followed by intercropping of wheat with lentil (Tables-112 & 113).

Table-112: Performance of intercropping systems

Crop/variety	Days to maturity	Grain yield (kg/ha)	Stalk yield (kg/ha)	Rainfall (mm)*	Maize/wheat equivalent yield (kg/ha)	RWUE (kg/ha-mm)
Kharif						
Maize sole	80	2063	5392	571	2063	3.61
Sole blackgram	86	650	4858	602	2167	3.60
Sole greengram	75	368	3358	539	1349	2.50
Maize (maize + blackgram)	80 (92)	1783 (372)	4496 (1748)	571 (605)	3023	5.29
Maize (maize + greengram)	80 (83)	1596 (251)	3907 (2456)	571 (602)	2516	4.41
Rabi						
Sole wheat	160	2903	5042	194	2903	-
Sole raya	144	1378	5153	160	2756	-
Sole lentil	144	986	2500	160	2958	-
Sole chickpea	151	1092	1989	162	2912	-
Wheat + chickpea	160 (151)	2840 (160)	4975 (264)	194 (162)	3267	-
Wheat + lentil	160 (144)	2753 (167)	4716 (319)	194 (160)	3254	-
Wheat + raya	160 (144)	2642 (306)	4691(1014)	194 (160)	3254	-
Chickpea + raya	151 (144)	1235 (333)	2185 (958)	162 (160)	3959	-

*Values in parthensis are of intercrops

Table-113: Economics of different intercropping systems

Crop/variety	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Kharif			
Maize sole	25851	10486	1.41
Sole blackgram	21039	11461	1.54
Sole greengram	20321	-81	0.996
Maize (maize + blackgram)	29089	20752	1.71
Maize (maize + greengram)	29170	12482	1.43
Rabi			
Sole wheat	23273	15945	2.50
Sole raya	15966	25374	2.59
Sole lentil	21126	23244	2.10
Sole chickpea	21662	22018	2.02
Wheat + chickpea	24859	39066	2.57
Wheat + lentil	24307	38651	2.59
Wheat + raya	24637	38246	2.55
Chickpea + raya	22697	36693	2.62

Evaluation of maize based double cropping systems

During monsoon months (July-September), the rainfall as deficit by 23.4% in July and 58.7% in September but was excess by 10.7% inAugust. In case of post monsoon period (October 2013-April 2014). The rainfall was excess by 52.1% in October and 26.1% in November but was deficit by 29.9% in December. During *Kharif* season two dry spells were recorded, first dry spell of 18 days duration occurred at early stage of the crop from 21st July to 8th August and crop suffered second spell of 11 days at later stages from 16th to 27th September. Among the various maize based cropping systems evaluated, maize - wheat (PBW 175) system performed better due to good rainfall (271.6 mm) received during crop season. The highest NMR of Rs 36,001/ha and B:C ratio of 2.47 with wheat equivalent yield (WEY of 3040 kg/ha were obtained in maize - wheat (PBW 175) system (Table-114).

Table-114: Productivity and economics of maize based cropping systems under rainfed conditions

Cropping system	Grain yield (kg/ha)		WEY (kg/ha)	Cost of cultivation (Rs)	Net return (Rs/ha)	B:C ratio
	Maize	*Rabi* crops				
Maize-taramira	2648	255	546	10092	-2442	0.76
Maize-raya	2648	1306	2798	15966	23214	2.45
Maize-lentil	2648	864	2777	21126	17754	1.84
Maize-wheat (PBW 175)	2648	3040	3040	24465	36001	2.47
Maize-wheat (local)	2648	2144	2144	23536	20508	1.87

Field view of *rabi* crops grown after maize

Rainwater management (*in-situ* & *ex-situ*)

About 80% of rainfall is received during *kharif* season (July-September), total precipitation (633.5 mm) was 189.33% of the evaporation (334.6 mm) during the same period which is quantitatively enough for most of the crop needs. However, the aberration in temporal and spatial distribution of rainfall makes the crop vulnerable to drought. Adverse effects on crops can be combated through *in-situ* conservation practices like earthing up in maize crop, summer ploughing, sowing and ploughing across the slope to develop a ridge and furrow type of land configuration for effective soil moisture conservation to overcome drought for longer period. sowing of maize after summer ploughing of fields gave maximum yield (3130 kg/ha) with net return of Rs 24415/ha and B:C ratio (1.87). The yield was 22% higher in comparison to sowing of maize without summer ploughing (2565 kg/ha). Sowing of maize across the slope gave maize grain yield of 2245 kg/ha with net return of Rs 11924/ha with B:C ratio of 1.44, which was 5.4% higher over sowing of maize along the slope (2130 kg/ha). Earthing up manually in maize resulted in maximum yield of 2648 kg/ha which was 33.3 and 7.9% higher in comparison to no earthing up and earthing up with wheel hoe, respectively with net return of Rs 18437/ha and B:C ratio of 1.67 (Table-115).

Table-115: Effect of different methods of sowing (Maize) on rainwater use efficiency and economics

Type of *in-situ* conservation technologies	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Cost of Cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
With Summer ploughing	3130	5.21	28202	24415	1.87
Without Summer ploughing	2565	4.27	25894	17887	1.69
Sowing across slope	2245	3.74	27098	11924	1.44
Sowing along slope	2130	3.54	26718	10315	1.39
Earthing up manually	2648	4.41	27412	18437	1.67
No earthing- up	1986	3.30	24518	10064	1.41
Earthing up with wheel hoe	2454	4.08	26309	16402	1.62

Alternate land use systems

Evaluation of amla and guava based agro-horticulture systems

The yield of blackgram in association with guava and amla was 247 & 284 kg/ha, respectively. During *rabi*, taramira yield in association with guava and amla plantation was 151 & 185 kg/ha, respectively. At the age of three years, amla and guava started fruit bearing. Guava and amla yielded 17050 kg/ha and 16200 kg/ha fruit, respectively which accounted for additional income of Rs. 226092 & 218890/ha, respectively (Tables 116, 117 & 118).

Table-116: Crop yield under different agri-horticulture systems

Season	Crop Yield (kg/ha)			
Kharif	Blackgram + Guava	Blackgram	Blackgram + Amla	Blackgram
	247	608	284	608
Rabi	Taramira + Guava	Taramira	Taramira + Amla	Taramira
	151	366	185	366

Table-117: Yield, growth parameters and economics of guava and amla plants

Crops	Yield (kg/ha)	Income (Rs/ha)	Height (cm)	Diameter (cm)	Tree spread (cm)	
					E-W	N-S
Guava	17050	341000	214	7.1	218	237
Amla	16200	324000	193	6.2	112	147

Table-118 : Yield and economics of guava and amla plants under alternate land use

Crops	Yield (kg/ha)	Cost of cultivation for three years (Rs/ha)	Net return (Rs/ha)	B:C ratio
Guava	17050	114908	226092	2.97
Amla	16200	105110	218890	3.08

Guava + taramira

Amla + taramira

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA centre, Ballowal-Saunkhri in Achalpur and Nainwan villages in Garhshankar tehsil in Hoshiarpur district, Punjab. The total cultivated area is 145.2 hectares in Achalpur and 320 hectares in Nainwan, out of which the rainfed area is 102 ha in Achalpur and 288.5 ha in Nainwan. The mean annual rainfall is 1081 mm with the seasonal rainfall of 903.7 mm during *kharif* (June - September). The major soil types are silt loam (silty clay loam). The major rainfed crops during *kharif* season are maize and sorghum, in *rabi* are wheat, raya and taramira. The small, marginal, medium and large farmers are 86, 11, 3 and 0% in Achalpur and 76, 13, 6 and 5% in Nainwan, respectively. Only one tube well is available in each village as a source of irrigation, which is covering 10% of cultivated area approximately.

Climate vulner*abi*lity in general

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 1081 mm, the southwest monsoon contributes 80%, north-east monsoon contributes 12% and summer contributes 8%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 43% deficit of the average rainfall. The onset (south-west) of monsoon was during 24 SMW and north-east monsoon was 40 SMW. For the past 15 years, the dry spells during crop season were experienced in the month of September at grain filling stage of kharif crops. The normal onset of the monsoon was first July and generally delayed by one week influencing the sowing of maize and its productivity. The soil moisture was generally deficit at sowing and at reproductive stages of rabi crops. The maximum and minimum temperature during kharif season ranged from 31.9 to 40.8˚C and 21.4 to 26.2˚C, whereas during rabi season it varied from 16.0 to 38.9˚C and 2.3 to 20.4˚C, respectively in the past 10 years. The area has been experiencing extreme events like hail storm and frost during rabi season.

Experienced weather conditions during 2013-14

During 2013, in Achalpur village, onset of monsoon was delayed by 10 days i.e., first week of July. A rainfall of 1215.8 mm was received which was excess by 353.8 mm compared to normal (862 mm) (Fig.), during south-west monsoon (kharif). During north-east monsoon (October- December), 116.5 mm rainfall was received which was excess by 54.6 mm compared to normal (61.9 mm). During summer (March - May), 47.1 mm rainfall was received which was deficit by 35 mm compared to normal (82.1 mm).

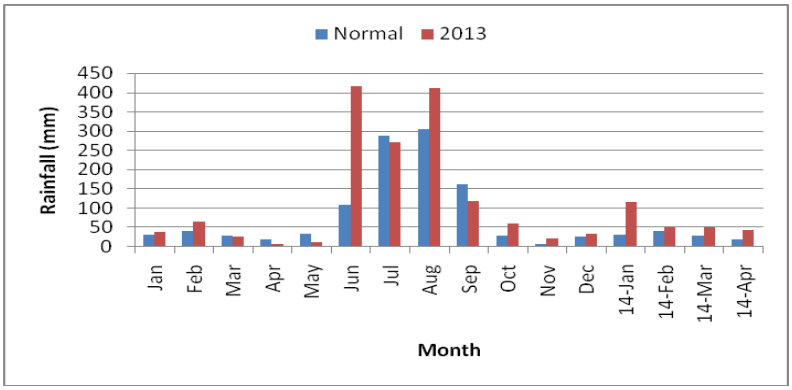


Fig.20: Normal and actual (2013) monthly rainfall at Achalpur

Interventions

The major interventions implemented include real time contingency planning, land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services.

Real time contingency planning

During 2013, in Achalpur village, onset of monsoon was delayed by 10 days i.e., first week of July. A rainfall of 1215.8 mm was received which was excess by 353.8 mm compared to normal (862 mm), during south-west monsoon (*kharif*). The rainfall was deficit in July (6.1%) and September (27%) but excess in August (35.5%). In an assessment of different maize cultivars during the *kharif* 2013, PMH 1 hybrid gave maximum productivity of 3880 kg/ha, net return of Rs. 42,473/ha and B:C ratio of 2.47 followed by JH 3459 (yield 3250 kg/ha, net return of Rs 31,257/ha) at village Achalpur, which was 54 and 29% higher than local cultivar, respectively. Similarly, at village Nainwan, PMH 1 gave highest grain yield of 3800 kg/ha, which was 27 and 90% higher over JH 3459 and local cultivar with NMR of Rs. 41,086/ha and B:C ratio of 2.43. The farmer' cultivar (local) gave minimum grain yield of 2000 kg/ha, lowest net return Rs. 11,383/ha with B:C ratio of 1.44 (Table-119).

Table-119: Varietal performance of maize hybrids under rainfed condition

Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur				
Local	2525	26212	20564	1.78
PMH 1	3880	28822	42473	2.47
JH 3459	3250	28169	31257	2.11
Nainwan				
Local	2000	25667	11383	1.44
PMH 1	3800	28739	41086	2.43
JH 3459	3000	27909	26946	1.97

During 2013, in Achalpur village, north-east monsoon (October- December), 116.5 mm rainfall was received which was excess by 54.6 mm compared to normal (61.9 mm). During summer (March - May) 47.1 mm rainfall was received which was deficit by 35 mm compared to normal (82.1 mm). In wheat, HD 2967 gave maximum grain yield (3113 kg/ha) with net return of Rs 32,657/ha and B:C ratio of 2.39, which was 2, 9 and 27% higher in comparison to PBW 644, PBW 175 and local cultivars, respectively. Similarly, at village Nainwan, HD 2967 gave maximum yield of 3433 kg/ha with net return of Rs 36,977/ha and B:C ratio of 2.58, which was 4, 17 and 37% higher in comparison to PBW 644, PBW 175 and local cultivars, respectively (Table-120).

Table-120: Varietal performance of wheat

Variety	Grain / seed yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs)	Net return (Rs/ha)	B:C ratio
Achalpur					
PBW 175	2869	102	23179	27204	2.17
PBW 644	3050	108	23367	30786	2.32
HD 2967	3113	110	23432	32657	2.39
Local	2450	87	22071	21657	1.98
Nainwan					
PBW 175	2935	104	23179	28095	2.21
PBW 644	3300	117	23367	34161	2.46
HD 2967	3433	122	23,432	36977	2.58
Local	2588	92	22071	23520	2.07

In an evaluation of different mash cultivars, Mash 114 cultivar recorded grain yield of 625 kg/ha at village Achalpur and 500 kg/ha at village Nainwan which was 14 and 9% higher over Mash 338 cultivar, respectively. Mash-114 cultivar gave higher net return and B:C ratio of Rs 20,441/ha of 2.20 at village Achalpur and Rs 12,941/ha and 1.76 at village Nainwan, respectively (Table-121).

Table-121: Varietal performance of black gram under rainfed condition

Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur				
Mash 114	625	17059	20441	2.20
Mash 338	550	16540	16460	2.00
Nainwan				
Mash 114	500	17059	12941	1.76
Mash 338	465	16540	11360	1.69

Similarly, among the two sesame cultivars (RT 346 and local), cultivar RT 346 recorded highest seed yield of 250 kg/ha at village Achalpur and 350 kg/ha at village Nainwan, which was 25 and 49% higher than the local cultivar (200 and 235 kg/ha respectively). The net return and B:C ratio of RT646 was Rs. 9,482/ha0 and B:C ratio (1.61) at village Achalpur and Rs.19,482/ha and B:C ratio (2.26) at village Nainwan, respectively (Table-122).

Table-122: Varietal performance of sesame under rainfed condition

Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur				
RT 346	250	15518	9482	1.61
Local	200	14374	5626	1.39
Nainwan				
RT 346	350	15518	19482	2.26
Local	235	14374	9126	1.63

Sesame (RT-346)

Mash (Mash-114)

The onset of monsoon was delayed by 10 days i.e., first week of July. A rainfall of 1215.8 mm was received which was excess by 353.8 mm compared to normal (862 mm). The rainfall was deficit in July (6.1%) and August (27%) but excess in August (35.5%). In pearlmillet at village Achalpur, FB:C 16 gave maximum fodder yield of 32000 kg/ha with net return of Rs 14,227/ha and B:C ratio of 2.10, which was 33% higher over the local cultivars (net return Rs 7,531/ha and B:C ratio of 1.59). Similarly, at village Nainwan, FB:C 16 gave maximum fodder yield of 28000 kg/ha with net return of Rs 10,827/ha and B:C ratio of 1.83, which was 40% higher over the local cultivars (net return Rs 4,131/ha and B:C ratio 1.32) (Table-123).

Table-123: Varietal performance of pearl millet under rainfed condition

Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur				
FB:C 16	32000	12973	14227	2.10
Local	24000	12869	7531	1.59
Nainwan				
FB:C 16	28000	12973	10827	1.83
Local	20000	12869	4131	1.32

During 2013, in Achalpur village, north-east monsoon (October- December), 116.5 mm rainfall was received which was excess by 54.6 mm compared to normal (61.9 mm). During summer (March - May), 47.1 mm rainfall was received which was deficit by 35 mm compared to normal (82.1 mm). Improved varieties of different *rabi* crops were demonstrated in Achalpur and Nainwan villages (Table…….). In raya, RLC 1 gave maximum seed yield of 1080 kg/ha with net return of Rs 22,828/ha and B:C ratio of 2.52 at village Achalpur and 1060 kg/ha, with net return of Rs 22,128/ha and B:C ratio of 2.48 at village Nainwan, which was 47 and 54% higher over the local cultivars, respectively. At Achalpur in Chickpea, PBG 1 gave seed yield of 1240 kg/ha with net return of Rs 32,291/ha and B:C ratio of 2.87, which was 38% higher over the local cultivars (yield 900 kg/ha, net return 19,936/ha and B:C ratio 2.24). At Nainwan, highest grain yield of 1430 kg/ha, with net return of Rs 39,891/ha and B:C ratio of 3.30 was recorded with PBG 1 of chickpea, which was 55% higher over the local cultivars, respectively. TMLC 2 of taramira gave seed yield of 547 & 665 kg/ha with net return of Rs 6811 and 10,587/ha and B:C ratio of 1.64 and 1.99, respectively which was 43 & 47% higher over local cultivar (290 and 378 kg) at Achalpur and Nainwan, respectively (Table-124).

Table-124: Varietal performance of raya, chickpea and taramira

Variety	Grain / seed yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur					
Raya					
Local	700	70	14855	9645	1.65
RLC 1	1080	109	14972	22828	2.52
Chickpea					
Local	900	87.46	16064	19936	2.24
PBG 1	1240	120.51	17309	32291	2.87
Taramira					
TMLC 2	547	55.03	10693	6811	1.64
Local	290	29.18	10714	-1434	0.87
Nainwan					
Raya					
Local	722	73	14855	10415	1.70
RLC 1	1,060	107	14972	22128	2.48
Chickpea					
Local	920	89.41	16064	20736	2.29
PBG-1	1430	138.97	17309	39891	3.30
Taramira					
TMLC-2	665	66.90	10693	10587	1.99
Local	378	38.03	10714	1382	1.13

Different intercropping systems were demonstrated in both NICRA villages during rabi 2013-14. The mean wheat equivalent yield (WEY) of 4345 kg/ha at Achalpur and 4462 kg/ha at Nainwan was recorded with wheat + raya intercropping which was 8 and 9% higher as compared to sole wheat crop. The NMR and B:C ratio of wheat + raya intercropping was Rs 38,436/ha and 2.90 at village Achalpur and Rs 39,816/ha and 2.95 at village Nainwan, respectively. The chickpea + raya intercropping also gave WEY of 4124 kg/ha at Achalpur and 4009 kg/ha at Nainwan with net returns of Rs 34,592 and Rs 33,295/ha, respectively. Therefore, raya intercropping sustains the productivity of wheat and chickpea based cropping system besides covering the risk of crop failure (Table-125).

Table-125.: Productivity and economics of raya intercropping in wheat and chickpea under rainfed conditions

Treatment	Grain yield (kg/ha)	WEY (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur					
Sole wheat	2869	4023	21640	32670	2.51
Wheat+ raya	2320+313	4345	20223	38436	2.90
Chickpea+ raya	1217+200	4124	21088	34592	2.64
Nainwan					
Sole wheat	2935	4116	21706	33853	2.56
Wheat+ raya	2520+250	4462	20423	39816	2.95
Chickpea+ raya	1130+255	4009	20830	33295	2.60

Different cropping sequences were demonstrated in farmers' fields of Achalpur and Naiwan villages for crop diversification. Among different cropping sequences, ash gourd based cropping system with wheat and raya gave the maximum net return and B:C ratio in comparison to other cropping systems. In other cropping systems maize – wheat cropping system gave maximum net return of Rs 58,203/ha at village Achalpur, and Rs 55,041/ha at village Nainwan. However, B:C ratio was maximum with maize – raya cropping sequence (2.32 & 2.23) (Table-126).

Table -126: Performance of difference cropping systems on net return and B:C ratio at on farm

Crop sequence	1st Crop (kg/ha)	2nd Crop (kg/ha)	MEY (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur						
Maize - wheat	3250	2869	7321	56078	58203	2.14
Maize - raya	3250	1080	6482	43141	54085	2.32
Maize - taramira	3250	547	5129	38862	38068	1.88
Pearlmillet - wheat	32000	2869	5172	36152	41431	2.14
Pearlmillet - raya	32000	1080	4333	27945	37055	2.31
Ash gourd - wheat	27250	2869	6992	39002	65881	2.81
Ash gourd - raya	27250	1080	6153	30795	61505	2.98
Nainwan						
Maize - wheat	3000	2935	7075	51088	55041	2.09
Maize - raya	3000	1060	6130	42881	49074	2.23
Maize - taramira	3000	665	5076	38602	37533	1.98
Pearlmillet - wheat	28000	2935	5005	36152	38922	2.02
Pearlmillet - raya	28000	1060	4060	27945	32955	2.16
Ash gourd - wheat	35714	2935	8180	39002	83700	3.36
Ash gourd - raya	35714	1060	7235	30795	77733	3.50

Rainwater harvesting *(in situ and ex situ)* and efficient use

A rainfall of 1215.8 mm was received which was excess by 353.8 mm compared to normal (862 mm). Similarly, during north-east monsoon (October- December), 116.5 mm rainfall was received which was excess by 54.6 mm compared to normal (61.9 mm). Harvested water in village rainwater harvesting structure remained available from August to February, which was utilized efficiently for life saving/supplemental irrigation. This irrigation water was applied to wheat crop for supplemental irrigation purpose at crop growth stages for maximizing the yields. Field demonstrations were conducted to evaluate the performance of wheat cultivar (PBW 175) under supplemental irrigation at two crop growth stages (crown root initiation and flowering stage) at village Nainwan. Application of supplemental irrigations (CRI and flowering stage) in rainfed wheat cultivar PBW 175 at village Nainwan recorded highest grain yield of 3125 kg/ha, which was 41 & 11% higher over the rainfed wheat and irrigation at CRI stage, respectively. The net return and B:C ratio was also maximum with supplemental irrigations at CRI and flowering stage (Rs 36,973/ha and 2.64) (Table-127).

Renovated water harvesting structure – village Nainwan

Table-127: Productivity and economics of wheat with supplemental irrigation at different crop stages

Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
CRI & Flowering stage	3125	22,558	36973	2.64
CRI stage	2826	22,259	31576	2.42
Rainfed	2215	21,648	20548	1.95

* Depth of irrigation water i.e. 70 mm per irrigation and rainfall (282 mm)

During summer (March - May), 47.1 mm rainfall was received which was deficit by 35 mm compared to normal (82.1 mm). Rainwater is usually lost as runoff and goes unutilized in slopy fields leading to lower maize yields as well as conserves less moisture for succeeding *rabi* crops. Therefore, *in situ* rainwater conservation can be done by summer ploughing, sowing across the slope and earthing up in maize crop. At village Achalpur**,** summer ploughing of field immediate after the wheat crop harvest conserved moisture and gave the maize yield of 3000 kg/ha with net return of Rs 27,100/ha and B:C ratio of 1.97 which was 12% higher in comparison to sowing without summer ploughing . At village Nainwan, summer ploughing of field gave yield of 3313 kg/ha in maize with NMR of Rs 31,470/ha and B:C ratio of 2.11, which was 10% higher in comparison to maize sowing without summer ploughing (Table-128).

Table-128: Effect of summer ploughing on maize yield and economics

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur				
Summer ploughing	3000	28001	27100	1.97
Without summer ploughing	2667	27655	21111	1.76
Nainwan				
Summer ploughing	3313	28326	31470	2.11
Without summer ploughing	3000	28001	26854	1.96

Similarly, at village Achalpur, sowing of maize across the slope gave the grain yield of 3000 kg/ha with net return of Rs 26,854/ha and B:C ratio of 1.96, which was 5.3% higher over sowing of maize along the slope (2850 kg/ha). At village Nainwan, sowing of maize across the slope gave the grain yield of 3208 kg/ha with net return of Rs 30,442/ha and B:C ratio of 2.08, which was 30.5% over sowing of maize along the slope (2458 kg/ha) (Table-129).

Table-129: Effect of sowing along and across the slope on maize yield and economics

Treatment	Yield (kg/ha)	Cost of Cultivation (Rs /ha)	Net return (Rs/ha)	B:C ratio
Achalpur				
Sowing along slope	2850	27845	25006	1.90
Sowing across slope	3000	28001	26854	1.96
Nainwan				
Sowing along slope	2458	27439	19532	1.71
Sowing across slope	3208	28217	30442	2.08

Earthing up (manually) in maize resulted in yield of 4250 kg/ha with net return of Rs 47,202/ha and B:C ratio of 2.61, which was 13% higher in compared to no earthing up (3750 kg/ha) at village Achalpur, however earthing up at village Nainwan gave grain yield of 4267 kg/ha with net return of Rs 44,791/ha and B:C ratio of 2.62, which was 20% higher over no earthing up (Table-130).

Table-130: Effect of earthing up on maize yield and rainwater harvesting (*in-situ*) and efficient use

Treatment	Yield (kg/ha)	Cost of cultivation (Rs /ha)	Net return (Rs/ha)	B:C ratio
Achalpur				
Earthing up	4250	29298	47202	2.61
Without earthing up	3750	26401	41099	2.56
Nainwan				
Earthing up	4267	29315	44791	2.62
Without earthing up	3567	26419	42461	2.45

Energy Management

In a trial on mechanized and traditional sowing methods in wheat, raya and taramira, sowing of wheat with seed cum fertilizer drill gave net return of Rs 34,565/ha & Rs. 36,394/ha, grain yield of 3048 & 3150 kg/ha which was 37 & 34% higher over broadcasting method of sowing (2224 and 2350 kg/ha) with B:C ratio of 2.49 and 2.57, respectively at village Achalpur and Nainwan. In raya, seed drill sowing gave seed yield 1020 and 1060 kg/ha, which resulted in 29 and 23% higher over broadcasting method of sowing at village Achalpur and Nainwan, respectively. In taramira, seed drill sowing gave seed yield 570 kg/ha & 660 kg /ha, which was 46 and 43% higher over broadcasting method of sowing at village Achalpur and Nainwan, respectively. The mechanized sowing clearly indicated the superiority, which gave higher net return over broadcasting method of sowing method (Table-131).

Table-131: Effect of sowing method on productivity and economics of wheat, raya & taramira under rainfed conditions

Crop	Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net rturn (Rs/ha)	B:C ratio
Achalpur						
Wheat	Seed drill	3048	108.1	23133	34565	2.49
	Wooden plough	2648	93.9	23900	26226	2.10
	Broadcasting	2224	78.9	23476	18624	1.79
Raya	Seed drill	1020	36.2	13104	22596	2.72
	Broadcasting	790	28.0	12793	14857	2.16
Taramira	Seed drill	570	20.2	10606	9344	1.88
	Broadcasting	390	13.8	10606	3044	1.29
Nainwan						
Wheat	Seed drill	3150	111.7	23235	36394	2.57
	Wooden plough	2750	97.5	24002	28055	2.17
	Broadcasting	2350	83.3	23602	20883	1.88

Raya	Seed drill	1060	37.6	13104	23996	2.83
	Broadcasting	860	30.5	12793	17307	2.35
Taramira	Seed drill	660	23.4	10606	12494	2.18
	Broadcasting	460	16.3	10606	5494	1.52

Modified wheat seed drill bullocks

Wheat Seed Drill at village Achalpur

Alternate land use system

Demonstration of *kharif* and *rabi* season crops under Kinnow plantation

In *Kharif* season, pearlmillet (fodder) was sown under four year old kinnow plantation. The crop gave fodder yield of 29200 kg/ha with additional income of Rs 7,467 with B:C ratio of 1.58. In *rabi* season, raya crop was sown under kinnow plantation. The crop gave seed yield of 607 kg/ha with additional income of Rs 3238/ha and B:C ratio of 1.22 (Table-132).

Table-132 : Cultivation of field crops under alternate land use system at on farm

Treatments	Yield (kg/ha)		Cost of cultivation (Rs/ha)*	NMR (Rs/ha)*	B:C ratio
	Fruit	Crop			
Kharif					
Kinnow + Pearlmillet	-	29200	12973	7467	1.58
Rabi					
Kinnow + raya	-	607	14972	3238	1.22

*Only cultivation cost of crop is taken

Taramira crop under kinnow plantation

Ash gourd cultivation was demonstrated at village Achalpur in 10 demonstration trials. Ash gourd gave the average yield of 27250 kg/ha with net return of Rs 38,677/ha and B:C ratio of 3.44. In village Nainwan, in 10 demonstration trials, average yield was 35714 kg/ha with net return of Rs 55605/ha and B:C ratio of 4.51 (Table-133).

Table-133: Cultivation of ash gourd under alternate land use system at village Achalpur and Nainwan

Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Achalpur				
Myhco	27250	15823	38677	3.44
Nainwan				
Myhco	35714	15823	55605	4.51

Ash gourd sowing in pits

Ash gourd crop

To evaluate the suitability *kharif* season crops in wild animal damage prone area, maize and sesame trials were conducted. It was observed that average yield of maize in wild and stray animals' prone areas was 1100 kg/ha, however the average sesame yield was 300 kg/ha. The damage by wild and stray animals was more in maize crop in comparison to sesame crop. Net return of maize was only Rs 571kg/ha due to stray/wild animal damage, whereas cultivation of sesame gave net income of Rs 14482/ha with B:C ratio of 1.93. Hence, sesame crop has potential for its cultivation in areas adjoining to forest and prone to stray/wild animal damage (Table-134).

Table-134: Evaluation of alternative crops in wild animal damage prone area for *kharif* season

Treatment	Grain / seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Sesame	300	15518	14482	1.93
Maize	1100	26030	571	1.02

To evaluate the suitability of rabi season crops in wild animal damage prone area, wheat and taramira demonstrations were conducted and the average wheat grain yield of 800 kg/ha was recorded in the animal prone areas, however the average yield of taramira was 345 kg /ha. The NMR of wheat was negative (i.e. Rs. -2,240/ha) due to stray/wild animal damage, whereas cultivation of taramira gave NMR of Rs 1,901/ha with B:C ratio of 1.19. Hence, taramira has potential for its cultivation in areas adjoining to forest and prone to stray/wild animal damage (Table-135).

Table-135: Productivity and performance of wheat and taramira in wild animal damage prone area

Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Wheat	840	18,242	-2,240	0.88
Taramira	345	10,174	1,901	1.19

1.2.3. RAKH DHIANSAR

a. Agro-ecological setting

Rakh Dhiansar is located in Western Himalayas of South Kashmir and Kumaon, warm moist to dry sub-humid transitional eco-sub-region (AESR 14.2) and low altitude sub-tropical agro-climate zone in Jammu & Kashmir. Annual average rainfall is 1148 mm. Annual potential evopotransportation is 1100 mm. Length of growing period is 150 - 210 days.

b. On-station experiments

During 2013, a rainfall of 1158.3 mm was received which was excess by 272.5 mm compared to normal (885.8 mm) (Fig.21), during south-west monsoon (kharif). During north-east monsoon (October - December), 55.1 mm of rainfall was received which was excess by 7.5 mm compared to normal (47.6 mm). During summer (March - May), 28.1 mm of rainfall was received which was deficit by 86 mm compared to normal (114.1 mm).

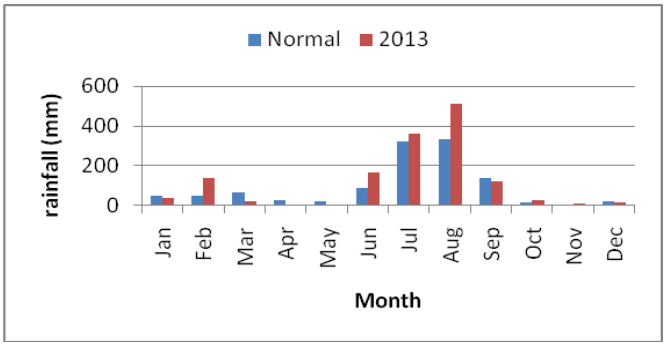


Fig.21: Normal and actual (2013) monthly rainfall at Rakh Dhiansar

Real time contingency planning

During 2013, the onset of monsoon was delayed by 8 days during first week of July. A rainfall of 1158.3 mm was received which was excess by 272.5 mm compared to normal (885.8 mm), during south-west monsoon (*kharif).* The rainfall in June month was excess by 81.2% followed by during July, and August months was excess by 12.0% and 53.1% whereas the rainfall during September month was deficit by 12.5%. Different maize varieties / hybrids were evaluated for their comparative performance under timely onset of monsoon and one week after onset of monsoon condition. The hybrid variety Double Dekalb performed well under both events *i.e.* sowing of maize on the onset of monsoon (2788 kg/ha) and 1 week after onset of monsoon *(*2451 kg/ha), followed by the variety PB-2475 with grain yield of 2648 and 2396 kg/ha, respectively (Table-136).

Table-136: Performance of different maize varieties / hybrids as influenced by two monsoonal events during *kharif* 2013

Events	Variety	Crop duration (in days)	Rainfall (mm)	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
				Grain	Stover				
Onset of monsoon	K-517	90	1004.1	2380	5501	2.37	18275	24487	1.34
	Double Dekalb	95	1004.1	2788	5870	2.78	19375	29856	1.54
	PB-2475	90	1004.1	2648	5812	2.64	18975	28139	1.48
	Tip Top	93	1004.1	2507	5427	2.50	18955	25338	1.35
1st week after onset of monsoon	K-517	87	904.7	2059	4921	2.28	18275	18963	1.04
	Double Dekalb	93	904.7	2451	5305	2.71	19375	24123	1.23
	PB-2475	89	904.7	2396	5409	2.65	18975	23881	1.26
	Tip Top	92	904.7	2333	5217	2.58	18955	22700	1.20

Intercropping

Different of intercropping systems were evaluated to cope with rainfall variability. During crop growth period crop received 1004 mm rainfall was received. Intercropping of mash (Uttara) + moong (PDM-14) in additive series (2:1) with no extra fertilizers for intercrop gave yield of 2257 and 198 kg/ha for maize and moong crops, respectively and maximum maize equivalent yield of 3145 kg/ha with a B:C ratio of 2.37 and RWUE of 3.06 kg/ha-mm (Table-137).

Table-137: Yield and economics of intercropping systems

Intercropping system	Grain/seed yield (kg/ha)		MEY (kg/ha)	RWUE (kg/ha-mm)		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Maize	Intercrop		Maize	Intercrop			
Maize + mash (2:1)	2295	183	2800	2.29	0.18	21625	25841	2.19
Maize + moong (2:1)	2257	198	3145	2.25	0.20	21958	30188	2.37

Cropping sequences

The rainfall of 1158.3 mm was received which was excess by 272.5 mm compared to normal (885.8 mm), during south-west monsoon (*kharif*). The rainfall in October month was excess by 46.1% followed by November, but December month received deficit rainfall by was excess by 60.9 and 24.2%. Under cropping sequence programme, seven different cropping sequences viz: pulse-oilseed (moong-mustard), pulse-pulse (mash-chickpea), pulse-cereal (moong-wheat), cereal-cereal (maize-wheat), cereal-oilseed (maize-mustard), oilseed-oilseed (til-mustard) and pastoral-pastoral (fodder-fodder) were tested with recommended package of practices and maize crop under cereal-oilseed and cereal-cereal systems produced highest Net return of Rs. 29341/ha and 28656/ha with B:C ratio of 2.51 and 2.48, respectively (Table-138).

Table-138:Yield and economics of different crops under various cropping systems

Cropping systems	Crop	Crop duration (in days)	Rainfall (mm)	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Pulses-oilseed	Moong	90	894.4	623	0.70	16440	24055	2.46
Pulses-pulses	Mash	91	894.4	594	0.66	15190	8570	1.56
Pulses-cereal	Moong	90	894.4	604	0.68	16440	22820	2.39
Cereal-cereal	Maize	95	1004.1	2746	2.73	19375	28656	2.48
Cereal-oilseeds	Maize	95	1004.1	2802	2.79	19375	29341	2.51
Oilseed-oilseed	Til	92	894.4	405	0.45	12295	16055	2.31
Pastoral-pastoral	Mixed fodder	65	875.7	--	41.3	11740	17220	2.47

During north- east monsoon (October - December), 55.1 mm of rainfall was received which was excess by 7.5 mm compared to normal (47.6 mm). Further, the rainfall during October and November months was excess by 46.1, 60.9%, respectively and whereas the rainfall during December month was deficit by 24.2%. Different wheat varieties were evaluated for their performance under prevalent rainfall conditions. Among 7 wheat varieties, significantly highest grain yield of 2775 kg/ha with B:C ratio of 3.7was given by RSP-5613. Significantly the lowest grain yield of 1550 kg/ha and B:C ratio of 2.29 was obtained in PBW-175 (Table-139).

Table-139: Performance of different wheat varieties at Rakh Dhiansar

Treatment	Rainfall (mm)	Days to maturity	Yield (Kg/ha)		Test weight (g)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
			Grain	Straw					
PBW-175	218.5	146	1550	3600	34	7.09	16287	21053	2.29
PBW-373	233.4	152	2113	4575	40	9.05	16287	33285	3.04
Raj-3077	219.3	148	1950	4825	38	8.89	16287	31873	2.96
Raj-3765	232.7	151	1638	4163	36	7.04	16287	24607	2.51
JAUW-598	233.4	154	1713	4400	37	7.34	16287	26665	2.64
JAUW-584	233.4	156	2275	4100	42	9.75	16287	33783	3.07
RSP-561	233.4	155	2775	4933	45	11.89	16287	44515	3.73

Intercropping

Wheat based intercropping systems were evaluated for enhancing productivity and profitability under rainfed conditions. In an intercropping of wheat with chickpea (GNG-469) and field pea (Rachna), highest grain yield of 1672 and 245 kg/ha was obtained for wheat and field bean and wheat equivalent yield of 2334 kg/ha with a B:C ratio of 2.79 and RWUE of 7.1 kg/ha-mm compared to wheat + chickpea system (Table-140).

Table140: Yield and economics of wheat crop under intercropping system with chickpea and field pea (2:2)

Intercropping system	Grain Yield (kg/ha)		Days to Maturity		WEY (kg/ha)	RWUE (kg/ha-mm)*		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Wheat	Intercrop	Wheat	Intercrop		Wheat	Intercrop			
Wheat + hickpea (2:2)	1572	210	175	170	2211	5.82	0.78	18017	26775	2.49
Wheat + field pea (2:2)	1672	245	175	168	2334	6.19	0.91	17057	30494	2.79

Cropping sequence

Out of seven different cropping sequences *viz.*, pulse-oilseed (moong-mustard), pulse-pulse (mash-chickpea), pulse-cereal (moong-wheat), cereal-cereal (maize-wheat), cereal-oilseed (maize-mustard), oilseed-oilseed (til-mustard) and pastoral-pastoral (fodder-fodder) tested, wheat under pulse-cereal system gave highest B:C ratio of 2.97 followed by cereal-cereal system, where wheat crop produced net return returns of Rs. 29517/ha with B:C ratio of 2.81, followed by fodder (oats) sown under pastoral-pastoral system and pulse-oilseed cropping sequence with the corresponding B.C ratio values of 2.70 and 2.60, respectively (Table-141).

Table-141: Yield and economics of different crops under various cropping systems

Cropping system	Rain-fall (mm)	Days to maturity	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Cost of culti-vation (Rs/ha)	Net return (Rs/ha)	B:C Ratio
Mustard (pulses-oilseed)	247.5	154	970	3.92	12335	19675	2.60
Chickpea (pulses-pulses)	270.3	168	535	1.98	17284	6791	1.39
Wheat (pulses-cereal)	270.3	165	2167	8.02	16287	32093	2.97
Wheat (cereal-cereal)	270.3	165	2033	7.52	16287	29517	2.81
Mustard (cereal-oilseeds)	247.5	148	855	3.45	12335	15880	2.29
Mustard (oilseed-oilseed)	247.5	152	875	3.54	12335	16540	2.34
Fodder (oats) (pastoral-pastoral	138.1	114	--	185.37	9100	15500	2.70



Field view of varietal, intercropping and cropping experiments, Rakh Dhiansar

Efficient Energy Use and Management

To evaluate the most efficient and effective implements for sowing of maize crop and which can consume less fuel different implements were evaluated for their fuel consumption (Table-142).

Table-142: Fuel consumption by farm machineries used for preparation of seed bed and sowing of maize crop

Treatments	Type of farm operation	Type of machinery used	Diesel consumption (lit/ha)
Farmerspractice (Broadcasting)	1 Ploughing	Disc plough	13.650
	2 Harrowing	Disc harrow	9.100
	1Tillering	Cultivator	4.375
	1Planking	Planker	4.375
Line sowing with liner	1 Ploughing	Disc plough	13.650
	2 Harrowing	Disc harrow	9.100
	1Tillering	Cultivator	4.375
	1Planking	Planker	4.375
Sowing with maize planter	1 Ploughing	Disc plough	13.65
	2 Harrowing	Disc harrow	9.100
	1Tillering	Cultivator	4.375
	1Planking	Planker	4.375
	Planting	Maize planter	7.800

The total input out put energy ratio was found to be lower (6.8) in broadcasting followed by line sowing with liner and sowing with maize planter. Whereas the total energy used by human labour was found maximum with farmer practice (broadcasting) and minimum in sowing with maize planter (Table-143).

Table-143: Energy used by different methods of sowing

Particular	Farmers' practice (Broadcasting)			Line sowing with liner			Sowing with maize planter		
	Quan-tity per ha	Total energy equivalent (MJ/ha)	% of energy use	Quan-tity per ha	Total energy equiva-lent (MJ/ha)	% of energy use	Quantity per ha	Total energy equivalent (MJ/ha)	% of energy use
Inputs									
Human labour (hrs)	1376.84	2698.6	30.62	1708.61	3348.87	35.39	1282.37	2513.45	27.62
Machinery / equipment (hrs)	9.00	126.97	1.44	9.00	126.97	1.34	11.23	158.43	1.74
Diesel (liters)	31.50	1773.76	20.13	31.50	1773.76	18.74	39.30	2212.98	24.32
Chemical fertilizers (kg)									
N	60	3636	41.26	60	3636	38.42	60	3636	39.96
P	40	444	5.04	40	444	4.69	40	444	4.88
K	20	134	1.52	20	134	1.42	20	134	1.47
Total energy equivalent (MJ)	-	8813.33	100	-	9463.6	100		9098.86	100
Out puts									
Grain yield (kg/ha)	1325	19477.5	-	1680	24696	-	1980	29106	
Straw yield (kg/ha)	3206.5	40081.25		3591	44887.5		4234	52925	
Total energy output (MJ)	-	59558.75	-	-	69583.5	-	-	82031	-
Input -output ratio	-	6.8	-	-	7.4	-	-	9.0	-

The performance of maize sowing with the liner took maximum energy followed by sowing with maize planter and broadcasting methods. Sowing with maize planter gave highest yield (1980 kg/ha) and B:C ratio (1.15) and minimum in the broadcasting method of sowing (Table-144).

Table-144: Performance and economics of different sowing methods with different implements in maize

Sowing method	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	B:C ratio
	Grain	Straw			
Broadcasting	1325	3206.5	7447.3	24022	0.45
Sowing with liner	1650	3591.0	12436.5	29311	0.74
Maize planter	1980	4234.0	18786.0	35061	1.15

The sowing of wheat crop was done using different methods in order to evaluate the most efficient and effective implements for sowing of wheat crop in *kandi* belt of Jammu region. Among all methods, lower diesel consumption was found in broadcasting and line sowing with liner (17.85) compared to seed cum fertilizer drill (Table-145).

Table-145: Fuel consumption by farm machineries used for preparation of seed bed and sowing of wheat

Treatment	Type of farm operation	Type of machinery used	Diesel consumption (lit/ha)
Farmers practice (Broadcasting)	2 Harrowing	Disc harrow	9.10
	1Tillering	Cultivator	4.375
	1Planking	Planker	4.375
Line sowing with liner	2 Harrowing	Disc harrow	9.100
	1Tillering	Cultivator	4.375
	1Planking	Planker	4.375
Seed cum fertilizer drill	2 Harrowing	Disc harrow	9.100
	1Tillering	Cultivator	4.375
	1Planking	Planker	4.375
	Planting	Seed cum fertilizer drill	7.000

The wheat sowing with the liner required maximum energy (6930.04 MJ/ha) followed by sowing with seed drill (6712.75 MJ/ha) and broadcasting (6627.51 MJ/ha). The total output energy was found maximum in case of sowing with seed drill (116392.5 MJ/ha) and minimum in the broadcasting method of sowing (74605 MJ/ha). Similar trend was observed in case of input-output ratio due the labour component (Table-146).

Table-146: Energy used by different methods of sowing in wheat

Introduction	Farmers' practice (Broadcasting)			Line sowing with liner			Sowing with Seed drill		
	Quantity per ha	Total energy equivalent (MJ/ha)	% of energy use	Quantity per ha	Total energy equivalent (MJ/ha)	% of energy use	Quantity per ha	Total energy equivalent (MJ/ha)	% of energy use
Inputs									
Human labour (hrs)	738.5	1447.47	21.84	892.86	1750.00	25.25	566.50	1110.34	16.54
Machinery /equipment (hrs)	5.10	71.91	1.09	5.10	71.91	1.04	7.10	100.11	1.49
Diesel (liters)	17.85	1005.13	15.17	17.85	1005.13	14.50	24.85	1399.30	20.85
Chemical fertilizers (kg)									
N	60	3636.00	54.86	60.00	3636.00	52.47	60.00	3636.00	54.17
P	30	333.00	5.02	30.00	333.00	4.81	30.00	333.00	4.96
K	20	134.00	2.02	20.00	134.00	1.93	20.00	134.00	2.00
Total energy input (MJ)	-	6627.51	100.00	-	6930.04	100.00	-	6712.75	100.00
Outputs									
Grain yield (Kg/ha)	2150	31605	-	2450	36015	-	3150	46305	-
Straw yield (Kg/ha)	3440	43000		4199	52487.5		5607	70087.5	
Total energy output (MJ)	-	74605	-	-	88502.5	-	-	116392.5	-
Input-output ratio	-	11.3	-	-	12.8	-	-	17.3	

The total energy required for sowing with liner (6930.04 MJ/ha) was found maximum as compared to seed cum fertilizer drill (6712.75 MJ/ha) and broadcasting (6627.51 MJ/ha), whereas the grain and straw yield of wheat was highest when sowing of wheat was done with seed cum fertilizer drill (3150 and 5607 kg/ha, respectively) and lowest in case of sowing of wheat with broadcasting (2150 and 3440 kg/ha, respectively). The B:C ratio was highest in sowing with seed drill (3.3) and followed by liner (2.1) broadcasting (1.9), respectively (Table-147).

Table-147: Performance and economics of different sowing methods in wheat

Method of sowing	Yield (kg/ha)		Total energy input (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivation (Rs/ha)	GMR (Rs/ha)	B:C ratio
	Grain	Straw					
Broadcasting	2150	3440	6627.51	74605	15570	45580	1.9
Sowing with liner	2450	4199	6930.04	88502.5	17010	53056	2.1
Seed cum fertilizer drill	3150	5607	6712.75	116392	16122	69048	3.3

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA centre, Rakh Dhiansar in Khaner village, Purmundal Block, Tehsil & District Samba, Jammu and Kashmir. The total cultivated area is 55 ha and 100% of the area is rainfed. The mean annual rainfall is 1140 mm with seasonal rainfall of 860 mm during kharif season (June-September). The major soil types are sandy loam. The major rainfed crops during kharif are maize, blackgram, greengram, sesame, fodder pearlmillet, fodder sorghum and during rabi season are wheat, chickpea and mustard. The number of small, marginal and medium farmers is 40, 18 and 32, respectively. The ground water table is 150-200 meters. There is no source of irrigation in the village.

Climate Vulnerability in General

In general, the climate in this agro-climatic zone is sub-humid. The rainfall is received through south-west monsoon (monsoon season), western disturbances (winter season) and summer (pre- monsoon) and contributes about 75, 13 and 12% of the annual rainfall, respectively. The historical rainfall data (25 years) indicated that the variability among normal rainfall during south-west monsoon is 26.2 and 17.5% surplus and deficit, respectively. The normal onset of (south-west) monsoon was during 26th SMW. For the past 15 years, the dry spells during the crop season experienced were 1, 5 and 6 during August, September and October, respectively and at initial and reproductive stages of the major rainfed crops. There was 20% probability of occurrence of severe drought during rabi season in the kandi belt of Jammu region. The chances of occurrence of normal and moderate drought were 7 and 12% during *kharif* season and 8 and 8% eachduring rabi season, respectively. In the district, the chances of normal season were more than 60% during crop growing season, whereas, the chances of normal (25% less from normal rainfall) and moderate (25-50% less from normal rainfall) drought were 24 and 12%, respectively. The chances of early, normal and late onset of monsoon are 16, 72 and 12%, respectively; whereas 28, 68 and 4% chances of early, normal and late withdrawal of monsoon, respectively. The soil moisture status remained deficit during establishment and reproductive stages of major rainfed crops in different years in the region with a lot of variability among the above said crop stages. The maximum/minimum temperature during *kharif* crop season is 34.3/23.7˚C and during *rabi* season the maximum/minimum temperature is 24.7/10.3˚C for the past 10 years. There was an increase in the maximum temperature during *kharif* season at the rate of 0.03˚C per year while during *rabi* season the mean temperature had also gone up by 0.04˚C per year. The day temperature in the district decreased by 0.7˚C from the last two decades, while the night temperature had gone up by 0.60C during this period. The rainfall showed an increasing trend at the rate of 2.0 mm per year for the past 20 years. The extreme events like unusual and high intensity rainfall in short span have been increasing in the month of August. The region had also been experiencing other extreme events like floods and cold waves. There was no shift in the rainfall pattern in the region and hence sowing window has remained the same.

Experienced weather conditions during the year (2013-14)

During 2013, in Khaner village, a rainfall of 1196.4 mm was received which was excess by 299.5 mm compared to normal (896.9 mm) (Fig.22), during south-west monsoon (*kharif).* During north-east monsoon (October - December), 64.1 mm of rainfall was received which was excess by 17.5 mm compared to normal (46.6 mm). During summer (March - May), 42.7 mm of rainfall was received which was deficit by 63.8 mm compared to normal (106.5 mm).

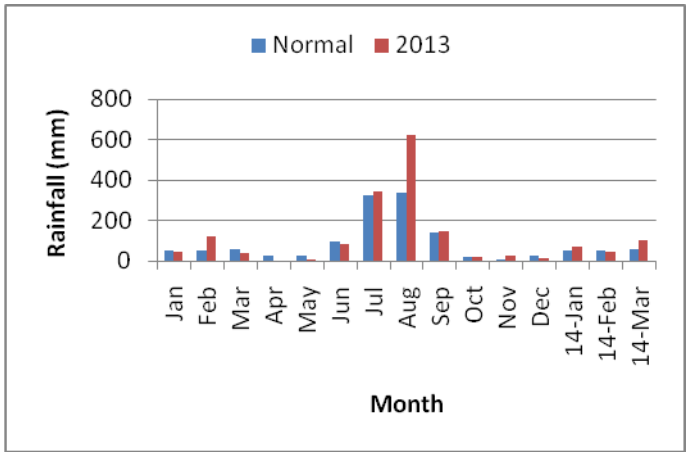


Fig.22: Normal and actual (2013) monthly rainfall at Khaner

Real time contingency crop planning

The rainfall in June month was deficit by 11.2% whereas the rainfall during July, August and September months was excess by 6.3, 84.3 and 4.2%, respectively compared to normal rainfall. During crop period the rainfall received was 1163.1mm. Different maize varieties/hybrids were demonstrated in farmers' fields to cope with rainfall variability during the season. Among four varieties of maize at 6 farmers' field, D*ouble Dekalb* gave maximum mean grain yield of 2718 kg/ha with B:C ratio of 2.48 followed by the varieties *PB-2475* and *Tip-Top* with mean grain yield and B:C ratio of 2610 kg/ha & 2.45 and 2478 kg/ha & 2.33, respectively. Mean rain water use efficiency (RWUE) was also found maximum in the variety *Double Dekalb* (2.34 kg/ha/mm), whereas, it was minimum in the variety *K-517* (1.99 kg/ha/mm) (Table-148).

Table-148: Yield and economics of maize (Double Dekalb) for different farmers at village Khanner (6 farmers)

Variety	Crop duration (days)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Test-weight (g)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Tip Top	88	2478	5482	31.2	216	2.13	18955	25199	2.33
K-517	91	2310	5357	30.1	213	1.99	18275	23255	2.27
Double Dekalb	93	2718	5769	32.0	232	2.34	19375	28689	2.48
PB-2475	90	2610	5726	31.3	221	2.24	18975	27458	2.45
Mean	91	2529	5584	31.2	221	2.17			

Maize (Double Dekalb) crop in farmers' fields at village Khanner

During *rabi* season, the rainfall as excess in October by 15% and November by 381% but was deficit by 32% in December. Wheat variety PBW-175 demonstrated at 24 farmers fields recorded a mean grain yield of 2473 kg/ha with NMR of Rs. 38500/ha, B:C ratio of 3.36 and rainwater use efficiency of 9.07 kg/ha-mm with an increase in grain yield of about 20% over the farmers' practice (1987 kg/ha) (Table-149).

Table-149: Yield and economics of wheat (PBW-175) under improved practices at village Khaner (24 farmers)

Grain yield (kg/ha)		Days to maturity	RWUE (kg/ha/mm)		Cost of cultivation (Rs/ha)		Net return (Rs/ha)		B:C ratio	
Improved practices	Farmers' practices		Improved practices	Farmers' practices	Improved practices	Farmers' practices	Improved practices	Farmers' practices	Improved practices	Farmers' practices
2473	1987	167	9.07	7.27	16287	17369	38500	30828	3.36	2.78
7.2	11.3									

Intercropping system of maize + urdbean (2:1 Additive series)

The rainfall in June month was deficit by 11.2% whereas the rainfall during July, August and September months was excess by 6.3, 84.3 and 4.2%, respectively compared to normal rainfall. During crop season rainfall of 1163.1mm was recived.Intercropping of mash crop (var. Uttara) with maize (var. Double Dekalb) crop at 6 farmers' fields in additive series (2:1) with no extra fertilizers for intercrop recorded a mean grain yield of 2142 and 176 kg/ha, respectively. The intercropping system registered a maize equivalent yield of 2627 kg/ha with a B:C ratio of 2.07. The rainwater use efficiency was found to be 1.84 and 0.15 kg/ha-mm for main and intercrop, respectively (Table-150).

Table-150: Yield and economics of maize crop under intercropping system with urdbean in additive series (6 farmers)

Intercropping system with row ratios	Grain yield of crop 1 & 2 (kg/ha)**	MEY kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Maize + mash 2:1 row ratio (Additive series)	2142 (176)	2627	1.84 (0.15)	21625	23110	2.07

Cropping Sequence

Seven different cropping sequences *viz.*, cereal-cereal (maize-wheat), cereal-oilseed (maize-mustard), pulse-cereal (moong-wheat), pulse-oilseed (moong-mustard), pulse-pulse (mash-chickpea), oilseed-oilseed (til-mustard) and pastoral-pastoral (fodder-fodder) were demonstrated at farmers' field during *kharif* 2013 using recommended package of practices for rainfed condition under sub-tropical region. It was observed that during *kharif* season, under cereal-cereal system maize variety Double dekalb produced highest net returns of Rs. 26161/ha

with B:C ratio of 2.35 and RWUE of 2.23 kg/ha-mm followed by pulse-oilseed cropping sequence of Rs. 20675/ha as net return and RWUE values were 2.26 and 0.59 kg/ha-mm, respectively. However, the lowest values of the same to the tune of Rs. 6970/ha, 1.46 and 0.55 kg/ha-mm, respectively was recorded in mash crop under pulse-pulse system (Table-151.).

Table-151: Yield and economics of different crops under various cropping systems at village Khaner (14 farmers)

Cropping system	Crop	Rain fall (mm)	Crop duration (in days)	Grain yield (kg/ha)	Test-weight (g)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Cereal-cereal	Maize	1173.1	96	2528	222	2.15	19375	25489	2.32
Cereal-oilseed	Maize	1155.1	96	2573	224	2.23	19375	26161	2.35
Pulse-cereal	Moong	1005.9	79	556	39.3	0.55	16440	19700	2.20
Pulse-oilseed	Moong	967.9	78	571	40.9	0.59	16440	20675	2.26
Pulse-pulse	Mash	1005.9	79	554	43.1	0.55	15190	6970	1.46
Oilseed-oilseed	Til	1047.7	106	345	6.2	0.33	12295	11855	1.96
Pastoral-pastoral	Mixed fodder	1016.1	64	--	--	31.73	11740	14060	2.20

* Rainfall (mm) from date of sowing to harvest, Maize var. Double Dekalb, Mash var. Uttara and Til var. PB-1**,**

During north-east monsoon (October - December), 64.1 mm of rainfall was received which was excess by 17.5 mm compared to normal (46.6 mm). The rainfall in October month was excess by 15.0% and November by 380.7%, where as December month was deficit by 31.5% compared to normal rainfall. Under cropping sequence programme, in seven different cropping sequences *viz:* cereal-cereal (maize-wheat), cereal-oilseed (maize-mustard), pulse-cereal (moong-wheat), pulse-oilseed (moong-mustard), pulse-pulse (mash-chickpea), oilseed-oilseed (til-mustard) and pastoral-pastoral (fodder-fodder) tested at farmers' field with recommended package of practices, during *rabi* season under pulse-cereal system wheat variety *PBW 175* produced maximum grain yield of 2861 kg/ha with highest NMR of Rs. 26048/-ha with B:C ratio of 2.60. However, an increase in grain yield of wheat, mustard and chickpea ranging from 17-24, 30-37 and 28 per cent was observed over farmers' practice in different cropping systems (Table-152).

Table-152: Yield and economics of different crops under various cropping systems for different farmers at village Khaner

Cropping system	Dura-tion (days)	Grain yield (kg/ha)		RWUE (kg/ha-mm)		Cost of cultivation (Rs/ha)		Net return (Rs/ha)		B:C ratio	
		Impro-ved prac-tices	Farmers' practices	Impro-ved prac-tices	Farmers' practices	Impro-ved prac-tices	Farmers' practices	Impro-ved prac-tices	Farmers' practices	Impro-ved prac-tices	Farmers' practices
Wheat in cereal-cereal	168	2627	2199	9.65	8.08	16287	16664	22593	15889	2.39	1.95
Mustard in cereal-oilseeds	157	815	525	3.30	2.13	12335	12720	13745	4080	2.11	1.32
Wheat in pulse-cereal	169	2861	2222	10.50	8.16	16287	17515	26048	15371	2.60	1.88
Mustard in pulse-oilseeds	157	765	503	3.10	2.04	12335	12803	12145	3293	1.98	1.26
Chickpea in pulse-pulse	172	456	355	1.67	1.30	17284	18756	3236	-2781	1.19	0.85
Chickpea in pulse-pulse	171	468	340	1.72	1.25	17284	18652	3776	-3353	1.22	0.82
Mustard in oilseed-oilseed	155	789	549	3.20	2.23	12335	12702	12913	4866	2.05	1.38
Oats in pastoral-pastoral	113			331.76	259.74	14279	14904	8201	2696	1.57	1.18

Under pastoral-pastoral demonstration mixed fodder at six farmers' fields, mean mixed fodder yield of 34000 kg/ha was obtained with net return of Rs. 15760/ha and B:C ratio of 2.32 with a RWUE of 33.82 kg/ha-mm. Similarly, in demonstration of fodder (oats) at six farmers' fields, mean fodder (oats) yield of 20900 kg/ha was obtained with net return of Rs. 11850/ha and B:C ratio of 2.30 with a RWUE of 159.17 kg/ha –mm.

Efficient energy use and management

The demonstration conducted on farmers' fields showed that energy required for different components and their % contribution varied depending on land type. Similarly, the input, output and their ratio was highest in the field of Parkash Chand (16.39) whereas it was found lowest in case of Ram Lal Sharma (11.97); it was lowest because of labour and diesel component as the land was undulated (Table-153).

Table-153: Fuel consumed (in term of energy used) for seed bed preparation and sowing of wheat

Name of farmer	Area (ha)	Seed bed preparation (hrs)	Sowing (hrs)	Diesel (lit/ha)	Energy (MJ/ha)
Ramlal Sharma	0.1	0.67	0.27	33.54	1888.64
Mangal Dass	0.2	1.33	0.5	32.9	1852.60
Parkash Chand	0.2	1.33	0.37	34.4	1937.06
Kamal Kumar	0.15	1	0.33	32.2	1813.18
Hakam Din	0.45	3	1.17	33.1	1863.86
Bashir Ahmned	0.15	1	0.33	32.5	1830.08
Girdhari Lal Sharma	0.35	2.33	0.75	31.9	1796.29
Sanjeev Kumar	0.75	5	1.67	32.45	1827.26
Keval Sharma	0.2	1.33	0.4	33.85	1906.09
Sushma Devi	0.15	1	0.32	31.6	1779.40
Rattan Lal	0.4	2.67	0.83	32.1	1807.55
Bansi Lal	0.3	2	0.7	33.35	1877.94
Bodh Raj Sharma	0.4	2.67	1	33.5	1886.39
Jagdev Singh	0.2	1.33	0.53	34.2	1925.80

Demonstrations on wheat sowing with seed drill were conducted for ensuring timely sowing, reduce cost of cultivation and improve crop yields. The mean yield of wheat over 14 farmers' fields was 2405 kg/ha with net return of Rs. 19360/ha and B:C ratio of 1.18 and total energy required was 6910 MJ/ha and total energy output was 93132 MJ/ha.

Alternate land use/farming systems for carbon sequestration and ecosystem services

Under agri-horti postoral system in four farmers' fields, under the anola which is about 6 to 7 year old mixed fodder crops were introduced and mixed fodder yield under agri-horti system was 256 q/ha and B:C ratio under this system was observed between 0.71 to 1.10. The rainwater use efficiency was found higher than the sole crop and it was observed between 25.09 to 30.87 with a mean of 27.90 at farmers' fields .Whereas on station, the B:C ratio was found much higher (1.17) than on farm along with higher rainwater use efficiency (31.85) (Table-154).

Table-154: Yield and economics under agri-horti-pastoral system on farm (4 farmers) as well as on station

Crop	Farmer location	Fodder yield (q/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Aonal + mixed fodder	On farm (4 farmers)	256	9411	8492	0.90	27.9
Mixed fodder	On station (DLRSS)	292	9411	11029	1.17	31.85

In another agri-horti system, in between aonla crop the pulses crop (mash) in combination with maize was included in additive series in place of mixed fodder. The mean maize equivalent yield under aonla + (maize + mash) system on farmers' fields was 2644'kg/ha with net return of Rs 25771/ha, B:C ratio of 1.27 and RWUE of 2.67 kg/ha-mm.

1.3. FINGERMILLET BASED PRODUCTION SYSTEM

1.3.1. BANGALORE

a. Agro-ecological setting

Bangalore is located in Deccan (Karnataka) plateau of central Eastern Ghats (AESR 8.2), dry zone in Karnataka. The climate is hot moist semi-arid. Annual average rainfall in the season is 926 mm. Length of growing period is 120-150 days.

On-station experiments

During 2013, the onset of monsoon was delayed by 10 days (3rd week of June). A rainfall of 576.8 mm was received which was excess by 59.9 mm compared to normal (516.9 mm) (Fig.23), during south-west monsoon (*kharif).* During north-east monsoon (October - December), 118.9 mm rainfall received which was deficit by 122.2 mm compared to normal (241.1 mm). During summer (March - May), 149.6 mm of rainfall was received which was deficit by 6.2 mm compared to normal (155.8 mm). There were 3 dry spells *viz.*, Jun-08 to Jun-20 (13 days) (All crops were at germination to seedling stage); Sept-23 to Oct-07 (15 days) (fingermillet: tillering to panicle initiation stage; pigeonpea: vegetative stage; groundnut: peg initiation stage; chilli, cluster bean, field bean, cowpea: flowering to fruiting stage; grain amaranth, minor millets: flowering stage; fodder maize: harvesting stage and castor: maturity stage) and Nov-05 to Nov-16 (12 days) (fingermillet, chilli and minor millets: harvesting stage; cowpea, pigeonpea and field bean: flowering to fruiting stage).

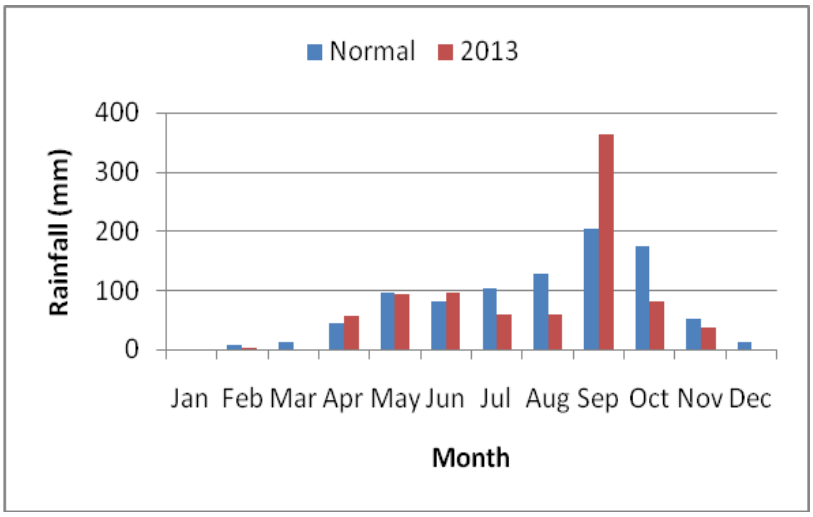


Fig.23: Normal and actual (2013) monthly rainfall at Bangalore

Dryland agri-tech park for the year 2013-14

At the centre, dryland agri-tech park was developed about 3 ha comprising of rainfed technology for demonstration under different theme areas of NICRA.

Real time contingency planning

Dryland agri-tech park in about 0.6 ha comprising of technologies under different theme areas of NICRA project was established on-station (Table 1, 2 and 3). Farmers along with officers of the line department visited the park and were convinced about the dryland technologies. There were 3 dry spells *viz.*, Jun-08 to Jun-20 (13 days) (All crops were at germination to seedling stage) Sept-23 to Oct-07 (15 days) (fingermillet tillering to panicle initiation stage, pigeonpea vegetative stage, groundnut: peg initiation stage, chilli, cluster bean, field bean, cowpea: flowering to fruiting stage, grain amaranth, minor millets: flowering stage, fodder maize: harvesting stage and castor: maturity stage) and Nov-05 to Nov-16 (12 days) (fingermillet, chilli and minor millets harvesting stage, cowpea, pigeonpea, field bean: flowering to fruiting stage). The performance of different crops is given in Table-155.

Table-155: Performance of different crops/varieties grown in demonstration plot

Pure crop	Grain/pod/ fruit yield (kg/ha)	Straw/ fodder yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Horsegram (PHG-9) – fingermillet (ML-365)	3000	3000	5.59	40708	2.83
Glyricidia – fingermillet (ML-365)	3000	4000	5.59	41708	2.87
Dry sowing of fingermillet (KMR-204)	3500	5500	6.48	56388	3.95
Rice bean (RBL-1)	923	-	1.92	3820	1.20
Horsegram (PHG-9)	1108	1662	2.30	13985	1.73
Field bean (HA-4)	1136	-	2.36	6628	1.30
Cowpea (PKB-6)	1219	-	2.53	40078	2.92
Cowpea (IT-38956-1)	1348	-	2.80	46528	3.23
Fingermillet (KMR-204) (DAP + drill sown)	3500	4000	6.48	55013	3.90
Fingermillet (GPU-28) + *Akkadi* crops (farmers' practice)	3600	5000	6.25	56762	3.99
Fodder bajra (Giant bajra)	-	79406	167.24	98117	5.67
Sweet sorghum (SSV-74)	-	74790	157.52	93713	6.07
Fodder maize (SAT)	-	104336	219.75	135089	7.31
Non nipped castor (DCS-9)	831	-	1.42	14613	1.78
Nipped castor (DCS-9)	1847	-	3.15	54053	3.73
Maize hybrid 1137 (Hema)	5540	4035	9.76	60795	3.92
Sunflower (KBSH-53)	617	-	1.28	3004	1.15
Niger (No. 71)	440	-	0.92	8073	1.44
Chilli Chikkaballapur local	1274	-	2.49	39209	2.60
Chilli Samrudhi with mulch	2077	-	4.07	79431	4.25
Proso millet	659	-	0.54	1678	1.09
Little millet	1080	-	2.24	14308	1.79
Foxtail millet	1579	-	3.28	29278	2.62
Kodo millet	869	-	0.77	7978	1.44
Cowpea (PKB-4)- fingermillet (GPU 48)	670/3800	3500	7.9	52890	2.33
Cowpea (IT38956-1)- fingermillet (GPU 48)	972/3800	3500	7.9	60440	2.52
Grain amaranth (Suvarna)	1177	-	2.45	407	1.02
Grain amaranth (KBGA-1)	852	-	1.77	-5443	0.74
Fingermillet (GPU-28) (FYM + NPK + Zn + B)	5000	6500	9.32	85365	5.38
Fingermillet (GPU-28) (Rec. NP + 150% K)	5250	7000	10.58	90412	5.56
Fingermillet (GPU-28) (FYM + NPK without lime)	3600	6000	6.67	57512	4.03
Fingermillet (GPU-28) (with lime)	4000	6000	8.06	64237	4.17

The performance of short, medium and long duration varieties of fingermillet, under real time contingency planning from second fortnight of June to second fortnight of August 2013 is presented in (Table). Among all the varieties, higher yield was recorded with August second fortnight sowing of GPU-66 (4000 kg/ha), net returns (Rs.65137/ha), B:C ratio (4.43) and rainwater use efficiency (8.31 kg/ha-mm) (Table-156).

Table-156: Yield and economics of fortnightly sown fingermillet

Sowing time	Variety	Grain yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
July first fortnight	GPU-48	3500	6250	6.13	55700	3.93
	GPU-66	3350	7000	5.86	53262	3.81
	MR-1	3900	7500	6.83	64637	4.40
July second fortnight	GPU-48	3000	5800	5.52	45362	3.39
	GPU-66	3500	7000	6.45	56262	3.96
	MR-1	3800	7500	7.00	62637	4.30
August first fortnight	GPU-48	3000	3500	5.59	43637	3.30
	GPU-66	3500	4000	6.52	54012	3.84
	MR-1	3230	4000	6.02	48612	3.56
August second fortnight	GPU-48	3800	4250	7.84	60200	4.17
	GPU-66	4000	5500	8.31	65137	4.43
	MR-1	3250	4500	6.75	49387	3.60

In pigeonpea and groundnut based intercropping systems, fingermillet + pigeonpea (8:2) performed better and crop equivalent yield was higher (4415 kg/ha), with net returns (Rs.67721/ha) and B:C ratio (4.29). Further, maize + pigeonpea (1:1) was also found to be better (Table157).

Table-157: Performance of intercropping systems

Cropping system	Crop yield (kg/ha)		CEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop				
Groundnut (TMV-2) + nipped castor (8:1)	762	831	1427	2.96	38738	2.19
Groundnut (TMV-2) + pigeonpea (8:2) (NPK + Zn + B)	646	351	948	1.64	17810	1.60
Maize (Nithyashree) + pigeonpea (TTB-7) (1:1)	4155	280	5015	8.70	48319	3.21
Pigeonpea (BRG 4) + soybean (1:1) (FYM + NPK + Zn + B)	600	162	694	1.20	6392	1.27
Pigeonpea (BRG 1) + cowpea (1:1) (FYM + NPK + Zn + B)	369	263	675	1.17	5559	1.24
Pigeonpea (BRG 2) + field bean (1:1) (FYM + NPK + Zn + B)	377	314	560	0.79	603	1.03
Fingermillet + pigeonpea (8:2) with conservation furrow	4000	166	4415	7.66	67721	4.29

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use

Catchment-storage-command relationship for enhancing water productivity in micro-watershed (On-station)

During 2013, the total rainfall received was 847.5 mm and the runoff causing rainfall during the year was 702.6 mm. Runoff water collected from the catchment was 214.33 and 183.18 m^3 where no live barrier was there and it was 245.65 m^3 in Nase and 220.57 m^3 in Khus live barrier. From a catchment area of 0.612 ha 2,20,570 liters of water was harvested and 480 liters of water used for growing of leafy vegetables and vegetables. From a catchment of 0.561 ha 2,45,650 liters of water was harvested, 42,984 liters of water used for three protective irrigation to fodder crops and 25,286 liters of water used for four irrigation to pomelo plantation crop. From a catchment of area of 0.561 ha 2,14,330 liters of water harvested and 5675 liters of water used to give one protective irrigation to chickpea crop (Table-158).

Table-158: Amount of water stored and used in different catchments during *kharif*, 2013

Treatment	Catchment area (ha)	Water harvested (m^3)	Water used (m^3)	Remarks
Life saving irrigation system around the farm pond (Bricks)	0.612	220.57	4.80	Leafy vegetables (area: 26 m^2)
Fish culture (soil + cement over laid with polythene sheet lining and brick compartment)	0.561	245.65	68.27	Fish rearing, fodder crops (three irrigation), pomelo (four irrigation)
Horticulture components around the farm pond	0.561	214.33	56.75	Chickpea (one irrigation)
Nourishing horticulture crops planted elsewhere	0.594	183.18	-	Harvested water not used

Different vegetables were grown around the farm pond by utilizing the harvested water. Due to this, an additional income of Rs.591 was realized with effective utilization of harvested water profitably (Table-159).

Table-159 : Performance of vegetable crops grown around the farm pond (26 m^2)

Leafy vegetables	Yield (kg)	Income (Rs)
Amaranth: Local	2.4	86.4
Amaranthus sp.	3.0	54.0
Sabakki: Local	2.8	61.6

Methi: Local	2.5	40.0
Coriander: Local	2.2	165.0
Coriander: Hybrid	3.5	140.0
Chakkota (Leafy vegetable)	2.0	44.0
Total		591.0

The mean grain and straw yield of fingermillet was higher in Nase grass live barrier plots (2638 and 3788 kg/ha, respectively) followed by Khus grass (1925 and 2350 kg/ha, respectively) as compared to control plots (2388 and 3475 kg/ha, respectively) (Table). Trends were similar with respect of B:C ratio (2.66 and 2.94, respectively) and RWUE (4.8 and 5.3 kg/ha-mm, respectively) (Table-160).

Table-160: Fingermillet yield as influenced by live barriers during *kharif*, 2013

Treatment	Fingermillet yield (kg/ha)		HI	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C	RWUE (kg/ha-mm)
	Grain	Straw					
Khus grass Upper	2300	3375	0.405	18938	29593	2.56	4.6
Lower	2475	3575	0.409	18938	33243	2.76	5.0
Mean	2388	3475	0.407	18938	31418	2.66	4.8
Nase grass Upper	2550	3650	0.411	18938	34800	2.84	5.1
Lower	2725	3925	0.410	18938	38506	3.03	5.5
Mean	2638	3788	0.411	18938	36653	2.94	5.3
Control	1925	2350	0.450	18938	21325	2.13	3.9

Alternate land use system

Evaluation of Amla based agri-horti system (2 ha area)

There were 3 dry spells *viz.*, Jun-08 to Jun-20 (13 days), Sept-23 to Oct-07 (15 days) and Nov-05 to Nov-16 (12 days). Delayed monsoon onset by 10 days was followed by excess rainfall in June (18.1%), deficit rainfall in July (42.5%) and August (54%). Significantly higher amla equivalent yield was observed in intercropped cowpea (1903 kg /ha) and it was on par with fingermillet (1849 kg/ha). The next best treatment was horse gram (1264 kg/ha) as an intercrop. Fingermillet, cowpea and horse gram were proved to be better intercrops in amla which registered higher B:C ratio and RWUE. Leguminous intercrops *viz.*, field bean, cowpea and horse gram enhanced the growth parameters as compared to fingermillet, grain amaranth and fodder maize (Tables 161 and 162).

Table-161: Growth parameters of amla as influenced by inter crops during 2013-14

Treatment	Plant height (cm)	No. of Branches	Collar Diameter (cm)	Canopy spread (cm)	Biomass (kg/tree)
Amla + fingermillet	240.3	2.1	21.8	146.1	157.6
Amla + cowpea	313.0	2.6	28.9	190.2	225.8
Amla + horse gram	340.5	2.6	28.2	182.4	219.3
Amla+ field bean	341.4	2.8	32.3	198.6	261.0
Amla+ fodder maize	248.0	2.6	25.9	155.8	196.5
Amla+ grain amaranth	238.7	2.3	22.6	151.6	164.9
Amla	207.4	2.0	20.9	106.0	148.5
CD (P=0.05)	46.6	0.4	3.9	20.4	38.1

Table-162: Performance of intercrops in amla based system during 2013-14

Treatment	Amla yield (kg/ha)	Intercrop yield (kg/ha)	AEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Amla + fingermillet	392	2187	1849	25649	29831	2.16	3.74
Amla + cowpea	420	890	1903	27533	29548	2.07	4.16
Amla + horse gram	432	831	1264	25916	11994	1.46	2.56

Amla + field bean	460	953	1255	28433	9210	1.32	2.54
Amla + fodder maize	366	9840	858	28470	-2726	0.90	1.87
Amla + grain amaranth	351	948	825	27439	-2687	0.90	1.67
Fingermillet	-	2424	1616	18988	29497	2.55	4.91
Cowpea	-	924	1540	20872	25340	2.21	2.02
Horse gram	-	1030	1030	19255	11654	1.61	2.09
Field bean	-	970	808	21772	2470	1.11	1.96
Fodder maize	-	10758	538	21809	-5673	0.74	23.50
Grain amaranth	-	1152	576	20779	-3506	0.83	2.33
Amla	493	-	493	8260	6537	1.79	-
CD (P=0.05)	52.07	-	151.42	-	-	-	-

Custard apple based agri-horti system (1 ha)

Significantly higher custard apple equivalent yield was observed with fodder maize (SA tall) (1468 kg/ha) and fingermillet (1317 kg/ha) in custard apple based agri-horti system. Fodder maize (SA tall) and fingermillet in custard apple registered higher net returns (Rs.59633/ha and Rs.53398, respectively) and B:C ratio (3.09 and 3.08, respectively) followed by cowpea and green chilli (Table-163). Custard apple recorded significantly higher plant height, more number of branches, stem diameter, canopy spread and biomass yield in field bean and cowpea as intercrops compared to sole custard apple (Table -164).

Table-163: Performance of intercrops in the custard apple based agri-horti system during 2013-14

Treatment	Custard apple yield (kg/ha)	Intercrop yield (kg/ha)	CEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha mm)
CA + fingermillet	305	3036	1317	25649	53398	3.08	5.58
CA + fodder maize	266	40082	1468	28470	59633	3.09	86.85
CA+ field bean	306	1144	782	28433	18507	1.65	2.11
CA+ niger	296	476	773	24988	21378	1.86	0.88
CA + green chilli	303	5140	1159	31152	38398	2.23	8.86
CA + cow pea	315	824	1002	27533	32579	2.18	1.58
CA + fox tail millet	290	1151	770	24752	21439	1.87	2.12
Custard apple (CA)	330	-	-	9760	10053	2.03	0.57
Fingermillet	-	3483	-	18988	50670	3.67	6.40
Fodder maize	-	45370	-	21809	59858	3.74	98.31
Field bean	-	1348	-	21772	11935	1.55	2.48
Niger	-	577	-	18327	16288	1.89	1.06
Green chilli	-	6023	-	24491	35741	2.46	10.38
Cow pea	-	873	-	20872	22754	2.09	1.67
Foxtail millet	-	1346	-	18092	15562	1.86	2.47
CD (P=0.05)	33.9	-	131.01	-	-	-	-

Table-164: Growth parameters of custard apple as influenced by intercrops during 2013-14

Treatment	Plant height (cm)	No. of Branches	Collar Diameter (cm)	Canopy spread (cm)	Biomass (kg/tree)
CA + fingermillet	197.9	3.0	11.0	226.4	65.2
CA + fodder maize	187.7	2.9	10.2	223.5	59.2
CA + field bean	205.3	3.1	11.3	233.0	67.3
CA + niger	174.1	2.8	9.6	215.3	54.8
CA + green chilli	191.7	2.9	10.3	225.1	60.2
CA + cow pea	201.9	3.0	11.3	229.4	67.3
CA + fox tail millet	179.5	2.9	9.7	218.2	55.3
Custard alone	167.1	2.4	9.4	198.1	53.3
CD (P=0.05)	24.81	0.37	1.10	19.81	8.23

C. On-farm experiments

Village profile

The program is being implemented by AICRPDA centre, Bangalore in Chikkamaranahalli village, Nelamangala Taluk in Bengaluru rural district, Karnataka. The total cultivated area is 409.2 ha out of which 367.4 ha is rainfed. The mean annual rainfall is 750 mm with seasonal rainfall of 442 mm during *kharif* (June-September). The major soil type is sandy clay loam. The major rainfed crops during *kharif* are fingermillet, groundnut and pigeonpea. The numbers of small, marginal, medium and large farmers are 48, 144, 7 and 2, respectively. The ground water table is 350 feet below surface. The source of irrigation is bore wells covering 4.39 ha of cultivated area.

Climate vulnerability in general

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 750 mm, the south-west monsoon contributes 55.5%, north-east monsoon 33.3% and summer 11.13%. The historical rainfall data (of 30 years) indicates that the variability in rainfall during south-west monsoon is 8% surplus of the average rainfall. The onset (south-west) of monsoon is during 23rd SMW (June 1st week) and north-east monsoon is 40th SMW. For the past 15 years, the dry spells during crop season are experienced in June, July, August, September and October and at vegetative and reproductive stages of the major rainfed crops. The onset of the monsoon has shifted to June 2nd week, followed by erratic rainfall. The soil moisture status is deficit during vegetative and reproductive stages of major rainfed crops. The extreme events like unusual and high intensity rainfall in short span are occurring during kharif and rabi seasons. The area is also experiencing other extreme events like hail storm.

Experienced weather conditions during the year (2013-14)

During the year 2013, in the Chikkamaranahalli village, onset of monsoon was earlier by 4 days during 1st week of June. A rainfall of 442 mm was received which was excess by 30.3 mm compared to normal (409.7 mm) (Fig.24), during south-west monsoon (kharif). During north-east monsoon (October - December), there was 91 mm of rainfall received which was deficit by 153.9 mm compared to normal (244.9 mm). During summer (March - May), there was 118 mm of rainfall received which was excess by 36.1 mm compared to normal (81.9 mm). There were 6 dry spells viz., Jun-04 to Jun-19 (16 days) Jun-30 to July-9 (10 days), July-21 to August-13 (24 days) (fingermillet, pigeonpea: germination to seedling stage) Sept-16 to Oct-7 (22 days) (fingermillet: tillering to panicle initiation stage pigeonpea: vegetative to flowering stage), Oct-09 to Oct-19 (11 days) fingermillet: panicle initiation to grain filling stage, pigeonpea: flowering stage), Nov-05 to Nov-22 (18 days) (fingermillet: harvesting stage, pigeonpea: flowering to pod filling stage).

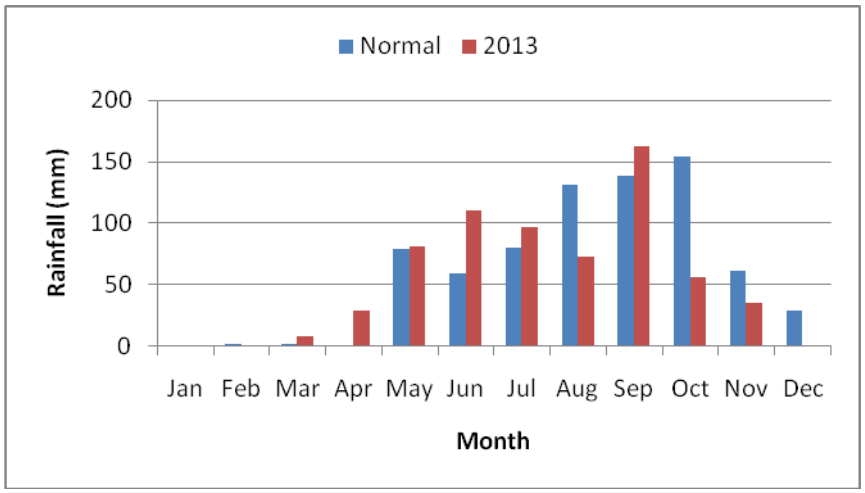


Fig.24: Normal and actual (2013) monthly rainfall at Chikkamaranahalli

Interventions

The major interventions implemented included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 36.08 ha in 141 farmers'fields.

Real time contingency planning

Two fingermillet varieties with improved practices were demonstrated in 9.2 ha in 27 farmers' fields. There were 6 dry spells viz., Jun-04 to Jun-19 (16 days) Jun-30 to July-9 (10 days), July-21 to August-13 (24 days) (fingermillet germination to seedling stage) Sept-16 to Oct-7 (22 days) (fingermillet tillering to panicle initiation stage, Oct-09 to Oct-19 (11 days) fingermillet panicle initiation to grain filling stage, Nov-05 to Nov-22 (18 days) fingermillet harvesting stage. During the cropping season 405 mm rainfall was received with four dry spells (>10days).Under conditions of excess rainfall in June (86.7%), July (20.6%) and September (16.5%) where as deficit rainfall in August (44.5%), October (63.7%), November (42.9%) and December (100%) compared to normal rainfall. Among two varieties, long duration variety MR-1 recorded higher grain yield (1967 kg/ha), net returns (Rs. 23510/ ha) and B:C ratio (2.24) than medium duration variety GPU-28 (1700 kg/ha, Rs.17972/ ha and 1.95, respectively). Rainwater use efficiency was higher in GPU-28 (5.21 kg/ha-mm) as compared to MR-1 (4.86 kg/ha-mm). Due to timely onset of monsoon, MR-1 performed better than medium duration variety GPU-28 (Table-165).

Table-165: Performance of different fingermillet varieties

Treatment	No. of far-mers	Area (ha)	Date of sow-ing	Date of har-vest-ing	Rain fall (mm)	Crop Dura-tion (days)	Yield (kg/ha)		Har-vest index	RWUE (kg/ha-mm)	Cost of cultiva-tion (Rs/ha)	Net returns (Rs/ha)	B:C ratio
							Grain	Straw					
MR-1 (Long duration)	23	8.4	10-07-2013	06-11-2013	405	119	1967	4210	0.32	4.86	18988	23510	2.24
GPU-28 (Medium duration)	4	0.8	19-08-2013	05-12-2013	326	108	1700	3947	0.30	5.21	18988	17972	1.95

Comparison between transplanted and direct sown fingermillet was demonstrated in 11 ha in 36 farmers' fields. During the cropping season 405 mm rainfall was received with four dry spells (>10 days).Transplanted fingermillet (MR-1) recorded higher grain yield (2417 kg /ha), net returns **(**Rs.31465/ha) and B:C ratio (2.72) as compared to direct sown fingermillet (1967 kg/ha, Rs. 23510/ha and 2.24, respectively). Transplanted fingermillet (GPU-28) recorded higher grain yield (1981 kg/ha), Net returns **(**Rs.22089/ ha) and B:C ratio (2.09) as compared to direct sown GPU-28 fingermillet (1700 kg/ha, Rs. 17972/ha and 1.95, respectively). In a situation with normal onset of monsoon direct sowing of MR-1 fingermillet variety was found to be more remunerative than direct seeding of GPU-28 (Table-166).

Table-166: Comparison between transplanted and direct sown methods in fingermillet

Treatment	Date of sowing/ Dof transplanting	Date of harves-ting	Rainfall (mm)	Crop duration (days)	Yield (kg/ha)		Harvest indexI	RWUE (kg ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
					Grain	Straw					
Direct sown (MR-1)	10-07-2013	06-11-2013	405	119	1967	4210	0.32	4.86	18988	23510	2.24
Direct sown (GPU-28)	19-08-2013	05-12-2013	326	108	1700	3947	0.30	5.21	18988	17972	1.95
Transplanted (MR-1)	28-08-2013	08-12-2013	263	102	2417	4417	0.35	9.19	20188	31465	2.56
Transplanted (GPU-28)	30-08-2013	03-12-2013	263	95	1981	3543	0.36	7.53	20188	22089	2.09

In-situ moisture conservation practices through conservation furrow for improved yield in fingermillet based cropping system was demonstrated in 4.8 ha in 17 farmers' fields. During the cropping season 405 mm rainfall was received with four dry spells (> 10days). In an assessment of fingermillet based cropping systems in Nelamangala taluk, Bangalore rural district, fingermillet (MR-1) + pigeonpea (TTB-7) in 8:2 ratio with conservation furrow between paired rows of pigeonpea, fingermillet recorded higher yield (1973 kg /ha), net return (Rs.21936 /ha) and B:C ratio (2.07) as compared to farmers' practice (1333 kg/ha, Rs.9929/ha and 1.52,

respectively). Percentage of increase in yield over control was 48.01. There were 6 dry spells *viz.*, Jun-04 to Jun-19 (16 days) Jun-30 to July-9 (10 days), July-21 to August-13 (24 days) (fingermillet, pigeonpea germination to seedling stage), Sept-16 to Oct-7 (22 days) (fingermillet tillering to panicle initiation stage pigeonpea vegetative to flowering stage, Oct-09 to Oct-19 (11 days): fingermillet panicle initiation to grain filling stage pigeonpea flowering stage, Nov-05 to Nov-22 (18 days) fingermillet: harvesting stage pigeonpea: flowering to pod filling stage).It is evident from the demonstration that *in-situ* moisture conservation furrow between two rows of pigeonpea will conserve rain water and maintain the soil moisture which helps in getting higher yields of fingermillet (Table-167).

Table-167: *In-situ* moisture conservation in fingermillet + pigeonpea (8:2) intercropping system

Treatment	Date of sow-ing	Dof harvest-ing	Rainfall (mm)	Crop dura-tion (days)	Fingermillet yield (kg/ha)		Harvest index	RWUE (kg ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
					Grain	Straw					
Fingermillet + pigeon pea (8:2) with conservation furrow	10-07-2013	06-11-2013	405	119	1973	4085	0.33	4.87	20579	21936	2.07
Farmers' practice	15-07-2013	04-11-2013	390	112	1333	3000	0.31	3.42	18988	9929	1.52

Intercropping system

Pulse based intercropping system with pigeonpea (1:1) was demonstrated in one farmers' fields. During the cropping season 449 mm rainfall was received with four dry spells (>10 days). In an assessment of pulse based intercropping systems, pigeonpea (BRG-1) + cowpea (IT38956-1) recorded higher grain equivalent yield (954 kg/ha), RWUE (2.12 kg/ha-mm), net returns (Rs.17566/ha) and B:C ratio (1.75) compared to pigeonpea sole crop (640 kg/ha, 1.42 kg/ha-mm, Rs. 6398/ ha and 1.30, respectively) (Table-168).

Table-168: Yield and economics as influenced by pulse based intercropping system in pigeonpea (1:1)

Treatment	Date of sow-ing	Date of harvesting	Rainfall (mm)	Crop duration (days)	Yield (kg/ha)		PEY (kg/ ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
					PP	CP					
Pigeonpea (BRG-1) + Cowpea (IT-38956-1)	17-06-2013	30-11-2013	449	166	654	516	954	2.12	23458	17566	1.75
Farmers' practice (Pigeonpea sole)	04-06-2013	28-11-2013	449	177	640	-	640	1.42	21102	6398	1.30

Application of micronutrient in fingermillet + pigeonpea (8:2) based intercropping system was demonstrated in 5.3 ha in 20 farmers' fields of chikkamaranahalli cluster villages. Yield and economics as influenced by micronutrient application in fingermillet (MR-1) + pigeonpea (TTB-7) (8:2), intercropping system with 100% recommended dose of fertilizer + 12.5 kg/ha of $ZnSO_4$ + bio-fertilizers recorded maximum grain yield (1895 kg/ha), net returns (Rs.20358/ha) and B:C ratio (2.00) compared to farmers practice of fingermillet + akkadi (fodder sorghum) (1067 kg/ha, Rs.4095/ha and 1.22, respectively). Percentage increase in yield over control was 77.60. From the demonstration it is evident that micronutrient application along with recommended dose of fertilizer will help in realizing higher yield in fingermillet + pigeonpea (8:2) based cropping system under rainfed conditions with deficit rainfall (Table-169).

Table-169 : Yield and economics as influenced by micronutrient application in fingermillet + pigeonpea (8:2) intercropping system

Treatment	Date of sowing	Date of harvesting	Rain fall (mm)	Crop duration (days)	Yield (kg/ha)		Harvest-index	RWUE (kg/ ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
					Finger millet	Straw					
Fingermillet + pigeonpea (4:2) with ZnSo4 @ 12.5 kg/ha + bio-fertilizers	12-07-2013	08-11-2013	405	119	1895	3727	0.34	4.68	20331	20358	2.00
Farmers' practice (fingermillet + *akkadi)* without $ZnSo_4$	15-07-2013	28-10-2013	373	105	1067	2333	0.31	2.86	18988	4095	1.22

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use

Farm ponds opened in NICRA villages

1. The water harvested in the farm pond at Mudalapalya in Mr. Ravikumar field was used for irrigating banana, drumstick, curry leaf, vegetables and leafy vegetables during dry spell and realized a profit of Rs. 2000, 300, 200, 3000 and 1500, respectively from these activities and the total profit was Rs. 7000.

2. Mr. Gubbanna, at Chikkamaranahalli used the farm pond water which was harvested for irrigating mango, drumstick and chilli which were grown around the farm pond. Drumstick and chilli cultivation generated a profit of Rs. 500 and 1200, respectively.

Adoption of ground water recharge

Excavation of pits and filling of materials was completed for two bore wells during 2011-12. Observations are being recorded twice in a week at Hosapalya, Nelamangala during 2013 (Table-170).

Table-170: Specifications of recharging of borewell by runoff water

Particulars	Borewell
Location	Hosapalya, Nelamangala
Depth	250 ft
HP of pump	5
Type of pump	Multi stage submersible
Filter dimensions	Length: 3.00 m Width : 3.00 m Depth : 2.9 m
Catchment	1 ha

After implementing recharge treatment, the discharge rate of borewell with filter bed was on an average of 10.02 l/min throughout the year and in the rainy season discharge rate was on an average of 11.89 l/min and in summer season it was on an average 7.15 l/min. The discharge rate was increased during the commencement of rainy season and declined towards the cessession of rainfall (Table -171).

Table-171 : Yield of borewell-2 (with filter bed) after recharging during the year 2013

Months	Discharge (lit/min)
January	7.67
February	7.97
March	5.83
April	7.69
May	6.63
June	15.19
July	9.72
August	12.42
September	14.93
October*	-
November	11.24
December	8.00

* Pump under repair

Efficient energy use and management

Custom hiring centre for efficient energy use and management

Following are the tools/implements/machineries parked in the custom hiring centre, and being used by farmers. Tools in greater demand are improved sickles, sprayers, cultivators, disc plough, seed drills and hand tools (Table-172).

Hand tools	Bullock drawn	Tractor drawn	Electric/ diesel operated
Improved sickles (50)	KM plough (3)	Disc plough (2)	Winnower (2)
Hand weeders (20)	Multi furrow opener(4)	MB plough (1)	Water lifting pump(2)
Groundnut (5) decorticator	Modified seed drill (6)	Cultivator (2)	Chaff cutter (1)
Maize sheller (5)		Post hole digger (1)	
Hand ridger (2)		Rotovator (1)	
Knapsack sprayer (5)		Leveler (1)	
		Spike tooth harrow(2)	

Figures in parenthesis are number available in custom hiring centre

Table-172: Impact of custom hiring centre during 2013 -2014

Implement	No. of units	Usage / unit (days)	Area covered (ha)	No. of farmers using implement	Labour saved (hr/ha)	Cost saving (Rs/ha)	Revenue generated from CHCs (Rs)
Hand tools							
Improved Sickles	30	59	16.2	59	40	750	59
Hand weeders	14	01	6.4	4	260	4875	5
Groundnut decorticator	5	-	-	-	-	-	-
Maize Sheller	5	-	-	-	-	-	-
Hand ridger	2	-	-	-	-	-	-
Knapsack sprayer	4	18	15.1	16			180
Bullock drawn							
KM Plough	3	01	0.2	2			10
Multi Furrow opener	4	-	-	-	-	-	-
Modified seed drill	5	24	34.4	107	20	370	480
Disc plough	2	-	-	-	17.5	400	0
MB Plough	1	2	12	2	17.5	400	400
Cultivator	2	7	62.2	137			700
Post Hole digger	1	-	-	-	-	-	-
Rotovator	0	-	-	-	-	-	-
Leveler	1	5	10.6	5	-	-	1100
Spike tooth Harrow	2	10	40.4	119	17.5	400	1000
Winnower	2	-	-	-	-	-	-
Water Lifting Pump	2	-	-	-	-	-	-
Chaff cutter	1	-	-	-	-	-	-
Total		127	197.5	451	372.5	7195	3934

Alternate land use / Farming systems for carbon sequestration and ecosystem services

Under alternate land use system in one farmer's field, fingermillet in mango orchard for efficient land use and additional returns has recorded yield of 2133 kg/ha and B: C ratio of 2.42. A rainfall of 442 mm was received which was excess by 30.3 mm compared to normal (409.7 mm), during south-west monsoon (*kharif).* During north-east monsoon (October - December), 91 mm of rainfall was received which was deficit by 153.9 mm compared to normal (244.9 mm). During summer (March - May), 118 mm of rainfall was received which was excess by 36.1 mm compared to normal (81.9 mm). There were 6 dry spells *viz.*, Jun-04 to Jun-19 (16 days) Jun-30 to July-9 (10 days), July-21 to August-13 (24 days) (Fingermillet germination to seedling stage) ,Sept-16 to Oct-7 (22 days) (tillering, panicle initiation stage to grain filling stage) (Table-173) .

Table-173: Performance of finger millet in mango orchard

Treatment	Date of sowing	Date of harvesting	Rain fall (mm)	Crop duration (days)	Yield (kg/ha)		Harvest index	RWUE (kg/ha- mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
					Grain	Straw					
Mango + fingermillet	10-07-2013	06-11-2013	405	119	2133	4267	0.33	5.27	18988	26879	2.42
Farmers' practice	12-07-2013	03-11-2013	380	114	2333	4333	0.35	6.14	18988	30929	2.63

No. of farmers: 1; Area: 0.4 ha; Age of mango plantation: 3 years; Area covered by fingermillet: ~70%

1.4. PEARLMILLET BASED PRODUCTION SYSTEM

1.4.1. AGRA

a. Agro-ecological setting

Agra is located in Northern Plain (and Central Highlands) including Ganga-Yamuna Doab and Rajasthan Upland (AESR 4.1) and South western semiarid agro-climatic zone in Uttar Pradesh. The climate is hot semi-arid. Annual rainfall is 669 mm. Length of growing period is 90-120 days.

b. On-station experiments

During the year 2013, the onset of monsoon was early by 16 days during second week of June i.e 16th June. A rainfall of 857.4 mm was received which was excess by 270.3 mm compared to normal (587.1 mm), during south-west monsoon (*kharif).* During north- east monsoon (October-December), 144.1 mm rainfall was received which was excess by 115.6 mm compared to normal (28.5 mm). During summer (March-May), 8.3 mm of rainfall was received which was deficit by 15.1 mm compared to normal (23.4 mm) (Fig.25). There was a dry spell of 25 days during 1st to 25th September.

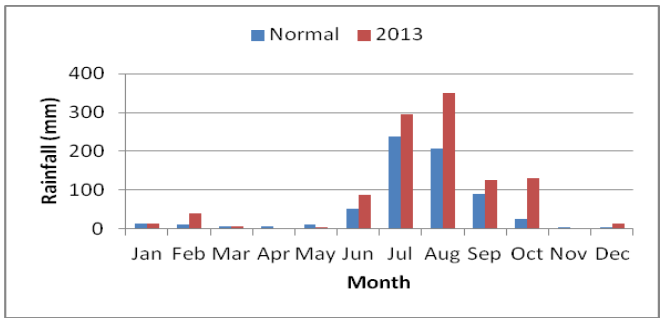


Fig.25: Normal and actual (2013) monthly rainfall at Agra

Rainwater management

During *kharif* 2013, three vegetable crops were taken under the theme of efficient utilization of harvested water in farm pond. Due to heavy and continuous rains during SMW 26-33, chilli crop was partially damaged due to water logging in the field, but heavy rains during SMW 39 & 40 amounting (230.3 mm), the established crop of chilly at flowering stage was completely damaged. Bottle gourd and lady's finger performed well and both the crops produced higher yield when they were sown under ridge and furrow method. Under this method both the crops were sown on shoulder of the ridges. Bottle gourd (2528 kg/ha) and lady's finger (2502 kg/ha) produced 48.5and 35.2% more yield with ridge system over to flat system, respectively. The net return, B:C ratio (1.76 and 1.45, respectively) and rain wateruse efficiency (2.88 and 2.86, respectively) were also higher under ridge system as compared to flat system with both the vegetable crops (Table-174).

Table-174: Yield of *kharif* vegetables, net return and B:C ratio as affected by methods of planting

Crop	Sowing method	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	Rain water use (mm)	Rain water use efficiency (kg/ha-mm)
Bottle guard	Ridge	2528	28705	21855	1.76	876.3	2.88
	Flat	1702	27850	6190	1.22	876.3	1.94
Lady's finger	Ridge	2502	43102	19448	1.45	876.3	2.86
	Flat	1850	42182	4068	1.10	876.3	2.11

Different methods of planting were evaluated in different *kharif* crops under normal and delayed onset of monsoon to cope with rainfall variability. Among *Kharif* crops PEY varied from 1166 to 2050 kg/ha with mean of 1656 kg/ha and 1483 to 2250 kg/ha with mean of 1913 kg/ha in flat system of sowing under normal as well as delayed sowing conditions. Highest PEY in flat system was obtained with sesame followed by pearlmillet plus clusterbean grown in strips (4:4) under both sowing conditions. In ridge planting PEY varied from 1521 to 2400 kg/ha with mean of 1957 kg in normal time of sowing and 1583 to 2620 kg/ha with mean of 2156 kg/ha obtained in delayed sowing. Highest PEY of 2400 and 2620 kg/ha was registered with sesame crops under normal as well as in delayed sowing followed by pearlmillet + clusterbean in strip cropping system (2344 kg/ha), under delayed sowing. It was observed that planting of *kharif* crops on ridge under delayed sowing proved to be more effective and produced 30.2 and 12.7% more PEY than PEY recorded under normal and delayed sowing condition under flat sowing, respectively. Economic analysis revealed that higher net return of Rs. 18032/ha was registered with pearlmillet sole followed by net return of Rs. 17,780/ha with sesame, while higher B:C ratio of 2.14 was recorded with sesame in ridge sowing followed by pearlmillet sole (2.04) under delayed sowing. Under delayed sowing conditions was sesame found to be more economic crop when grown on ridges (Tables-175 & 176).

Table-175: Yield and economics of various crops grown under normal monsoon conditions

Treatment	Yield (kg/ha)		Pearlmillet equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Grain	Straw					
Flat bed sowing							
Pearlmillet	1820	4841	1820	2.02	17660	11441	1.65
Blackgram	280	883	1166	0.31	15766	-1766	0.89
Greengram	305	908	1397	0.34	16439	336	1.02
Sesame	205	461	2050	0.23	14660	9940	1.68
Clustebean	325	1044	1571	0.36	14572	4278	1.29
Pearlmillet + clustebean	940+205	2538+547	1930	1.04+0.23	8830+7286	6257+4604	1.71 +1.63
Ridge & furrow system							
Pearlmillet	2100	5683	2100	2.34	17,660	16064	1.91
Blackgram	365	962	1521	0.40	15766	2484	1.16
Greengram	370	1053	1696	0.41	16439	3911	1.34
Sesame	240	629	2400	0.27	14660	11740	1.80
Clustebean	390	1157	1885	0.43	14572	8048	1.55
Pearlmillet + clustebean	1080+220	2983+617	2143	1.20+0.24	8830+7,286	8604+5474	1.97+1.75
Rainfall during season (mm) - 987.1							
Rainfall during crop growth (mm) - 900.0							

Table-176: Yield and economics of various crops grown under delayed monsoon conditions

Treatment	Yield kg/ha		Pearlmillet equivalent yield kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Grain	Straw					
Flat bed sowing							
Pearlmillet	1980	4686	1980	3.24	17660	13129	1.74
Blackgram	356	775	1483	0.58	15766	2034	1.13
Greengram	372	832	1705	0.61	16439	4021	1.24
Sesame	225	447	2250	0.37	14660	12340	1.84
Clustebean	402	963	1943	0.65	14572	8628	1.59
Pearlmillet + clustebean	1005+232	2444+515	2126	1.64+0.38	8830+7286	6896+6190	1.78+1.85
Ridge & furrow system							
Pearlmillet	2290	5475	2290	3.75	17660	18032	2.02
Blackgram	380	917	1583	0.62	15766	3234	1.20
Greengram	410	1007	1879	0.67	16439	6111	1.37

Sesame	262	554	2620	0.43	14660	17780	2.14
Cluste bean	460	1081	2223	0.75	14572	12108	1.83
Pearlmillet + clustebean	1175+242	2819+578	2344	1.92+0.40	8830+7286	9498+6750	2.07+1.93
Rainfall during season (mm) - 987.1							
Rainfall during crop growth (mm) - 610.8							

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA Center, Agra in Nagla Dulhe Khan village, Faziyatpura block, Kheragarh Tehsil in Agra District, Uttar Pradesh. Nagla Dulhe Khan is situated in the South-western part of Agra district and lies between 26˚55` to 26˚56`North latitude and 77˚ 40`30`` to 77˚ 42`30`` East longitude. The total cultivated area is 981 ha, out of which 878 ha is rainfed. The mean annual rainfall is 665 mm with seasonal rainfall of 589 mm during *kharif* (June- September). The major soil types are sandy loam to loamy sand. The major rainfed crops during *kharif* are pearlmillet, pigeonpea, greengram, blackgram, sesame and sorghum for fodder purpose and during *rabi* are mustard, barley, chickpea, lentil and linseed under rainfed conditions. The number of small, medium and large farmers are 326, 256 and 37, respectively. The ground water table is 40 m, which is saline. The source of irrigation is bore well covering 30% of cultivated area.

Climate Vulnerability in General

In general, the climate in this agro-climatic zone is semi arid with heat waves during summer (March to mid June). The south-west monsoon contributes 88%, north-east monsoon 9.0% and summer 2.5% of the total annual average rainfall of 665 mm. Historical rainfall data (of 30 years) indicated that the variability in rainfall during southwest monsoon was 30.5% of the average rainfall. The onset (south-west) of monsoon is 1st week of July during 27th SMW. The temperature reaches 48˚C in June and as low as up to 1.0˚C or below during January. Heat wave during summer and cold wave during winter were common along with frost or foggy conditions during crucial crop growth stages. The dry spells during crop season had been experienced, for the past 10 years, in July, August and September respectively at germination, vegetative and grain formation stage of the major rainfed crops. The onset of monsoon was normal (1st week of July). Out of 12 years study, early season drought or weak monsoon was experienced in 6 times i.e. 2001, 2002, 2004, 2007, 2009 and 2010, in July and mid season drought was recorded in 2000, 2001, 2003, 2005, and 2006 in August at vegetative stage and late season drought was experienced during September in 2004,2005, 2006 and 2007. The onset of monsoon was during 20th June to July 15th in the last 38 out of 40 years. The withdrawal of monsoon was during 10th September and 25th September in 29 out of 40 years. In 8 years, withdrawal was noticed after 25th September and too early withdrawal registered in three years i.e. 1979 (11th August), 2001 (26th August) and 2006 (16th August).

Experienced weather conditions during the year (2013-14)

During 2013, in Nagla Dulhe Khan a village, onset of monsoon was early by 16 days during second week of June. A rainfall of 942.1 mm was received which was excess by 353 mm compared to normal (589.1 mm) (Fig.26), during south-west monsoon (*kharif).* During north-east monsoon (October-December), 105.5 mm rainfall was received which was excess by 77 mm compared to normal (28.5 mm). During summer (March - May), there was 8.3 mm of rainfall received which was deficit by 15.1 mm compared to normal (23.4 mm). There was a dry spell of 25 days (during 1st to 25th September).

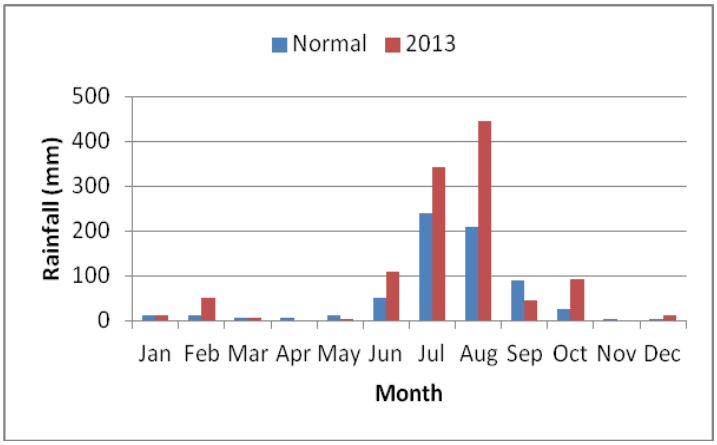


Fig.26: Normal and actual (2013) monthly rainfall at Nagla Dulhe Khan

Interventions

The major on-farm interventions included land configuration, crops / varieties / cropping systems, rainwater harvesting and recycling, timely operations through custom hiring centre and alternate land use systems. These interventions covered an area of 75.6 ha in 189 farmers' fields.

Real time contingency crop planning

The onset of monsoon was early by 16 days during second week of June. A rainfall of 942.1 mm was received which was excess by 353 mm compared to normal (589.1 mm), during south-west monsoon (*kharif*. There was a dry spell of 25 days (during 1st to 25th September). The rainfall was excess by 113.2% in June, 43.2% in July, 112.5% in August and deficit by 49.9% in September. To assess the superiority of pearlmillet variety, ten demonstrations were conducted on two varieties i.e. Proagro 9450 and 86 M 88. The grain yield with different varieties varied from 1950 to 2410 kg/ha. Proagro 9450 variety of pearlmillet gave higher mean seed yield (2244 Kg/ha) as compared to 86 M 88 (2040/ha). The highest net returns of Rs. 21461/ha and B:C ratio of 2.46 was recorded with Proagro 9450 kg. Six demonstrations on two sesame varieties i.e. Pragati and RT-46 were conducted at farmers' fields in NICRA village to assess the varietal superiority of sesame. The variety Pragati gave higher mean seed yield of 295 kg/ha as compared to yield obtained with RT-46 (270 kg/ha), which was 9.3% superior over RT-46 yield. The mean net return of Rs. 23796/ha, RWUE 0.37 kg/ha-mm and B:C ratio of 3.04 was obtained with Pragati as compared to net return of Rs. 20890/ha, RWUE of 0.34 kg/ha-mm and B:C ratio of 2.81 recorded with RT-46, respectively (Table-177).

Table-177: Performance of varieties in farmers' fields

Crop	Variety	Yield (kg/ha)	Harvest index (%)	RWUE (kg/ha-mm)	Cost of Cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Pearlmillet	Proagro-9450	2244	26.76	2.85	14676	21461	2.46
	86 M 88	2040	26.86	2.59	14676	18123	2.23
Sesame	Pragati	295	19.69	0.37	11604	23796	3.04
	RT-46 (Local)	270	19.33	0.34	11510	20890	2.81

Four varietal demonstrations on cluste bean were conducted at farmers' fields. The variety RGC-1002 produced highest mean yield of 450 kg/ha, which was 5.4% superior over seed yield recorded with RGC-1017 (427 kg/ha). The highest gross return of Rs. 26100/ha, net return of Rs. 12724/ha, RWUE of 0.53 kg/ha-mm and B:C ratio of 1.95 was recorded with variety RGC-1002 (Table-178).

Table-178: Performance of cluste bean varieties on farmers' fields

Variety	Yield (kg/ha)	Harvest index (%)	RWUE (kg/ha-mm)	Cost of Cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
RGC-1002	450	26.76	0.53	13376	12724	1.95
RGC-1017	427	26.51	0.50	13376	11390	1.84

During north-east monsoon (October-December), 105.5 mm rainfall was received which was excess by 77 mm compared to normal (28.5 mm). The rainfall was deficit by 49.9% in September and 100% in November whereas excess rainfall in October (278%) and December (557%) compared to normal rainfall. Five varieties of mustard were tested on ten farmers' fields at NICRA village under conserved soil moisture condition for their superiority & yield potential. The Bio-902 variety proved superiority by producing higher mean yield (1560 kg/ha) followed by NRCHB-101 (1520 kg/ha), Urvashi (1470 kg/ha), Rohini (1440 kg/ha) and Laxmi (1385 kg/ha), respectively. The highest mean net return (Rs. 41836/ha) and B:C ratio (3.67) were recorded under Bio-902. Six demonstrations were conducted at farmers' fields to test the yield potential of chickpea varieties (Avarodhi and Uday) under conserved moisture condition. The Avrodhi variety proved superiority by producing higher mean yield (1810 kg/ha) followed by Uday (1590 kg/ha). The highest mean net return (Rs. 49597/ha) and B:C ratio (4.60) were recorded under Avrodhi. Four varieties of wheat were tested on eight farmers' fields for their productivity. These trials were conducted under irrigated conditions. Variety HD-2851 produced highest mean grain yield (3975 kg/ha), net return (Rs. 67168/ha) and B:C ratio (3.79) followed by HD-2932 (3680 kg/ha) and DBW-17 (3610 kg/ha). Lowest yield of 3458 kg/ha was recorded in WR 544 (Table-179).

Table-179: Performance of varieties on farmers' fields

Crop	Variety	Yield (kg/ha)	Harvest index (%)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Mustard	Bio-902	1560	20.53	15630	41836	3.67
	Urvashi	1470	20.20	15630	38666	3.47
	NRCHB101	1520	20.49	15630	40379	3.58
	Laxmi	1385	20.20	15630	35527	3.27
	Rohini(Local)	1440	20.45	15630	37455	3.39
Chickpea	Avrodhi	1810	47.01	13753	49597	4.60
	Uday	1590	46.58	13753	41897	4.04
Wheat	DBW-17	3610	46.19	24012	57179	3.38
	HD-2851	3975	44.64	24012	67168	3.79
	WR-544	3458	45.97	23986	53999	3.25
	HD-2932	3680	45.66	24012	59296	3.46

The rainfall was excess by 113.2% in June, 43.6% in July, 112.5% in August and deficit by 49.9% in September. To demonstrate the benefit of strip cropping, two trials on strip cropping of pearlmillet with association of clusterbean (4:4) were conducted at farmers' fields. Maximum mean pearlmillet equivalent yield of 2623 kg/ha was recorded in pearlmillet + clusterbean grown in strip cropping system, which was 56.13% more productive than pearlmillet grown in sole system (1680 kg/ha). The mean highest net return (Rs.17456/ha) and B:C ratio (2.24) was obtained under strip cropping as compared to mean net return of Rs. 13,883/ha and B:C ratio of 2.07 recorded with pearlmillet sole system, which was Rs. 3,573/ha higher over pearlmillet sole. Similarly, demonstrations on pearlmillet + sesame in strip cropping (4:4) were conducted at two farmers' fields. The highest mean pearlmillet equivalent yield of 2785 kg/ha was obtained when pearlmillet grown with association of sesame in 4:4 row ratio, which was 57.34% more beneficial compared to sole pearlmillet yield (1770 kg/ha). The highest net return (Rs. 20280/ha) and B:C ratio (2.54) was obtained under pearlmillet + sesame strip cropping system as compared to net return of Rs. 15525/ha and B:C ratio of 2.19 recorded with pearlmillet sole (Table-180).

Table-180: Performance of pearlmillet under sole and strip cropping system on farmers' fields

System	Variety	Yield (kg/ha)	Pearlmillet equivalent yield (kg/ha)	Harvest index (%)	Land equivalent ratio	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Pearlmillet + clusterbean	Proagro-9444+ RGC-1002	1415 + 250	2623	37.19	1.39	14026	17456	2.24
Pearlmillet (sole)	Proagro – 9444	1680	1680	27.40	1.0	12954	13883	2.07
Pearlmillet + sesame	Proagro9450 + RT-46	1465+132	2785	38.75	1.27	13140	20280	2.54
Pearlmillet (sole)	Proagro9450	1770	1770	26.84	1.0	12954	15525	2.19

Four demonstrations were conducted on chickpea + mustard intercropping at farmers' fields in NICRA village to demonstrate the benefit of intercropping system. The highest mean chickpea equivalent yield of 1621 kg/ha was recorded with chickpea + mustard in 5:1 row ratio, which was 11.8% more productive as compared to sole chickpea yield 1450 kg/ha. The highest net return (Rs. 41655/ha) and B:C ratio (3.32) were obtained under chickpea + mustard intercropping system as compared to sole crop of chickpea with net return of Rs. 34412/ha and B:C ratio of 2.87 (Table-181).

Table-181: Performance of chickpea in sole and intercropping system on farmers' fields

Treatment	Variety	Yield (kg/ha)	Chickpea equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Chickpea + mustard	Avrodhi + Bio -902	1307 + 342	1621	17893	41655	3.32
Chickpea (Sole)	Avrodhi	1450	1450	18373	34412	2.87

Two demonstrations were conducted on moong – mustard crop sequence at farmers' fields for enhancing the soil quality and to improve the organic carbon in soil through moong incorporated in soil. The seed yield of moong varied from 328 to 402 kg/ha with a mean value 365 kg/ha. The highest mustard equivalent yield varied from 2291 to 2244 kg/ha with a mean value of 2267 kg/ha recorded under green gram – mustard crop sequence. The highest net return of Rs 42,902/ha was recorded under moong – mustard crop sequence as compared to net return of Rs 35,939/ha recorded under farmers' practice (fallow-mustard) (Table-182).

Table-182: Performance of mustard with and without moong crop sequence on farmers' fields

Crop sequence	Variety	Yield (kg/ha)	Mustard equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Moong - mustard	K-851 + Bio-902	365 + 1640	2267	29652	42902	2.44
Fellow-mustard	Bio-902	1365	1365	14757	35939	3.43

Two demonstrations were conducted on sesbania – mustard crop sequence on farmers' fields. Mustard grown after green manuring in *kharif*, produced mean seed yield of 1775 kg/ha as compared to farmers practices (1375 kg/ha), which was 29% higher yield over farmers' practice. The mean net return (Rs 48750/ha) and B:C ratio (3.92) was also found to be higher under green manure – mustard crop sequence as compared to farmers' practices of fallow-mustard system (Rs 35920/ha) and B:C ratio (3.43) (Table-183).

Table-183: Performance of mustard with and without green manuring in farmers' fields

Crop sequence	Yield (kg/ha)	Harvest index (%)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Green manuring – mustard (Improved practice)	1775	20.44	16,680	48750	3.92
Without green manuring - mustard (Farmers' practice)	1375	20.46	14757	35920	3.43

To demonstrate the influence of N split application on pearlmillet for efficient use of nitrogen, eight demonstrations were conducted at NICRA village. The improved practice (N of RDF, 1/3+1/3+1/3 split) of pearlmillet gave higher mean yield of 2401 kg/ha compared to farmers' practice (40 kg N/ha in 2 splits), which was 22% superior over farmers' practice (1968 kg/ha). The higher net return (Rs 22924/ha) and B:C ratio (2.51) was obtained with improved practice as compared to net return (Rs.17951/ha) and B:C ratio (2.38) recorded with farmers' practice. It is well emphasized that splitting of nitrogen improved overall growth of the crop in terms of yield and economics (Table-184).

Table-184: Effect of split application of N on pearlmillet in farmers' fields

Treatment	Variety	Rainfall (mm)	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
N Split equally three time	Proagro 9450	787.3	2401	3.04	15148	22924	2.51
Without Split N	Proagro 9450	787.3	1968	2.50	12954	17951	2.38

The rainfall was deficit by 49.9% in September, and 100% in November whereas excess rainfall in October by 278% and December by 557% compared to normal rainfall. Eight demonstrations were conducted at farmers' fields to demonstrate the impact of potassium fertilizer on mustard productivity. Mustard seed yield of 1740 kg/ha was recorded under potassium application, and 1370 kg/ha under without application of potash. The seed yield with potassium application was 27% higher over without potash application. The net return and B:C ratio clearly indicated that 50 kg K_2O with RDF application (60 kg N + 40 kg P_2O_5) produced highest mean net return of Rs.47113/ha and B:C ratio 3.76 as compared to net return (Rs. 36382/ha) and B:C ratio (3.41) obtained without K application, which was Rs. 10731/ha higher over without K_2O application (Table-185).

Table-185: Effect of potassium application on mustard yield in farmers' fields

Treatment	Variety	Rainfall (mm)	Yield (kg/ha)	Harvest index (%)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
50 kg K_2O + RDF	Bio-902	97.1	1740	20.46	17013	47113	3.76
Without K_2O + RDF	Bio-902	97.1	1370	20.43	14757	36750	3.41

To maximize income through nutrient management along with moisture conservation practices, four demonstrations were conducted at farmers' fields. Application of RDF + zinc of (120, 80, 40 + 25, NPK + Zn kg/ha) along with compartmental bunding, produced higher mean grain yield (3930 kg/ha) as compared to without INM along with compartmental irrigation (3410 kg/ha). The grain yield of wheat with INM was 15.2% higher over farmers' practice. The mean net return (Rs. 65712/ha) and B:C ratio (3.59) were higher under INM as compared to under farmers' practices (Rs. 51996/ha) and B:C ratio (3.16). Thus, higher net return (Rs. 13716/ha) was obtained under INM over farmers' practices (Table-186).

Table-186: Performance of wheat under INM with *in-situ* moisture conservation practices in farmers' fields

Treatment	Variety	Rainfall (mm)	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
INM (RDF) with compartmental bunding	DBW-17	111.1	3930	25275	65712	3.59
Without INM farmers' practices	DBW-17	111.1	3410	23942	51996	3.16

Rainwater management (*in–situ* moisture conservation practices)

Five demonstrations were conducted on *in–situ* moisture conservation by compartmental bunding at farmers' field in NICRA village. The pearlmillet yield under compartmental bunding was 2062 kg/ha compared to farmers' practices (1777 kg/ha). The maximum net return of Rs.18166/ha and B:C ratio of 2.21 was registered with compartmental bunding, compared to net return (Rs. 14993/ha) and B:C ratio (2.15) recorded under farmers' practices (Table-186).

Table-187: Effect of compartmental bunding on pearlmillet in farmers' fields

Treatment	Variety	Rainfall	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Compartmental bunding	Proagro9450	787.3	2062	2.61	1497 6	18166	2.21
No compartmental bunding	Proagro9450	787.3	1777	2.25	12954	14993	2.15

The rainfall was excess by 113% in June, 44% in July and 113% in August but deficit by 50% in September. Ridges and furrow method of pearlmullet planting was demonstrated to cope with excess and deficit rainfall during crop season. Five demonstrations were conducted on sowing of pearlmillet on shoulder of ridge by ridger seeder. The highest mean yield of pearlmillet was recorded when pearlmillet was sown by ridger seeder (2232 kg/ha) as compared to mean yield of 1890 kg/ha under sowing by broadcasting, which was found to be 18.1% more over broadcasting method of sowing. The highest net return (Rs.20756/ha) and B:C ratio (2.39) was also registered under ridger seeder sowing as compare to net return (Rs. 16790/ha) and B:C ratio (2.29) recorded under broadcasting system. The ridger seeder gave higher net return (Rs. 3966/ha) over without ridge and furrow system. About 4.4% more B:C ratio was registered with ridge sowing (Table-188).

Table-188: Performance of pearlmillet under different sowing methods in farmer's fields

Treatment	Variety	Rainfall (mm)	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Ridger Seeder	Proagro 9450	787.3	2232	2.91	14886	20756	2.39
Without Ridger Seeder	Proagro 9450	787.3	1890	2.39	12954	16790	2.29

Improved practice (ridger seeder)

Farmers' practice (without ridger seeder)

In dryland areas, deep ploughing once in three years is mainly linked with improved moisture conservation and retention, improved aeration and pest control. Five demonstrations were conducted on mustard with and without deep ploughing. The deep ploughing produced higher mean seed yield of 1603 kg/ha which was 15.32% more compared to without deep ploughing (1390 kg/ha). The higher net returns (Rs. 42563/ha) and B:C ratio 3(.58) was registered with deep ploughing as against net return and B:C ratio obtained without deep ploughing, (net return Rs. 36502/ha) and B:C ratio (3.47) (Table-189).

Table-189: Performance of mustard under deep ploughing in farmers' fields

Treatment	Variety	Rainfall (mm)	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Deep ploughing (summer)	Bio-902	97.1	1603	16470	42563	3.58
Without deep ploughing	Bio-902	97.1	1390	14757	36502	3.47

Deep ploughing

Without deep ploughing (farmers' practice)

The demonstrations were conducted on tillage after each effective rains and mustard was grown at five farmers' fields in fallow – mustard crop sequence under conserved soil moisture condition in *rabi* season. Seed yield of mustard improved with moisture conservation practices (tillage after each effective rains) with mean yield of 1595 kg/ha, while in farmers' practices mean yield of 1385 kg/ha was harvested, which was lower by 15.16% compared to improved tillage practice for *in–situ* moisture conservation. The mean net return (Rs. 42410/ha) and B:C ratio (3.59) of improved practices (tillage after each effective rains) was found to be superior over farmers' practice (Rs. 36311/ha) and B:C ratio of 3.46 (Table-190).

Table-190.: Effect of *in–situ* moisture conservation practices on mustard in farmers' fields

Treatment	Variety	Rainfall (mm)	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Tillage after each effective rainfall	Bio-902	107.6	1595	16365	42410	3.59
Without tillage	Bio-902	107.6	1385	14757	36311	3.46

Tillage after each effective rain

Without tillage

To explore the yield potential of wheat through number of irrigations using micro-irrigation system, two demonstrations were conducted at NICRA village. Wheat gave mean yield of 3690 kg/ha under improved irrigation practice and in limited water conditions (farmers' practice) with a mean value 3305 kg/ha. The improved irrigation practice increased the yield by 11.65% over farmers' practice. The net return and B:C ratio data clearly indicated that supplemental irrigation gave highest net return of Rs 61063/ha and B:C ratio (3.71) as compared to farmers' practice (Rs 50691/ha) and B:C ratio (3.11) (Table-191).

Table-191: Effect of supplemental irrigation through micro irrigation system

Treatment	Rainfall (mm)	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Micro irrigation system	111.1	3690	22490	61063	3.71
Without micro irrigation system	111.1	3305	23942	50691	3.11

Supplemental irrigation through micro irrigation system

Without micro irrigation system

1.4.2. HISAR

a. Agro-ecological setting

Hisar is located in western Plain, Kachchh and part of Kathiawar peninsula, Rajasthan Bagar, north Gujarat Plain and South-western Punjab plain (*AESR 2.3)* and South-western dry zone in Haryana. The climate is hot arid. Annual rainfall is 411 mm. Annual potential evapotranspiration is 769 mm.

b. On-station experiments : Nil

During the year 2013, the onset of monsoon was delayed by 10 days (first week of August). A rainfall of 559.3 mm was received which was excess by 223.5 mm compared to normal (335.8 mm) (Fig.27), during south-west monsoon (*kharif).* During north- east monsoon (October - December), 8.2 mm of rainfall was received which was deficit by 1 mm compared to normal (9.2 mm). During summer (March - May), 23.4 mm of rainfall was received which was deficit by 14.6 mm compared to normal (38 mm). There were dry spells during 22nd to 31st and 20th August 21st September (coinciding with initial stage of crops and grain filling stages).

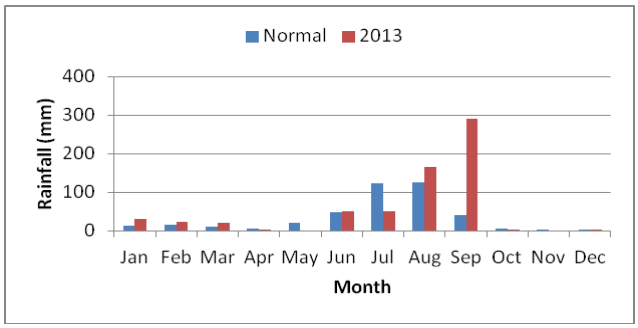


Fig.27: Normal and actual (2013) monthly rainfall at Hisar

c. On-farm experiments

Village profile

Balawas

The program is being implemented by AICRPDA Centre, Hisar in Balawas village, Tehsil Hisar in Hisar district of Haryana. The total cultivated area is 800 ha out of which 560 ha is rainfed. The mean annual rainfall is 350 mm with seasonal rainfall of 320 mm during *kharif* (June- September). The major soil types are loamy sand to sandy loam. The major rainfed crops in *kharif* are pearlmillet, clusterbean, greengram, mothbean, sesame and castor and during *rabi* are mustard, chickpea barley and rapeseed. The number of small, marginal, medium and large farmers is 138, 22, 2 and 4 respectively. The ground water table is about 25 m. The source of irrigation is canal and tube well covering 30% of the cultivated area.

Charnod

The program is being implemented in the village Charnod Tehsil, Hisar in district Hisar (Haryana). The total cultivated area is 418 ha out of which 251 ha is rainfed. The mean annual rainfall is about 360 mm with seasonal rainfall of 325 mm during *kharif* (June-September). The major soil types are loamy sand to sandy loam. The major rainfed crops in *kharif* are pearlmillet, clusterbean, greengram, mothbean, sesame and castor and during *rabi* are mustard, chickpea barley and rapeseed. The number of small, marginal, medium and large farmers are 132, 10, 22 and 14 respectively. The ground water table is about 20 m. The source of irrigation is canal and tube well covering 60% of cultivated area.

Budhshelli

The program is being implemented in the village of Buhshelli, Tehsil Siwani in district Bhiwani (Haryana). The total cultivated area is 985 ha out of which 886 ha is rainfed. The mean annual rainfall is 280 mm with seasonal rainfall of 220 mm during *kharif* (June-September). The major soil types are loamy sand to sandy loam. The major rainfed crops in *kharif* are pearlmillet, clusterbean, greengram, mothbean, sesame and castor and during *rabi* are mustard, chickpea barley and rape seed. The number of small, marginal, medium and large farmers is 285, 22, 88 and 5 respectively. The ground water table is about 35 m. The source of irrigation is tubewell covering 10% of cultivated area.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is semi-arid. The south-west monsoon contributes 85-90%, compared to 10-15% during winter from the total annual average rainfall of 280-320 mm. The historical rainfall data of 30 years indicated that the variability in rainfall during south-west monsoon, every fourth year is a drought year. The onset (south- west) of monsoon is during 26 SMW. The dry spells during the crop season were experienced for the past 10 to 15 years during July, August and October and at seedling, vegetative, and reproductive stages of the major rainfed crops. The soil moisture status was deficit during vegetative and reproductive stages of major rainfed crops. The maximum/minimum temperature during crop season was almost static but frost occurred during *rabi* in December and January (-0.112/-0.071˚C) during past 10 years. The extreme events like unusual and high intensity rainfall in short span had been increasing during *kharif*. The area had also been experiencing other extreme events like frost and cold wave. There had also been considerable shift in rainfall pattern with late onset (29/30 SMW) and early withdrawal (35/36 SMW) and sowing window to 31 or 32 SMW of the dominant rainfed crops *viz.*, pearlmillet, clusterbean, blackgram and castor.

Experienced weather conditions during the year (2013-14)

During 2013, in Balawas village, onset of monsoon was delayed by 26 days (first week of August). A rainfall of 112 mm was received which was deficit of 98.7 mm compared to normal (210.7 mm) (Fig.28), during south- west monsoon (*kharif).* During north-east monsoon (October - December), there was deficit rainfall of 22 mm compared to normal (22 mm). During summer (March - May), 12 mm of rainfall was received which was deficit by 31.1 mm compared to normal (43.1 mm). There were 10 dry spells *viz*., Jan 19th to 3rd Feb, 24th Feb to 13th March, 1st April to 10th July, 23rd July to 23rd September, 26th September to 31st December.

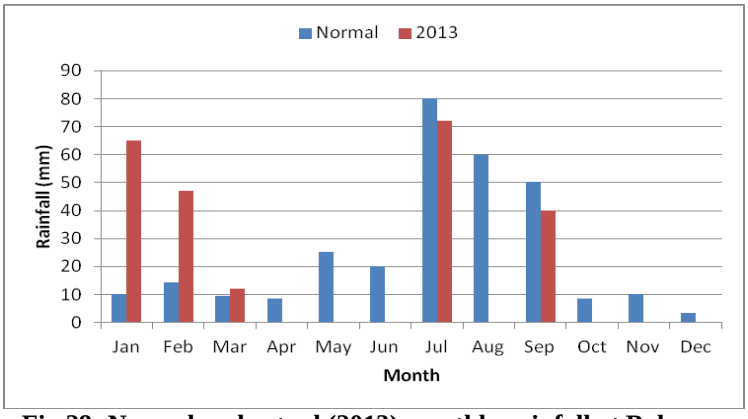


Fig.28: Normal and actual (2013) monthly rainfall at Balawas

Interventions

The major interventions implemented under on-farm included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring centre and alternate land use systems. These interventions covered an area of 56.4 ha in 151 farmers' fields.

Real time contingency crop planning

The rainfall during June, July, August and September months was deficit by 100,10.2,100 and 20.5%, respectively compared to normal rainfall. The drought management practices were demonstrated in pearlmillet cropping system in the NICRA villages during *kharif* 2013. Mean yield of pearl millet was 763 kg/ha and straw yield of 1560 kg/ha, net return of Rs.3304/ha, RWUE of 5.64 kg/ha-mm and B:C ratio of 0.41 were recorded at maturity harvesting. After sowing of demonstrations in 2nd week of July, there was no moisture stress during initial growth period. Thereafter, there was a long dry spell of 65 days starting from 3rd week of July. This affected the yields in spite of the fact that some farmers could arrange life saving irrigation (Table-192).

Table-192: Drought management in pearlmillet

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
	Grain	Straw			
At maturity harvesting	763	1560	5.64	3304	0.41
Every 3rd row harvesting in case of drought	There was no moisture stress as farmers gave light life saving irrigation, though with poor quality water in mid August. So 3rd row was not harvested.				

Field view of pearlmullet during *kharif* 2013

During *kharif* 2013, demonstrations wre conducted on strip cropping of pearl millet and pearl millet with mungbean. The highest grain yield was recorded in pearl millet + mungbean (2617 kg/ha) with net return of Rs. 20342/ha, RWUE of 18.08 kg/ha-mm, B:C ratio of 2.2 and harvest index 27.1 as compared to pearlmillet sole in Balawas village. There were wide variations in the pearl millet yield due to variation in rainfall in both adopted villages. There was a dry spell of >60 days after mid July that affected the millet yield but mungbean was not much affected (Table193).

Table-193: Performance of strip cropping of pearl millet -legume association

crop	Grain yield (kg/ha) Y1 + Y2	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Budhshelly				
Pearlmillet sole	1422	9.8	5977	1.31
Pearlmillet + mungbean	2617	18.08	20342	2.2
Balawas				
Pearlmillet sole	1296	11.57	3919	1.2
Pearlmillet + mungbean	2449	20.57	17603	2.0

Duration of pearl millet- 64 days, Mungbean-83 days; *PM= Pearlmillet

Intercropping of pearlmillet + mungbean

The rainfall during June, July, August and September months was deficit by 100, 10.2, 100 and 20.5% compared to normal rainfall. During *kharif* 2013, demonstrations were conducted on strip cropping of pearlmillet with clusterbean. The highest grain yield was recorded in pearl millet + clusterbean (2134 kg/ha) with net return of Rs. 12982 kg/ha, RWUEof 14.71 kg/ha-mm, B:C ratio of 1.73 and harvest index of 28 Balawas village. To ensure some harvest, interventions of strip cropping a legume in pearl millet system has been found best. It was observed that to cover the risk, pulses are the first causality under early drought and excessive rains at maturity. The clusterbean yields were adversely affected by late heavy rains in September (Table-194).

Table-194: Strip cropping of pearl millet and clusterbean (8:4)

Crop	Yield kg/ha		RWUE (kg/ha-mm)	Net return (Rs/ha)	Clusterbean equivalent yield (kg/ha)	Maturity	B:C ratio	Land equivalent ratio
	grain	straw						
Budhshelly								
Pearlmillet sole	1280	3291	8.82	3696	–	63	1.21	–
Pearlmillet + clusterbean	2134	2548	14.71	12982	260	63	1.73	1.10
Balawas								
Pearlmillet sole	1300	3344	11.6	4026		63	1.23	
Pearlmillet + clusterbean	2125	2638	18.97	12991	250	63	1.74	1.195

Field view of pearlmillet + clusterbean (8:4) strip cropping

Farmers do not apply the recommended fertilizers as there is risk involved but it must be kept in mind that all high yielding varieties of crops need optimum nutrition for good harvest and consequently, the recommendation should be followed. Demonstrations were conducted on improved production technologies of mungbean. From the results of field demonstrations at both locations, it is evident that adoption of package of practices resulted in higher grain yield (764 and 778 kg/ha, respectively) net returns (Rs.27273 and Rs.34076/ha, respectively), higher B:C ratio (2.60 and 2.90, respectively) and rainwater use efficiency (5.26 and 6.94 kg/ha-mm) (Table-195).

Table-195: Adoption of recommended practices in clusterbean and mungbean

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
	Seed	Stover			
Budhshelly					
Package of practice	764	2028	5.26	27273	2.60
Farmers' practice	635	1676	4.37	20333	2.30
Balawas:					
Package of practice	778	2072	6.94	34076	2.90
Farmers' practice	644	1709	5.75	27279	2.80

Weed management in rainfed crops is essential to conserve soil moisture, reduce nutrient losses and enhance crop productivity. Demonstrations were conducted on weed management in pearlmillet using Kasola and wheat hand hoe (WHH). From the results of field demonstrations at both locations, it is evident that weeding with Kasola gave higher grain yield (1420 and 1361 kg/ha, respectively) compared to WHH (1375 and 1320 kg/ha, respectively) but the major advantage lies in the labor savings as WHH is almost two times efficient in weed control and hence less labor intensive. In today's' context of shortage of labor, it is very useful and shall be advocated aggressively even if it is given to the farmers free of cost (Table-196).

Table-196: Weed management in pearlmillet

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C
Budhshelly				
Kasola 30 DAS	1420	9.8	5988	1.30
WHH 30 DAS	1375	9.5	6353	1.39
Balawas				
Kasola 30 DAS	1361	12.15	4971	1.3
WHH 30 DAS	1320	11.80	5427	1.3

The rainfall during June, July, August and September months was deficit by 100, 10.2, 100 and 20.5% compared to normal rainfall. Seven demonstrations were conducted in both Budhshelly and Balawas villages for demonstrating the performance of new pearlmillet hybrid (HHB-226). HHB -226 yielded higher than HHB-197. While evaluating the results, it should be considered that this season was not normal w.r.t. rainfall and true picture could be available when weather is normal and this needs further confirmation to arrive at a logical and valid conclusion on the suitability of new hybrid (Table-197).

Table-197: Demonstration of new pearlmillet hybrid (HHB-226)

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Budhshelly				
HHB-197	1476	10.17	6504	1.4
HHB-226	1591	10.97	8526	1.5
Balawas				
HHB-197	1293	10.17	11.5	1.23
HHB-226	1445	10.97	12.90	1.37

Rainwater harvesting and recycling

During north-east monsoon (October - December), there was deficit rainfall of 22 mm compared to normal (22 mm). The rainfall during October, November and December months was deficit by 100% compared to normal rainfall. Trials conducted at both locations revealed that moisture conservation for mustard with disc harrow gave better seed yields of 721 and 709 kg/ha with net return of Rs. 5136 kg/ha and B:C ratio of 1.29 as compared to country plough (Table-198).

Table-198: Moisture conservation in chickpea with different implements

Hybrid	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Seed	Stalk			
Budhshelly					
Country plough	612	791	17680	1687	1.09
Disc harrow	721	930	17680	5136	1.29
Balawas					
Country plough	592	760	17680	1052	1.06
Disc harrow	709	910	17680	4754	1.27

Demonstrations were conducted in Ghangala and Balawas during *rabi* 2013-14 on different methods of mustard sowing. Sowing of mustard with ridger seeder recorded 12% higher seed yield over country plough. Wide variations in yields with both methods were recorded and some farmers harvested less yields due to poor rains. The maximum mean seed yield of 1260 kg/ha was recorded in ridge seeder sowing with net return of Rs. 10009/ha as compared to Camel drawn plough / seed drill (Table-199).

Table-199: Demonstration of ridger seeder for sowing of mustard

Treatment	Seed yield (kg/ha)	Net returns (Rs/ha)
Ridger seeder	1260	10009
Camel drawn plough/seed drill	1092	8877

Demonstrations in Balawas village were conducted as farmers in Budhshelly showed inclination for mustard cultivation. Only one trial was successful and the result showed that disc harrow had slight edge over country plough. Yields (1510 kg/ha) were low due to no rainfall in the crop season. Such trials need to be repeated in normal rainfall years as poor rains may give misleading results (Table-200).

Table-200: Moisture conservation by different implements in mustard

Treatment	Yield kg/ha		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Seed	Stalk			
Balawas					
Country plough	1270	4000	18510	24225	2.31
Disc harrow	1510	4770	18510	32315	2.74

Efficient energy use and management

Demonstrations were conducted on mechanical weed control inmustard using Kasola and Wheel Hard Hoe (WHH) to reduce drudgery, cost of cultivation and enhance crop yields. Two trials in Budhshelly village indicated that there was no perceptible benefit in yield but the cost of cultivation (Rs.16560/ha) for WHH was low due to better labour efficiency and thereby less labour requirement for weeding by WHH compared to Kasola (Table-201).

Table-201: Weed management in mustard

Treatment	Yield kg/ha		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Budhshelly					
Kasola	745	961	17680	23523	1.34
WHH	740	953	16560	6963	1.42

1.4.3. SK NAGAR

a. Agro-ecological setting

Saradar Krishinagar is located in Western Plain, Kachchh and part of Kathiawar peninsula, Rajasthan Bagar, north Gujarat Plain and southwestern Punjab plain (AESR 2.3). Annual rainfall is 782 mm.

b. On-station experiments

During 2013, the onset of monsoon was timely (13th June). A rainfall of 1021.9 mm was received which was excess 423.8 mm compared to normal (598.1 mm) (Fig.29), during south-west monsoon (*kharif).* During north-east monsoon (October- December), 61.9 mm of rainfall was received which was excess by 34.8 mm compared to normal (27.1 mm). During summer (March- May), 25.5 mm of rainfall was received which was excess by 16.7 mm compared to normal (8.8 mm). There were two dry spells during 25th June to 3rd July (9 days) and 6th to 21st September (16 days).

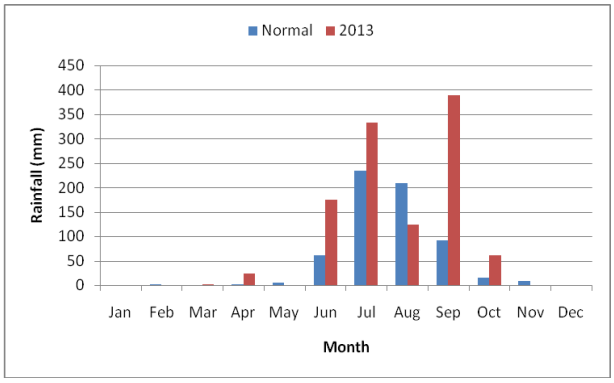


Fig.29 : Normal and actual (2013) monthly rainfall at S K Nagar

Real time contingency crop planning

The onset of monsoon was timely (13th June). A rainfall of 1021.9 mm was received which was excess 423.8 mm compared to normal (598.1 mm), during south-west monsoon (*kharif*). The rainfall in June, July and September months was excess by 187.3, 41.8 and 320.5% whereas August month was deficit by 40.7%. During kharif, the drought tolerant varieties/ hybrids of pearlmillet, castor, greengram, clusterbean, mothbean, castor (GCH 7) + greengram (GM 4) were introduced to cope with the rainfall variability. Among the varieties pearlmillet (GHB 558) recorded higher seed yield (1192 kg/ha), whereas B:C ratio was higher in castor + greengram (5.15) and rainwater use efficiency was higher in pearlmillet + karingada in third row of pearlmillet (1.68 kg/ha-mm) (Table-202).

Table-202: Performance of improved varieties/hybrids and intercropping system during *kharif* 2013

Crops	Seed yield (kg/ha)	Economics		RWUE (kg/ha-mm)
		Gross returns (Rs/ha)	B:C ratio	
Pearlmillet (GHB 538)	1079	22490	2.88	1.02
Pearlmillet (GHB 558)	1192	24124	3.09	1.12
Castor (GCH 2)	660	23400	2.63	0.62
Castor (GCH 4)	775	27453	3.08	0.73
Castor (GCH 5)	1005	35577	4.00	0.95
Castor (GCH 7)	1038	36764	4.13	0.98
Greengram (GM 3)	241	10647	2.09	0.23
Greengram (GM 4)	324	14206	2.79	0.31
Clusterbean (GG 1)	200	19263	3.70	0.19
Cluster bean (GG 2)	255	24213	4.66	0.24
Castor + greengram	941	45864	5.15	1.24
Pearlmillet + karingada in third row of pearlmillet	958	23178	3.18	1.68

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA centre, SK Nagar in Kalimati/Dholiya village, taluka Amirgadh, Banaskantha district and Chandanki village, taluka Becharaji in Mehsana district, Gujarat. The total cultivated area is 652.91 ha (Kalimati/Dholiya) and 448.0 ha (Chandanki) out of which 322.91 ha and 423.0 ha (Chandanki) is rainfed. The mean annual rainfall is 1028.8 mm (Kalimati/Dholiya) and 1110.3 mm (Chandanki) with seasonal rainfall of 1028.8 mm (Kalimati/ Dholiya) and 1110.3 mm (Chandanki) during kharif (July-September). The major soil types are sandy loam and clay. The major rainfed crops during *kharif* are pearlmillet, greengram, castor, cotton, blackgram, sorghum, clusterbean and maize, and cumin during *rabi*. The number of small, marginal, medium and large farmers are 83, 49, 75 and 39 in Kalimati/Dholiya, while 60, 15, 37 and 31 in Chandanki, respectively. The source of irrigation is well, tube well, canal, check dam and farm ponds covering 51.05% of cultivated area in Kalimati/Dholiya and 5.58% in Chandanki.

Climate Vulnerability in General

In general, the climate in this agro-climatic zone is semi-arid. The south-west monsoon contributes 94%, north-east monsoon 4% and summer 2% of the total annual average rainfall of 613 mm. The historical rainfall data (of 30 years) indicated that there was variability in rainfall during south- west monsoon. The onset (southwest) of monsoon was during 26 SMW. The dry spells during crop season were experienced, for the past 15 years, during August and September and at vegetative to reproductive stages of the major rainfed crops. The onset of the monsoon had been shifting from 26 SMW (June) to 27 SMW (July). The soil moisture status was deficit during vegetative, reproductive and maturity stages of major rainfed crops. The data on maximum/minimum temperature during crop season *viz.*, *kharif* Tmax was increasing (0.011°C) and no increase in *rabi* season, while Tmin was increasing at the rate of 0.018 and 0.021 °C per year in *kharif* and *rabi* season, respectively, during past 10 years. The extreme events like unusual and high intensity rainfall in short span were increasing in July and August during *kharif* season. The area was also experiencing other extreme events like floods, heat wave and cold wave. There had been considerable shift in rainfall pattern and uneven distribution with shift in sowing window from 27 to 28 SMWs of the crops pearlmillet, green gram, sorghum, clusterbean, maize, castor, cotton etc.

Experienced weather conditions during the year (2013-14)

In Kalimati village, a rainfall of 969 mm was received which was excess by 186.2 mm compared to normal (782.8 mm) (Fig.), during south- west monsoon (*kharif).* During north-east monsoon (October - December), 153 mm of rainfall received there was excess rainfall of 129.9 mm compared to normal (23.14 mm). During summer (March - May), 46.6 mm of rainfall was received which was excess by 3.5 mm compared to normal (43.1 mm).

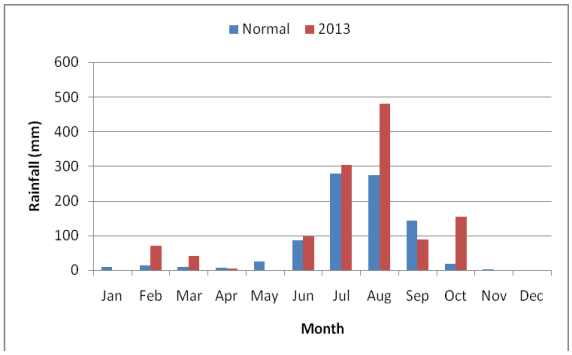


Fig.30 : Normal and actual (2013) monthly rainfall at Kalimati village

Interventions

The major interventions include land configuration, crops or varieties, cropping system, rainwater harvesting and recycling, timely operations through custom hiring center. These interventions covered an area of 134.29 ha in 332 farmers' fields.

Real time contingency crop planning

A rainfall of 969 mm was received which was excess by 186.2 mm compared to normal (782.8 mm) (Fig.), during south- west monsoon (*kharif).* The rainfall in June, July and August months was excess by 11.1%, 9.0% and 74.3%, respectively whereas the rainfall during September month was deficit by 37.3% compared to normal rainfall. *I*mproved varieties of *kharif* rainfed crops pearlmillet (GHB 558, GHB 538), maize (GM 2, HQPM 1), castor (GCH 2, GCH 5, GCH 7), blackgram (Guj. Urad 1), greengram (Guj. Mung 4), clusterbean (GG 2) and cotton (G cot 21) during *kharif* were demonstrated in the villages. The improved varieties increased yield by 16.10% in castor to 58.63% in maize over local varieties. Pearlmillet hybrid (GHB 558) recorded significantly highest seed (1890 kg/ha) and B:C ratio (4.35). Similarly, maize (HQPM 1), castor (GCH 7), blackgram (Guj. urad 1), greengram (Guj. mung 4) and clusterbean(GG 2) gave higher yields (2780, 1246, 570,520 and 360 kg/ha), respectively) and B:C ratio (5.37,4.34, 4.05, 3.04 and 5.77, respectively) in Kalimati/Dholiya village. Whereas, in Chandanki village improved varieties of pearlmillet (GHB 558), castor (GCH 7), cotton (G cot 21) and castor + greengram (GCH 7+ guj. mung 4) gave higher yield (1950, 1160, 630 and 1931 kg/ha, respectively), and B:C ratio (3.36,3.63,2.93 and 4.63, respectively). Dry spells during last week of August to second week of September (about 20-25 days) in both villages resulted in inadequate moistutre supply to the maize, greengram, blackgram, castor leading to severe water stress at reproductive stage due to early cessation of rains (Table-203).

Table-203: Performance of improved varieties hyvrids of *kharif* rainfed crops

Crop	Improved variety	Yield (kg/ha)		Increase in yield (%)	B:C ratio
		Improved variety	Local variety		
Kalimati/Dholiya village					
Pearlmillet	GHB 558	1890	1152	39.04	4.35
	GHB 538	1550	1152	25.67	3.57
Maize	GM 2	1810	1150	36.46	4.44
	HQPM 1	2780	1150	58.63	5.37
Castor	GCH 2	888	745	16.10	3.09
	GCH 5	1039	745	28.29	3.62
	GCH 7	1246	745	40.20	4.34
Blackgram	Guj. urad 1	570	430	24.56	4.05
Greengram	Guj. mung 4	520	390	25.00	3.04
Cluaterbean	GG 2	360	270	25.00	5.77
Chandanki village					
Pearlmillet	GHB 558	1950	1280	34.35	3.36
	GHB 538	1680	1280	23.80	2.90
Castor	GCH 2	830	680	18.07	2.59
	GCH 5	970	680	29.89	3.03
	GCH 7	1160	680	41.39	3.63
Cotton	G cot 21	630	490	22.22	2.93
Castor + greengram	GCH 7+ guj. mung 4	1931			4.63

Crops/Varieties/Cropping system

The rainfall in June, July and August months was excess by 11.1%, 9.0% and 74.3%, respectively whereas the rainfall during September month was deficit by 37.3% compared to normal rainfall. Improved cropping system castor + greengram was introduced to cope with the rainfall variability. The improved practice gave 2390 kg/ha at Kalimati with RWUE of 2.52 kg/ha-mm and B:C ratio of 5.89 (Table-204). Similarly, in Chandanki villages castor + greengram intercropping system produced higher yields compared to sole castor cropping.

Table-204: Performance of intercropping system

Crop	Improved variety	Yield (kg/ha)	B:C ratio	RWUE (kg/ha-mm)
Kalimati/Dholiya Village				
Castor + greengram	GCH 7+ Guj. Mung 4	2390	5.89	2.52
Castor	GCH 7	1529	5.05	1.61
Chandanki Village				
Castor + greengram	GCH 7+ Guj. Mung 4	1931	4.63	3.33
Castor	GCH 7	1316	4.11	2.27

Castor + greengram intercropping

Castor sole (GCH 7)

Rainwater harvesting and recycling

Due to uncertain monsoon behavior, adequate moisture supply to the crop during its critical growth period is not possible and this leads to complete failure of crop. Therefore, it is essential to evaluate drought management practices like compartmental bunding. The rainfall in June, July and August months was excess by 11.1%, 9.0% and 74.3%, respectively whereas the rainfall during September month was deficit by 37.3% compared to normal rainfall. Further, dry spells occurred during last week of August to second week of September (about 20-25 days) in both villages. The results showed that in-situ moisture conservation practices (compartmental bunding) exerted their significant influence on seed and fodder yield of pearlmillet during kharif 2013 in NICRA villages. The compartmental bunding treatment recorded significantly highest seed and fodder yield of pearlmillet (1980 kg/ha and 4850 kg/ha, respectively) over local practices. The highest, net return (28765 Rs/ha), benefit cost ratio (4.16) and RWUE (2.09 kg/ha-mm) were recorded with compartmental bunding treatment in Kalimati village. The compartmental bunding recorded significantly highest pearlmillet grain and fodder yield of 1990 kg/ha and 4820 kg/ha, respectively over local practices. The highest net return (Rs. 32600/ha), B:C ratio (4.51) and RWUE (3.43 kg/ha-mm) were recorded with compartmental bunding in Chandanki village (Table-205).

Table-205: Effect of compartmental bunding on yield of pearlmillet

Treatment	Yield (kg/ha)		Cost of cultivation	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Fodder				
Kalimati/Dholiya						
Compartmental bunding	1980	4850	9100	28765	4.16	2.09
Local practices (No bunding)	1720	4100	8500	24115	3.84	1.81
Chandanki						
Compartmental bunding	1990	4820	9300	32600	4.51	3.43
Local practices (No bunding)	1630	3270	8700	23928	3.75	2.81

Compartmental bunding in pearl millet

Local practices

Kalimati/dholiya

Compartmental bunding in Pearlmillet

Local practices

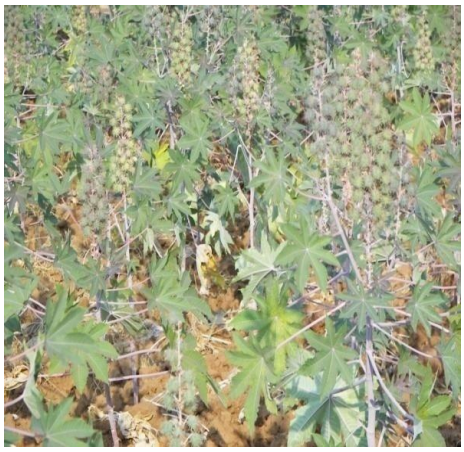
Chandanki

The ridge and furrow method of sowing of castor were demonstrated in NICRA villages. The ridge & furrow method of sowing of castor recorded significantly highest seed and stalk yield of 1380 kg/ha and 2360 kg/ha, respectively over local practices. The highest net return (Rs. 37763/ha), B:C ratio (4.23) and RWUE (1.45 kg/ha-mm) were recorded with ridge & furrow method of sowing of castor in Kalimati village. Similarly, the ridge and furrow recorded the highest seed and stalk yield of 1230 kg/ha and 2748 kg/ha, respectively over local practices. The highest net return (Rs. 32826/ha), B:C ratio (3.83) and RWUE (2.12 kg/ha-mm) were recorded with ridge and furrow system in castor in Chandanki village (Table-206).

Table-206: Effect of ridge and furrow system on yield of castor

Treatment	Yield (kg/ha)		Cost of cultivation	Net return (Rs/ha)	B: C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Kalimati/Dholiya						
Ridge & furrow	1380	2360	11700	37763	4.23	1.45
Local practices	870	1680	10550	20740	2.97	0.92
Chandanki						
Ridge & furrow	1230	2748	11600	32826	3.83	2.12
Local practices	870	2240	10850	20722	2.91	1.50

Castor with ridge & furrow



Local practices

Kalimati/dholiya

Castor with ridge & furrow

Local practices

Chandanki

Rainwater harvesting *ex-situ* (castor)

The rainfall is inadequate uncertain and erratic as well as soil is loamy sand with low moisture retention capacity. The combination of these factors results in excessive runoff from the field and soil profile generally remain unsaturated. The benefit obtained by using the rainwater to replenish the soil moisture deficit during critical stages of crop growth is well documented. *Ex-situ* moisture conservation practices-supplemental irrigation in castor exerted their significant influence on seed and stalk yield of castor. Supplemental irrigation recorded significantly highest seed and stalk yield of 1240 kg/ha and 2650 kg/ha, net return (Rs. 32925/ha), B:C ratio (3.79) and RWUE (2.14 kg/ha-mm) compared to local practice in Chandanki village (Table-207).

Table-207: Effect of supplemental irrigation on yield of castor

Treatment	Yield (kg/ha)		Cost of cultivation	Net return Rs/ha)	B: C ratio	RWUE (kg/ha-mm)
	Seed	Fodder				
Supplemental irrigation	1240	2650	11800	32925	3.79	2.14
Local practices (rainfed)	940	1920	11000	22860	3.08	1.62

Supplemental irrigation in castor

Rainfed castor

Similarly, *ex-situ* moisture conservation (supplemental irrigation) in cumin (GC-4) exerted their significant influence on seed and stalk yield. Supplemental irrigation in cumin (GC-4) recorded significantly higher yield (581 kg/ha) over local control. The higher net return (Rs.77792), B:C ratio (9.02) and WUE (1.00 kg/ha-mm) were recorded with supplemental irrigation in Chandanki village (Table-208).

Table-208: Effect of supplemental irrigation on yield of cumin

Treatment	Yield (kg/ha)		Cost of cultivation	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Supplemental irrigation	581	647	9700	77792	9.02	1.00
Local practices (rainfed)	422	504	8200	55351	7.75	0.73

Supplemental irrigation (GC 4)

Local practice (rainfed)

Chandanki

Efficient energy use and management

Different seed drills were evaluated for their efficacy in enhancing greengram yield and net returns. The data revealed that different conservation equipments in green gram (GM 4) exerted their significant influence on seed yields. The seed sown with roto till drill recorded significantly highest seed yields 740 kg/ha over the rest of treatments. The highest net return (Rs.28980), B:C ratio (5.46), rainwater use efficiency (0.78 kg/ha-mm) and input output energy ratio 8.45 were recorded with roto till drill (Tables 209 & 210).

Table-209: performance of different seed drills in greengram (GM 4)

Implement	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Roto till drill	740	28980	5.46	0.78
Strip till drill	660	25170	4.87	0.70
Zero till drill	580	21210	4.26	0.61
Local practices	460	14870	3.09	0.48

Table-210: Energy use analysis of different implements

Information	Quantity/ha				Total energy equivalent (MJ/ha)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Inputs								
Human labour (hrs)	163	163	163	170	319.5	319.5	319.5	333.2
Machinery/ equipment (hrs)	-	-	-	100	600 J/ha	600 J/ha	600 J/ha	100 J/ha
Diesel (liters)	42	42	42	56	2365.03	2365.03	2365.03	2985.4
Chemical fertilizers (kg)								
Nitrogen (N) (Urea)	10	10	10	10	600	600	600	600
Phosphate (P) (DAP)	87	87	87	87	939.6	939.6	939.6	939.6
Seed (kg)	15	15	15	20	600	600	600	800
Bullock (hr.)	16	16	16	48	161.6	161.6	161.6	484.8
Total energy requirement (MJ)	-	-	-	-	5586	5586	5586	6243
Outputs								
Crop yield (kg)	740	660	580	460	29600	26400	23200	18400
Total energy output (MJ)	-	-	-	-	47200	42200	36600	29000
Output-input ratio	-	-	-	-	8.45	7.56	6.55	4.64

T1- Roto till drill; T2- Strip tilldrill ; T3- Zero till drill; T4- Local practice

Roto Till Drill

Strip Till Drill

Zerro Till Drill

Traditional method

1.5. SORGHUM BASED PRODUCTION SYSTEM

1.5.1 BIJAPUR

a. Agro-ecological setting:

Bijapur is in Karnataka Plateau (AESR 3). The climate is hot arid. Potential evapo-transpiration is 622 mm. The annual rainfall is 594 mm. The length of growing period is 90-120 days. Drought is quite common and occurs once in five years. Water erosion is of high severity with strong loss of top soil, and moderate loss of top soil, affecting 26-50% area. The soils are deep loamy and clayey mixed red and black soils. Available water capacity is low to medium. The dominant rainfed crops during *kharif* are pigeonpea and during *rabi* are sorghum and chickpea.

b. On-station experiments

During the year 2013, a rainfall of 563 mm was received which was excess by 174.4 mm compared to normal (388.6 mm) during south-west monsoon (*kharif*). During north-east monsoon (October - December), 112.5 mm of rainfall was received which was deficit by 21.7 mm compared to normal (134.2 mm) (Fig.31). During summer (March-May), 83.3 mm of rainfall was received which was excess by 17.7 mm compared to normal (65.6 mm).

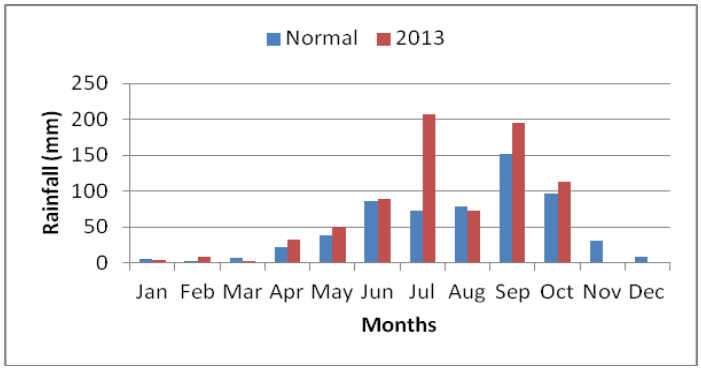


Fig.31: Normal and actual (2013) monthly rainfall at Bijapur

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA Centre, Bijapur in Kavalagi village, Bijapur tehsil in Bijapur district, Karnataka. The total cultivated area is 1327 ha out of which 1307 ha is rainfed. The mean annual rainfall is 594.4 mm with seasonal rainfall of 387.5 mm during *kharif (*June - September). The major soil types are shallow to medium deep black soils, shallow red soils and gravelly soils. The major rainfed crops during *kharif* are pearlmillet, pigeonpea, greengram, groundnut, maize and sorghum, chickpea, wheat, sunflower and safflower during *rabi* season. The number of small, marginal, medium and large farmers is 144, 53, 200 and 04, respectively. The ground water table is 70-90 m. The source of irrigation is open-wells and bore- wells covering only 1.5% of cultivated area.

Climate Vulnerability in General

The climate in this agro-climatic zone is dry semi-arid. Out of the total annual average rainfall of 594.4 mm, the south-west monsoon contributes 65%, north-east monsoon contributes 22.5% and summer contributes 12.5%. The historical data (30 years) indicates that the variability in rainfall during south-west monsoon was manifested in delayed onset and drought.

Experienced weather conditions during the year (2013-14)

During the year 2013, in the Kaulagi village, the onset of monsoon was delayed (July 8) rainfall of 80.6 mm was received which was deficit by 306.9 mm compared to normal (387.5 mm) during south-west monsoon (*kharif*). During north-east monsoon (October - December), 353.3 mm of rainfall was received which was excess by 219.3 mm compared to normal (134.0 mm) (Fig.32). During summer (March-May), 12.8 mm of rainfall was received which was deficit by 53.3 mm compared to normal (66.1 mm). The dry spells occurred during crop seasons; one during 21st September to 12th October (22 days) coinciding with grand growth and flowering stage of *kharif* crops. Another dry spell during November coinciding with vegetative growth stage of *rabi* crops.

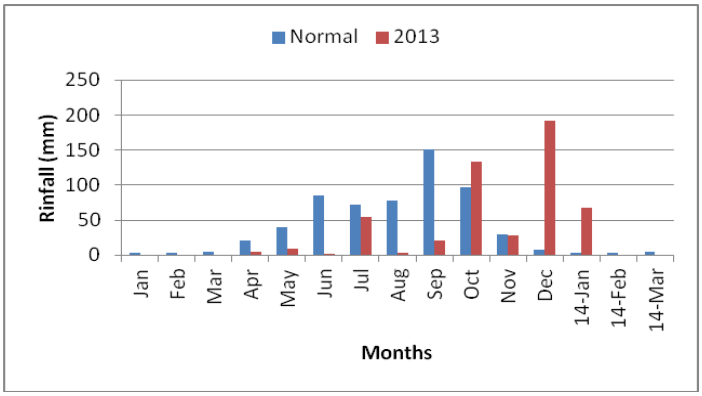


Fig.32: Normal and actual (2013) monthly rainfall at Kaulagi

Interventions:

The major interventions implemented include land configuration, crops or varieties/cropping systems, rainwater harvesting and recycling, timely operations through custom hiring centre, alternate land use and ecosystem services.

Land configuration

Compartmental bunding helps in efficient moisture conservation particularly during *rabi* season. Compartment bunding increased the yield of chickpea, *rabi* sorghum and sunflower to an extent of 13.20, 285.51 and 108.33%, respectively. While the RWUE in the compartment bunding plots in case of chickpea, *rabi* sorghum and sunflower were 8.80, 6.50 and 4.60 kg/ha-mm, respectively (Table-211). The compartmental bunds helped in conserving moisture, resulted in mitigating dry spell during vegetative stages of *rbi* crops and enhanced crop yields.

Table-211: Performance of sorghum, chickpea and sunflower with compartmental bunding

Crop	Yield (kg/ha)		Increase in yield (%)	BC ratio	RWUE (kg/ha-mm)	
	Improved practice (compartmental bunding)	Farmers' practice (flat sowing)			With compartmental bunding	Without compartmental bunding
Chickpea	1200	580	106.89	1.7	8.80	8.50
Rabi Sorghum	825	214	285.51	2.5	6.50	3.10
Sunflower	1200	576	108.33	3.5	4.60	2.20

Rainwater harvesting and recycling

The information on rainfall, intensity and volume of water harvested during each runoff event is presented in the following Table-212. The data reveals that because of the good runoff producing rainfall events, 3107.67cum of water was harvested.

Table -212: Rainfall intensity v/s volume of water harvested in the farm pond

Date	Rainfall (mm)	Rainfall intensity (mm/hr)*				Volume of water harvested (cum)	Cumulative water harvested (cum)
		1	2	3	4		
07.07.2013	0.0					00.00	0000.00
08.07.2013	110.0	42.58				1965.00	1965.00
12.07.2013	34.2	24.00	20.40			70.08	2035.08
13.07.2013	13.0	26.00				40.51	2075.59
23.07.2013	31.0	1.60	3.80	3.60		39.09	2114.68
06.08.2013	25.4	7.26				18.93	2133.61
16.08.2013	12.8	2.40				18.76	2152.37
18.08.2013	20.4	7.00				46.17	2198.54
02.09.2013	13.1	2.70				45.86	2244.40
09.09.2013	17.9	1.80	2.65	0.50		73.66	2318.06
10.09.2013	19.8	33.00	0.50	2.50		28.03	2346.09
11.09.2013	10.5	5.71	1.20			9.39	2355.48
12.09.2013	11.8	22.60	1.00			9.41	2364.89
15.09.2013	35.4	20.33	2.00			141.23	2506.12
17.09.2013	15.4	21.20	0.60	1.60	3.68	57.60	2563.72
18.09.2013	31.0	9.00				78.19	2641.91
13.10.2013	26.3	4.00	11.06	17.76	8.40	46.08	2687.99
23.10.2013	50.0	22.00	19.43			391.36	3079.35
25.10.2013	10.5	4.67				28.32	3107.67

*Intensity during the different spells of rainfall during the day

The farm pond waterwas used for supplemental irrigation to chickpea and sorghum. One supplementary irrigation of 5 cm depth was given through sprinkler at flowering stage of both chickpea and sorghum crops. In the irrigated plot an additional yield by 25 and 31.4% were recorded in the chickpea and sorghum, respectively (Table-213).

Table-213: Impact of supplementary irrigation on chickpea and sorghum

Treatment	Yield (kg/ha)
Chickpea	
5 cm depth of irrigation	1250
Control (rainfed)	1000
Sorghum	
5 cm depth of irrigation	1150
Control (rainfed)	875

Bore well and open well recharge

During the monsoon season, the runoff from the nala was diverted to the open well through the filter. It was 80% full during July and in the month of September it was completely full, the farmers used this water for irrigating two acres of land. Because of the bore well recharge, the well yield was increased and also during the summer it did not run dry.

Real time contingency crop planning

During *kharif* 2013, a rainfall of 80.6 mm was received which was deficit by 306.9 mm compared to normal (387.5 mm) during south-west monsoon (*kharif*) with 98% deficit in June, 26% deficit in July, 94.9% deficit in August and 86.0% deficit in September. The drought tolerant varieties/hybrids of pearl millet, groundnut, sunflower, pigeonpea, chickpea, moth bean, horsegram and safflower and different intercropping systems were demonstrated to cope up with the rainfall variability.

In pearl millet, ICTP-8203 gave 16% higher grain yield over ICMV 211 and 131% over GHB 558. Intercropping of pearl millet + pigeonpea (2:1) gave higher yield of 1425 kg/ha as compared to other row ratios with same intercropping. In pearl millet + groundnut (2:4) the higher yield of 765 kg/ha was recorded as compared to other row ratios of same intercropping (Table-214).

Table -214: Performance of pearl millet and pearl millet based cropping system

Treatment	Row ratio	Variety	Yield (kg/ha)
Pearl millet varietal trial		ICMV-211	1875
		ICTP-8203	2175
		GHB-558	938
Intercropping of pearl millet + pigeonpea	4:2	ICTP-8203	1350
	5:1		900
	2:1		1425
Intercropping of pearl millet + groundnut	1:2	ICTP-8203	525
	2:4		765
	1:5		375
Pearl millet (wider row) – *Rabi* sorghum + chickpea (2:4)		ICTP-8203	2550
Pearl millet (wider row) – sunflower (wider row)		ICTP-8203	2250

Under groundnut varietal demonstrations, the variety TMV-2 produced 975 kg/ha of pod yield followed by GPBD-4 (900 kg/ha) and DH-101(600 kg/ha) (Table-215). Among intercropping systems, groundnut + pigeonpea (4:2) gave higher yield (833 kg/ha) compared to other row ratios. Similarly, groundnut + pigeonpea intercropping in 4:2 row ratio performed better (900 kg/ha) compared to other row ratios.

Table -215: Performance of groundnut and groundnut based intercropping system

Crop/ cropping system	Row ratio	Variety	100 seed weight (g)	Pod yield (kg/ha)
Groundnut varietal trial		TMV-2	31.4	975
		GPBD-4	44.5	900
		DH-101	39.2	600
Groundnut + pigeonpea	4:2	DH-101	33.4	833
	5:1		38.1	593
	2:1		33.0	750
Groundnut + pearl millet	2:1	DH-101	36.0	750
	4:2		35.2	900
	5:1		38.0	525

In sunflower varietal trial, KBSH 1 and KBSH 53 produced 26.5 and 25.6% higher seed yield than DSFH-3 (Table-216). Sunflower – pearlmillet cropping systems was found better than sunflower – sorghum + chickpea cropping systems

Table-216: Performance of sunflower and sunflower based cropping systems

Crop/cropping system	Variety	100 seed weight (g)	Yield (kg/ha)
Sunflower(wider row) -sorghum+ chickpea (2:4)	KBSH-1	5.1	2550
Sunflower wider row(*Rabi*)- pearl millet wider row (*Kharif*)	KBSH-1	6.1	2650
Sunflower varietal trial	KBSH-1	4.8	1275
	KBSH-53	4.6	1350
	DSFH-3	5.0	600

In pigeonpea varietal demonstrations in medium black soils, Asha and TS-3R produced 36.8 and 26.3% higher yield than Maruti. Whereas, under pigeonpea varietal trial in shallow black soils, the variety ICPL 87 and TS-3R produced 40.0 and 30.0% higher yield than Gulayal local (Table-217). Among intercropping systems, pigeonpea + pearlmillet in1:2 row ratio was better than other row ratios. Similarly, pigeonpea + groundnut in 2:4 row ratio gave higher yield than other row ratios.

Table -217: Performance of pigeonpea and pigeonpea based intercropping system

Crop/cropping system	Row ratio	Variety	100 seeds weight (g)	Yield (kg/ha)
Pigeonpea varietal trial		TS - 3R	8.3	1200
		BSMR-736	9.0	1000
		Asha	9.6	1300
		Maruti	8.5	950
Pigeonpea + pearlmillet	1:2	ICPL-87	9.5	825
	1:5		9.3	525
	2:4		815	600
Pigeonpea + groundnut	2:4	ICPL-87	9.2	1125
	1:5		9.3	525
	1:2		8.5	600
Pigeonpea varietal trial		TS-3R	9.2	975
		WRP-1	8.5	750
		ICPL-87	8.6	1050
		Gulayal	9.1	750

During *rabi* season 2013 (October - December), 353.3 mm of rainfall was received which was excess by 219.3 mm compared to normal (134 mm) with 37.3% excess in October, 3.7% deficit in November and 184.1 mm excess in December. In chickpea varietal trials, BGD 103 and JG 11 produced 16.6 and 8.3% higher yield than Annigeri-1. Chickpea + safflower intercropping (1:5) recorded 1425 kg/ha yields as compared to other row ratios (Table-218).

Table -218: Performance of chickpea and chickpea based intercropping systems

Crop/cropping system	Row ratio	Variety	100 seed weight (g)	Yield (kg/ha)
Chickpea varietal trial		Annigeri-1	27	1500
		JG-11	25	1725
		BGD-103	26	900
Chickpea varietal trial		BGD-103	21	900
		JG-11	21	975
		Annigeri-1	20	1050
Chickpea + safflower	2:4	A-1	18	1350
	1:5		14	1425
	1:2		13	900
Bajra after chickpea		A-1	17	1500
Pearl millet after chickpea		A-1	28	2050

In case of sorghum varietal demonstrtions, M-35-1 and BJV-44 produced 23.7 and 4.6% higher yield than DSV 4. Intercropping of *rabi* sorghum + chickpea (2:4) recorded higher yield of 1725 kg/ha as compared to other row ratios of sorghum + chickpea intercropping (Table-219).

Table-219: Performance of sorghum and sorghum based cropping systems

Crop/ cropping system	Row ratio	Variety	100 seed weight (g)	Yield (kg/ha)
Rabi sorghum + chickpea	2:4	M-35-1	4.0	1725
	1:5		3.8	1425
	1:2		3.6	1275
Bajra after *rabi* sorghum + chickpea (2:4)		M-35-1	3.8	2150
Pearl millet after *rabi* sorghum + chickpea (2:4)		M-35-1	3.7	1100
Sorghum varietal trial		M-35-1	4.2	975
		BJV-44	4.7	825
		DSV-4	4.8	788

Improved varieties of mothbean and horsegram were demonstrated in fasrmers' fields. The moth bean variety KBMB-1 produced 17.6% higher seed yield than local variety (Table-220). Similarly, the horsegram variety GPM 6 produced 25% higher seed yield than local variety.

Table -220: Performance of mothbean and horsergram varieties

Crop	Variety	100 seed weight (g)	Yield (kg/ha)
Mothbean	Local	3.2	340
	KBMB-1	3.0	400
Horsegram	Local	4.0	200
	GPM-6	4.2	205

In safflower varietal demonstration, the variety A-1 produced 10% higher yield than A-2. However under safflower + chickpea intercropping system with different row ratios the ratio, 2:1 recorded higher yield (975 kg/ha) over other row ratios of intercropping system (Table-221).

Table-221: Performance of safflower varieties and safflower + chickpea intercropping system

Crop/cropping system	Row ratio	Variety	100 seed weight (g)	Yield (kg/ha)
Safflower varietal trial		A-1	6.0	550
		A-2	5.8	500
Safflower + chickpea	2:4	A-1	7.2	900
	5:1		6.5	750
	2:1		6.9	975

Among different intercropping systems, in case of pigeonpea + groundnut intercropping systems, pigeonpea + groundnut (2:4) gave higher net return of Rs.41850/ha and RWUE of 3.3 kg/ha-mm as compared to other row ratios. In pigeonpea + pearlmillet intercropping systems, pigeonpea + pearlmillet (2:4) gave higher net income of Rs. 20550/ha than other intercropping systems. In case of pearlmillet + groundnut intercropping systems, pearlmillet + groundnut (2:4) gave higher net income of Rs. 20033/ha than other row ratios systems. In chickpea + sorghum intercropping systems, chickpea + sorghum (5:1) gave higher net returns of Rs. 54277/ha as compared to other row ratios in same intercropping system while in safflower + chickpea intercropping systems, safflower + chickpea (2:4) gave higher net returns of Rs.47851/ha compared to other row ratios from same intercropping systems (Table-222).

Table-222: Performance of different intercropping systems

Intercropping system	Row ratio	Yield (kg/ha)	Rainfall (mm)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Pigeonpea + groundnut	2:4	1125	337.8	3.3	22500	41850	2.9
		833		2.5			
	1:5	525	337.8	1.6	22500	13650	1.6
		593		1.8			
	1:2	600	337.8	1.8	22500	21000	1.9
		750		2.2			
Pigeonpea + pearl millet	1:2	525	287.8	1.8	22500	5325	1.2
		900		3.1			
	1:5	600	287.8	2.1	22500	13463	1.6
		1425		5.0			
	2:4	825	287.8	2.9	22500	20550	1.9
		1350		4.7			

Pearl millet + groundnut	1:2	375	287.8	1.3	15000	11438	1.8
		750		2.6			
	2:4	765	287.8	2.7	15000	20033	2.3
		900		3.1			
	1:5	525	287.8	1.8	15000	6263	1.4
		525					
Chickpea + sorghum	4:2	1500	68.1	22.0	8500	53377	7.3
		1725		25.3			
	5:1	1725	68.1	25.3	8500	54277	7.4
		1425		20.9			
	2:1	900	68.1	13.2	8500	32226	4.8
		1275		18.7			
Safflower + chickpea	2:4	975	68.1	14.3	9900	47851	5.8
		1350		19.8			
	5:1	1425	68.1	20.9	9900	45151	5.6
		750		11.0			
	2:1	450	68.1	6.6	9900	23401	3.4
		900		13.2			

In performance of different crop varieties, safflower variety A1 produced 10% higher yield than A2. In chickpea, BGD-103 and JG-11 produced 16.6 and 8.3% higher yield than Annigeri-1. Sorghum variety M 35-1 and BJV-44 produced 23.7 and 4.6% higher yield than DSV-4. In sunflower, KBSH-1 and KBSH-53 produced 26.5 and 25.6% higher seed yield than DSFH-3 (Table-223).

Table-223: Performance of different crop varieties

Crop	Variety	Yield (kg/ha)	Rainfall (mm)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Safflower	A-1	550	92.1	6.0	9900	4400	1.4
	A-2	500	92.1	5.4	9900	3100	1.3
Chickpea	Annigeri-1	900	68.1	13.2	6800	14801	3.2
	JG-11	975	68.1	14.3	6800	16601	3.4
	BGD-103	1050	68.1	15.4	6800	18401	3.7
Sorghum	M-35-1	975	92.1	10.6	8500	6125	1.7
	BJV-44	825	92.1	9.0	8500	3875	1.5
	DSV-4	788	92.1	8.6	8500	3313	1.4
Sunflower	KBSH-1	1073	222.3	4.8	11240	24153	3.1
	KBSH-53	1065	222.3	4.8	11240	23905	3.1
	DSFH-3	848	222.3	3.8	11240	16728	2.5

In demonstrations on vegetable based relay cropping systems for enhancing crop rpdoctivity and profitability, intercropping of onion + chilli (1:5) relayed with *rabi* sorghum gave higher net returns of Rs. 105050/ha than onion + chilli (2:4) relayed with *rabi* sorghum (Table-224).

Table-224: Performance of relay cropping systems

Cropping system	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Chilli + onion (2:4)	600	2.1	11200	78800	8.0
	6000	20.8			
Chilli + onion (1:5)	525	1.8	11200	105050	10.4
	9000	31.3			

Timely operations through custom hiring centre/efficient energy use and management

A custom hiring centre was established in the village with need based implements. A custom hiring committee was constituted to facilitate the activities smoothly. As per the demand of the farmers, the improved implements for primary tillage, sowing, weeding and interculture were provided through custom hiring cntre. During the year 2013-14, custom hiring services have significantly contributed to alleviate labour shortage during peak demand period. The implements made available at the custom hiring centre are listed below (Table-225).

Table-225: Improved implements made available at custom hiring centre

Equipment	Number
Single Bottom Reversible M.B. (45 hp)	01
M.B. Plough	01
Bund former	04
Bund farmer (Sarayantra)	04
Automatic seed-cum-fertilizer drill	01
Automatic seed-cum-fertilizer drill (general type)	02
Cycle drawn seed cum fertilizer drill	02
Cycle weeder	03
Knapsack sprayer	02
Knapsack sprayer	02
Improved sickle	20
Thermometers – Maximum and Minimum with stand and screen box	01
Miscellaneous equipments:	
a) Roto Tiller (Power operated weeder)	01
b) Groundnut digger	01
c) Power operated cutter	01
d) Disc harrow	01
e) Hand ridger	02
f)Twin wheel hoe	02

1.5.2. SOLAPUR

a. Agro-ecological setting

Solapur is in Deccan Plateau of South Western Maharashtra and North Karnataka Plateau (AESR 6.1). The climate is hot semi-arid. Annual average potential evapo-transpiration is 589 mm. Annual rainfall is 721.4 mm. The length of growing period is 90-120 days. Solapur is a rainfall shadow area and has drought occurring once in ten years. Water erosion is of high severity with moderate loss of top soil, affecting 51-100% area. The soils are shallow and medium loamy black soils (deep clayey black soils). Available water capacity is medium to high. Soil reaction is alkaline.

On-station experiments

Experienced weather condition during the year (2013-14)

During 2013, a rainfall of 666.9 mm was received in 38 rainy days which was deficit by 7.6 mm compared to normal (721.4 mm). During south-west monsoon, 522.6 mm rainfall was received which was deficit by 12.6 mm than normal 535.2 mm (*kharif*). During north-east monsoon (October- December), 75.9 mm of rainfall was received which was deficit by 49.6 mm compared to normal (125.5 mm). During summer (March-May), 64.6 mm of rainfall was received which was excess by 12 mm compared to normal (52.6 mm) (Fig.33).

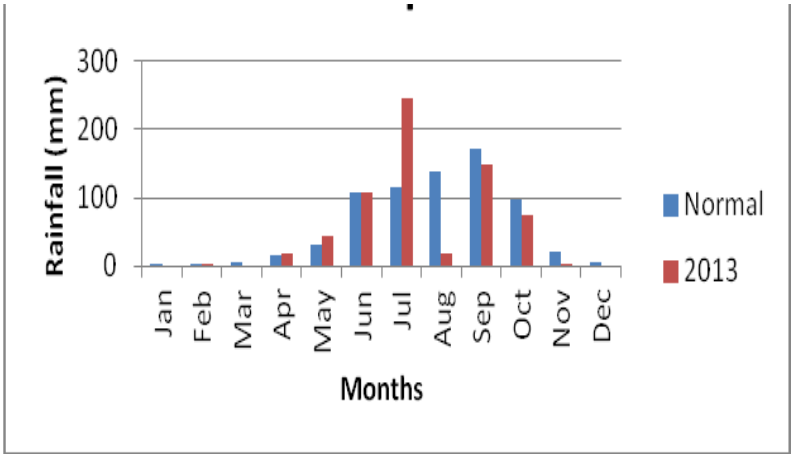


Fig.33: Normal and actual (2013) monthly rainfall at Solapur

Real time contingency crop planning

Different crops were introduced to cope up with the rainfall variability of the region. During 2013-14, annual rainfall received was 666.9 mm. Maximum rainfall (246.2 mm) was received in the month of July 2013 in 16 rainy days, which was very useful for sowing of *kharif* crops. Among different crops, pigeonpea Cv. Vipula cultivated with improved technology gave 1400 kg/ha yield over farmer`s practice (1133 kg/ha) and the per cent increase over farmer`s practice was 23.56%. In sunflower Cv. Bhanu gave 750 kg/ha yield over farmer`s practice (593 kg/ha) which was 26.47% increase over farmer`s practice. Same trend was found in case of pearl millet cv.Shanti. Improved technology produced yield of 1033 kg/ha over farmer`s practice (887 kg/ha) which was about 19.14% higher over farmer`s practice. Similarly the values of gross return, net return and B:C ratio were maximum with improved technology over farmer`s practice in all crops.

Two varieties of sorghum were introduced to cope up with rainfall variability of the region. Sorghum cv. Vasudha produced maximum yield (1300 kg/ha) under improved technology over farmers' practice (1188 kg/ha), whereas maximum gross return, net return and B:C ratio were recorded with improved technology (Rs.32500/ha, Rs. 17200/ha and 2.12, respectively) over farmers' practice (29722, 15211 and 2.04, respectively). The per cent increase in yield under improved technology was 9.42% over farmers, practice (Table-226).

Chickpea variety Vijay produced higher by yield of 1050 kg/ha with improved technology as compared to farmers practice (796 kg/ha) which was 31.90% over farmers practice. While, maximum GMR, NMR and B:C ratio were also recorded under improved technology over farmers practice (Rs.36750/ha, Rs. 19222/ha and 2.09, respectively) (Table-226).

Table-226: Performance of different crops for contingent crop planning during *kharif* (2013)

Crop/ Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)		Net return (Rs/ha)		B:C ratio		% increase over Farmers practice
	Improved technology	Farmers practice	Improved technology	Farmers practice	Improved technology	Farmers practice	Improved technology	Farmers practice	
Pigeonpea Cv. Vipula	1400	1133	17100	16141	43100	32233	3.52	2.99	23.56
Sunflower Cv. Bhanu	750	593	15200	14165	8050	4373	1.52	1.30	26.47
Pearlmillet Cv. Shanti	1033	887	10100	8321	4972	3304	1.58	1.39	19.14
Sorghum Cv. Vasudha	1300	1188	15300	14511	17200	15211	2.12	2.04	9.42
Sorghum Cv. nuradha	1496	983	15325	14311	22075	10263	2.44	1.71	52.18
Gram Cv. Vijay	1050	796	17525	16510	19225	11349	2.09	1.68	31.90

Assessment of production potential of pigeonpea (cv. Vipula)

Assessment of production potential of sunflower (cv. Bhanu)

Intercropping of pigeonpea (Vipula) + sunflower (Bhanu) (2:1) gave maximum crop yield, NMR and B:C ratio with improved technology (750 kg/ha, Rs.33750/ha and 2.97, respectively) over farmer`s practice and the per cent increase over farmer`s practice was 46.77% (Table-227).

Table -227: Performance of intercropping systems for contingent crop planning during *kharif* (2013)

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)		Net return (Rs/ha)		B:C Ratio		% increase over FP		Pigeonpea equivalent yield (kg/ha)
	Main crop		Inter crop										
	IT	FP	IT	FP	IT	FP	IT	FP	IT	FP	Main crop	Inter crop	
Pigeonpea (Vipula) + Sunflower (Bhanu) (2:1)	750	511	600	416	17100	15442	33750	19457	2.97	2.25	46.77	44.23	11.82

IP: Improved technology, FP: Farmers practice


Assessment of production potential of Pigeonpea + Sunflower (2:1)

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use

Performance of *in-situ* moisture conservation practices i.e. compartmental bunding and ridges and furrows were evaluated on-station followed by sowing of *rabi* sorghum (Table-228 & 229). Compartmental bunding helped in conserving soil moisture which resulted in enhancement of crop yield by 35.03% and RWUE by 34.99% compared to farmers' practice (Table-228). Whereas ridges and furrows also resulted in higher yield, RWUE, net returns and B:C ratio. The per cent increase in yield was 26.20% and 26.18% in RWUE as compared to farmers' practice (Table-229).

Table-228: Performance of *rabi* sorghum with compartmental bunding

Treatment	Mean yield (kg/ha)	Increase in yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Improved practice (Compartment bund)	979	254	10.30	9359	1.83
Farmer's practice (Two harrowing)	725	-	7.63	5025	1.49

Table-229 : Performance of *rabi* sorghum with ridges and furrows

Treatment	Mean yield (kg/ha)	Increase in yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Improved practice (Ridges and furrow)	1498	311	15.76	20258	2.80
Farmer's practice (Two harrowing)	1187	-	12.49	14627	2.42

Efficient energy use and management

Sowing of *rabi* sorghum with improved bullock drawn CRIDA planter gave higher energy output and net return than the farmers' practice. Total energy requirement for sowing of sorghum with bullock drawn CRIDA planter was less (16875 MJ/ha) than sowing with farmers' practice (18215 MJ/ha). Total energy output was higher with bullock drawn CRIDA planter i.e. 22106 MJ/ha compared to farmers, practice (two bowl ferti-seed drill) (21210 MJ/ha). With the improved implement, grain yield of sorghum was increased by 40.72% as compared to farmers' practice (Table-230).

Table-230: Performance of improved bullock drawn CRIDA planter in *rabi* sorghum

Name of the implement	Energy input (MJ/ha)	Energy output (MJ/ha)	Grain yield (kg/ha)	Increase in yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Improved (Bullock drawn CRIDA planter)	16875	22106	1365	405	2.05	14270	1.98
Local (Two bowl ferti seed drill)	18215	21210	970	-	1.45	6170	1.43

On-farm experiments

Village profile

The program is being implemented by AICRPDA centre, Solapur in Narotiwadi village, North Solapur Tehsil in Solapur district. The total cultivated area is 560.7 ha out of which 450 ha is rainfed. The mean annual rainfall is 734.2 mm with seasonal rainfall of 535 mm during *kharif* (June-September). The major soil types are sandy loam, loam and clay loam. The major rainfed crops in *kharif* are sunflower, pigeonpea and blackgram, and sorghum and chickpea in *rabi* season. The number of small, marginal, medium and large farmers are 52, 122, 86 and 22, respectively. The ground water table is 15 to 18 m. The source of irrigation is open dug wells and bore wells covering 15-19% of cultivated area.

Climate Vulnerability in General

The climate of this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 637 mm, the south-west monsoon contributes 80% and north-east monsoon contributes 20%. The historical rainfall data (30 years) indicates that the variability in rainfall during south-west monsoon was 12% deficit of the average rainfall. The onset (south-west) of monsoon was during 21 SMW and north- east monsoon was during 40 SMW (October). For the past 15 years, the dry spells during crop season were experienced during August and at flowering stages of the major rainfed crops. The onset of the monsoon is normal. The extreme events like unusual and high intensity rainfall in short span are increasing during *kharif* during 28 SMW (July).

Experienced weather conditions during the year (2013-14)

During 2013, in the Narotiwadi village, onset of monsoon was early by 8 days. A rainfall of 509.65 mm was received which was deficit by 25.4 mm compared to normal (535.1 mm) during south-west monsoon (*kharif*) (Fig.34). During north-east monsoon (October-December), 6.2 mm of rainfall was received which was deficit by 119.4 mm compared to normal (125.6 mm). During summer (March-May), 19.7 mm of rainfall was received which was deficit by 32.9 mm compared to normal (52.6 mm). There were dry spells during 2nd and 3rd week of August coinciding with flowering stage of *kharif* crops.

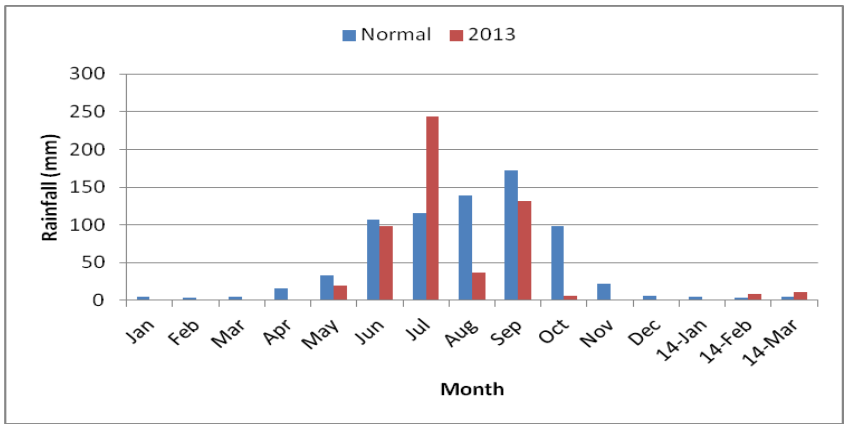


Fig.34: Normal and actual (2013) monthly rainfall at Narotiwadi

Rainwater harvesting (*in-situ* and *ex-situ*) and recycling

A study of runoff, storage and recycling was conducted during the year 2013. During the year 2013, rainfall received was 554.75 mm in 38 rainy days which was deficit by 179.45 mm compared to normal of 734.2 mm. There was no runoff producing storm, and hence there was no runoff harvested in the farm pond.

In-situ moisture conservation to overcome dry spells with improved practice i.e. compartmental bunding enhanced the crop yield of *rabi* sorghum by 29.81% compared to farmers practice (Table-231). During the season, only 6.2 mm rainfall was received during October while there was no rainfall during November and December months.

Table-231: Performance of *rabi* sorghum to compartmental bunding

Mean yield (kg/ha)		Increased in yield (%)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Improved practice (Compartment bund)	Farmers' practice (Two harrowing)				
1071	825	29.81	7991	2.55	11.28

Similarly, the ridge and furrow system facilitated the drainage during intense rainfall events in September resulting in better performance of *rabi* sorghum and there was an increased in yield by 21.74% compared to farmers' practice (Table-232).

Table-232: Performance of *rabi* sorghum under ridges and furrows method of planting

Mean yield (kg/ha)		Increased in yield (%)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Improved practice (Ridges and furrows)	Farmer's practice (Two harrowing)				
1572	1291	21.74	21812	2.94	16.54

Ridges & furrow method of *in-situ* moisture conservation

Compartment bund method of *in-situ* moisture conservation

Rabi sorghum grown on receding soil moisture

Crops/varieties/cropping systems

During *kharif* 2013, a rainfall of 509.65 mm was received which was deficit by 25.4 mm compared to normal (535.1 mm) during south-west monsoon (*kharif*). The rainfall was deficit by 8% in June, 74% in August and 24% in September but excess in July by 110%. Pigeonpea + sunflower (1:2) intercropping system was introduced on 14 farmers' fields under real time rainfall situation to cope with the climate variability. Results revealed that pigeonpea equivalent yield (1121 kg/ha) and LER (1.25) were higher in improved package of practices. The per cent increase in pigeonpea yield was 20.54% in improved package of practices over farmers practice while it was 32.93% in sunflower yield (Table-233).

Table--233: Performance of intercropping systems for contingent crop planning during *kharif* (2013)

Intercropping system	Yield (kg/ha)				Cost of cultivation (Rs/ha)		Net return (Rs/ha)		B:C Ratio		Pigeonpea equivalent yield (kg/ha)	LER
	Main crop		Inter crop									
	IT	FP	IT	FP	IT	FP	IT	FP	IT	FP		
Pigeonpea (Vipula) + Sunflower (Bhanu) (2:1)	616	511	553	416	17175	15442	26487	19457	2.54	2.25	1121	1.25

IP: Improved technology, FP: Farmers practice

Real time contingency crop planning

Under this component, the improved package of practices of pigeonpea, sunflower, blackgram, pearlmillet and chickpea were introduced under real time rainfall situation to cope with the weather variability. A rainfall of 509.65 mm was received which was deficit by 25.4 mm compared to normal (535.1 mm) during south-west monsoon (*kharif*) whereas during north-east monsoon (October-December), 6.2 mm of rainfall was received which was deficit by 119.4 mm compared to normal (125.6 mm). The improved varieties gave yield of 1308 kg/ha in pigeonpea, 705 kg/ha in sunflower, 703 kg/ha in blackgram, 1193 kg/ha in pearl millet and 1046 kg/ha in chickpea with B:C ratio of 3.33, 1.46, 3.29, 1.72 and 2.09, respectively (Table-234).

Table-234: Performance of crops under improved package of practices during *kharif* 2013

Crop	Variety	Mean yield (kg/ha)		Increased in yield (%)	Net returns (Rs/ha)	B:C ratio
		Improved variety	Local variety			
Pigeonpea	Vipula	1308	1187	15.44	39375	3.33
Sunflower	Bhanu	705	593	18.88	6850	1.46
Blackgram	TPU-4	703	506	39.93	21060	3.29
Pearlmillet	Shanti	1193	887	34.49	6578	1.72
Chickpea	Vijay	1046	909	31.40	19128	2.09

Field view of blackgram (cv. TPU-4)

Field view of pearlmillet (Shanti)

During *rabi* 2013 (October-December), 6.2 mm of rainfall was received which was deficit by 119.4 mm compared to normal (125.6 mm). Further, no rainfall was received during November, December and January months. Four varieties of sorghum were introduced on-farm to cope up with rainfall variability of the region. The varieties (Revati, Vasudha, Anuradha, Suchitra) produced maximum yield of 1010, 1316, 1196 and 1712 kg/ha with improved technology as compared to farmers practice, respectively. The maximum gross return, net return and B:C ratio were also recorded under improved technology as compared to farmers' practice in case of all four varieties. The per cent increase in yield with improved technology was 15.29, 10.74, 21.66 and 10.45% over farmers' practice with sorghum varieties Revati, Vasudha, Anuradha and Suchitra, respectively (Table-235). Among the four varieties, Suchitra gave higher grain yield (1712 kg/ha) compared to other varieties.

Table-235: Performance of sorghum under real time contingent crop planning during *rabi* (2013-14)

Crop/ Variety	Yield (kg/ha)		Gross return (Rs/ha)		Net return (Rs/ha)		B:C Ratio		% increase over FP
	IT	FP	IT	FP	IT	FP	IT	FP	
Sorghum (Revati)	1010	876	25250	21900	10570	8260	1.72	1.60	15.29
Sorghum (Vasudha)	1316	1188	32516	29722	17656	15211	2.14	2.048	10.74
Sorghum (Anuradha)	1196	983	29900	24575	14666	10263	1.96	1.71	21.66
Sorghum (Suchitra)	1712	1550	42812	38750	27576	24417	2.81	2.70	10.45

IP: Improved technology, FP: Farmers practice

Efficient energy use and management

As per the demand of the farmers, the improved implements for primary tillage, sowing and weeding were provided through custom hiring centre. Custom hiring services have significantly contributed to alleviate labour shortage during peak demand period. The farm implement made available at the custom hiring centres are listed below (Table-236).

Table-236: Improved implements made available at custom hiring centre

Name	Number
Tractor operated four blade Baliram plough with harrows	1
Cultivator 9 teeth and 5 teeth	1
Two way M.B. Plough	1
Baliram Plough - 12" (Bullock drawn) with wooden handle and wooden beam	3
Cycle Hoe	05
Laxmi sickle	25
CRIDA 9 row tractor drawn seed cum fertilizer planter along with four sets of metering plates	1
CRIDA 4 row Bullock Drawn seed cum fertilizer planter with major crop metering plates	1
CRIDA 3 row Bullock drawn seed cum fertilizer planter with major crop metering plates	1
Total	**39**

Tractor drawn seed drill cum fertilizer


Bullock drawn seed drill at Village Narotewadi during 2013-14

Alternate land use for carbon sequestration and ecosystem services

Horti-pasture systems were demonstrated on farmes's fields. Among different introduced grasses, Phule Jaywant gave maximum yield, gross returns and B:C ratio as compared to other grasses. The mean yield, gross return, net return and B:C ratio were 2711 bundles, Rs.43781/ha, Rs.19321/ha and 1.81, respectively (Table-237).

Table-237: Performance of grasses on farmers' fields

Farmer name	Crop	Yield (grass leaf bundles No.)	Expenditure incurred (Rs/ha)	Net return (Rs/ha)	B:C ratio
Jananrdhan Eknath Umbare	Phule Jaywant	2766	18938	26842	2.41
	Stylo	2875	35293	35025	1.99
	Madras Anjan	2473	17722	10851	1.61
Baban Manohar Patil	Phule Jaywant	2978	22970	24342	2.05
	Madras Anjan	2564	33811	24958	1.73
Laxman Dharmanna Durlekar	Phule Jaywant	2688	19726	15689	1.79
	Marvel	2722	25938	24380	1.93
	Madras Anjan	2487	34293	21487	1.62
Shrihari Ganpat Kolekar	Phule Jaywant	3100	30722	29596	1.96
	Stylo	2551	16945	21628	2.27
	Madras Anjan	2436	16845	11514	1.68
Abhimayu Chandrahar Umbare	Phule Jaywant	2788	17970	7942	1.44
	Phule Gowardhan	2975	33811	3501	1.10
	Madras Anjan	2544	17455	12745	1.73
	Mean	**2711**	**24460**	**19321**	**1.81**

Field view of Phule Jaywant Grass

Plantation of horticultural crops on farmers' fields

1.5.3. JHANSI

a. Agro-ecological setting

Jhansi is located in Bundelkand uplands (AESR 4.4) and Bundelkand agro-climatic zone in Uttar Pradesh. The climate is hot, moist semi-arid.

b. On-station experiments - Nil

c. On-farm experiments

Village profile

The program isbeing implemented in Kadesara Kalan village, Talbehat BlockTehsil of Lalitpur district. The general topography is undulating to gentle sloping plain. The total cultivated area is 875.1 ha out of which 292.64 ha is rainfed. The mean annual rainfall is 1022 mm with seasonal rainfall of 684.7 mm during *kharif* (June-September. The major soil types are loamy sand, sandy loam and sandy clay loam. The major rainfed crops during *kharif* are groundnut, sesame and blackgram and wheat, chickpea and mustard during *rabi* season. The source of irrigation is ground level pumpset covering 45% of cultivated area.

Climate Vulnerability in General

In general, the climate in this agro-climatic zone is semi-arid. The south-west monsoon contributes 82.39%, north-east monsoon contributes 7.75% and summer contributes 0.5% of the total annual rainfall of 906.5 mm. The major climatic vulnerabilities of the region are delayed onset of monsoon, intermittent dry spells of >10 days, excess runoff causing moisture stress during reproductive phase of rabi crops, terminal heat causing reduced maturity period in wheat, terminal drought at grain filling stage of wheat and migration of farmers/ labours from village after March-April in search of employment. For the past 15 years, the dry spells during crop season had been experienced, during August & September and at varying growth stages of the major rainfed crops. The onset of monsoon has shifted (27th SMW) in July. The soil moisture status was deficit during (pod filling in *kharif* crops, germination to harvesting in *rabi* crops depending on rainfall) stages of major rainfed crops. The maximum/ minimum temperature during crop season was Tmax (*kharif*) = 33.60C, Tmin (*kharif*) = 23.90C; & Tmax (*rabi)* = 28.70C; Tmin (*rabi*) = 10.50C in the past 10 years. The extreme events like unusual and high intensity rainfall in short span were increasing during *kharif* and *rabi* seasons. The region was also experiencing other extreme events like cold waves. There has been a considerable shift in rainfall pattern and amount has been decreasing at the rate of 2.0 mm/year during *kharif* season in the sowing window of the dominant rainfed crops.

Experienced weather conditions during the year (2013-14)

During 2013, in Kadesara kala village a rainfall of 1353.7 mm was received which was excess by 586.8 mm compared to normal (766.9 mm) during south-west monsoon (*kharif).* During north-east monsoon (October to December), 127.4 mm rainfall was received which was excess by 83 mm compared to normal (44.4 mm). During summer, 8.3 mm rainfall was received which was deficit by 22.6 mm compared to normal (30.9 mm) (Fig.35).

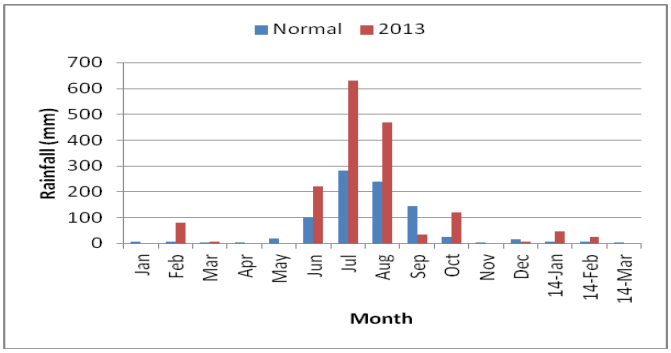


Fig.35: Normal and actual (2013) monthly rainfall at Kadesara Kalan

Interventions:

The major on-farm interventions included demonstration of crops or varieties or cropping system, timely operations through custom hiring centre and alternate land use and ecosystem services.

Real time contingency crop planning

During *kharif* and *rabi* 2013, the drought tolerant varieties/hybrids of blackgram, paddy, wheat, chickpea, berseem and oat were introduced to cope with the rainfall variability. During *kharif*, there was excess rainfall by 43.34%. The excess rainfall reduced the growth and productivity of groundnut and sesame severely. Due to above reason the production of both the crops was not up to the mark.

Evaluation of drought tolerant varieties/hybrids of different crops

During *kharif* 2013, a rainfall of 1353.7 mm was received which was excess by 586.8 mm compared to normal (766.9 mm) during south-west monsoon. The rainfall was excess by 118% in June, 125% in July and 95% in August but was deficit by 77% in September. Among the three varieties of blackgram, Shekhar-3 performed best yielding 1094 kg/ha grain and 2124 kg/ha stover, on average basis, which was marginally better than Uttara (1085 kg/ha grain and 2365 kg/ha stover) (Table-238).

Table-238: Performance of improved varieties of blackgram

Variety	Yield (kg/ha)		Harvest Index (%)	RWUE (kg/ha-mm)	GMR (Rs/ha)
	Grain	Stover			
Uttra	1085	2365	31.45	0.85	49020
Shekhar-3	1094	2124	34.00	0.86	49166
Azad-2	986	2186	31.07	0.77	44570
Local variety	720	2175	24.87	0.57	33135

Paddy variety NDR-97 was introduced in the partially submerged area of check dam. As evident from the meteorological data this year was high rainfall year i.e. during *kharif* season, 1353.7 mm rainfall was received which was excess by 586.8 mm compared to normal (766.9 mm). Paddy (NDR-97) performed well with grain yield of 3921 to 4345 kg/ha. The average yield across different farmers' fields was 4160 kg/ha grains and 5887 kg/ha straw. The crop recorded RWUE of 3.27 kg/ha-mm with gross return of Rs. 105730/ha (Table-239).

During *rabi* season, 127.4 mm rainfall was received which was excess by 83 mm compared to normal (44.4 mm) and hence the introduced varieties of wheat, gram, mustard, berseem and oat performed well. The rainfall was excess by 379% in October but there was no rainfall during November followed by deficit rainfall (48.5%) in December.

The Harshita (HI-1531) and Amrita (HI-1500) varieties of wheat were introduced which are suitable for limited water availability situation, requires two irrigations during the growing period. Amrita (HI-1500) variety recorded 3450 and 4375 kg/ha of grain and straw yield, respectively whereas, Harshita (HI-1531) recorded 3325 and 5016 kg/ha of grain and straw yield, respectively as compared to local variety. The per cent yield increased was 7.81 and 3.76% by Amrita (HI-1500) and Harshita (HI-1531), respectively as compared to local variety (Table-240).

Table-240: Performance of less water requiring wheat varieties

Variety	Yield (kg/ha)		Harvest Index (%)	GMR (Rs/ha)
	Grain	Straw		
Harshita (HI-1531)	3325	5016	39.86	63232
Amrita (HI-1500)	3450	4375	44.09	63950
Local variety	3200	5517	36.71	62234

With the construction of the check dam, the quantity and duration of the water availability improved considerably in the village particularly in the vicinity of the check dam and downstream farms. To harness the benefits of improved water availability, four high yielding varieties of wheat namely Raj-3765, Purna (HI-1544), Pusha Bahar (HD-2987) and Naveen Chandausi (HI-1418) were introduced. Among varieties, Naveen Chandausi (HI-1418) recorded higher grain (4280 kg/ha) and straw yield (6130 kg/ha) followed by Raj-3765 (4260 kg/ha grain and 5320 kg/ha straw yield). The per cent yield increase was 33.75, 33.12, 17.71 and 11.96% by Naveen Chandousi (HI-1418), Raj 3765, Pusha Bahar (HD-2987) and Purna (HI-1544), respectively over control (local variety) (Table-241).

Table-241: Performance of high yielding wheat varieties

Variety	Yield (kg/ha)		Harvest Index (%)	GMR (Rs/ha)
	Grain	Straw		
Raj 3765	4260	5320	44.47	78801
Naveen Chandousi (HI-1418)	4280	6130	41.12	80747
Purna (HI-1544)	3583	5583	39.09	68500
Pusha Bahar (HD-2987)	3767	5150	42.24	70567
Local variety	3200	5517	36.71	62234

Unnat Halna variety of wheat was introduced for the farmer growing short duration variety Arkel of vegetable pea. The wheat variety matured in 85 to 90 days and gave gain yield of 4825 kg/ha and 5275 kg/ha of straw yield with gross return of Rs.87750/ha as compared to local variety. The per cent increase in grain yield by improved variety was 33.7% over local variety (Table-242).

Table-242: Performance of late wheat variety (Unnat Halna)

Variety	Yield (kg/ha)		Harvest index (%)	GMR (Rs/ha)
	Grain	Straw		
Unnat Halna	4825	5275	47.77	87750
Local variety	3200	5517	36.71	62234

In chickpea cv. Avarodhi gave seed yield of 993 kg/ha with rainwater use efficiency of 12.17 kg/ha-mm and Rs.32273/ha of gross return. The per cent increase in yield was 32.4% by Avarodhi over local variety. In general, the chickpea yields were less due to absence of rainfall during November and about 48.5%deficit rainfall during December (Table-243.).

Table-243: Performance of chickpea (Avarodhi variety)

Variety	Yield (kg/ha)		Harvest index	GMR (Rs/ha)
Crop/variety	Grain	Stover		
Chickpea cv. Avarodhi	993	1733	36.43	32273
Local variety	750	1100	40.54	23950

Berseem variety BB-3 was introduced in 25 farmers' fields. This year the stakeholders exhibited increasing interest in berseem crop due to flexibility in cutting stage, interval and duration. The economic product yield (green fodder yield) ranged between 45600 and 65400 kg/ha in comparison to (41700 kg/ha). The crop recorded an average increase of 18.9% over local variety. The RWUE ranged between 50.6 to 80.0 kg green fodder/ha-mm.

Oat variety JHO-99-1 was introduced in 12 farmers' fields. The economic product yield (green fodder yield) ranged between 31700 and 36700 kg/ha in comparison to local variety (29100 kg/ha). The crop recorded yield increase of 15.9% over local variety. The RWUE ranged between 30.8 to 40.4 kg green fodder/ha-mm.

Efficient energy use and management

The improved implements viz; diesel pumpset, seed drill, leveler, disc plough, rotavator, cultivator, sprayer, power sprayer and decorticator gave higher output energy and crop yield compared to normal implements. Custom hiring services have significantly contributed to alleviate labour shortage during peak demand period.

Alternate land use and eco-system services

Agri-horti pasture system was established in the field of four farmers' sites. The establishment and maintenance was successful at all the sites. The survival was better in guava (100%) followed by aonla and citrus The growth performance of different fruit species also showed the same trend. Due continuous rain, Shri Lakhan Singh could not transplant the grass species during this year. He has used bund for transplanting of guinea grass, Hybrid Napier and Cenchrus for forage production and produced 2.3 t DM/ha from bund. Mr. Siddique has one year's established pasture. He has received Rs.11050 from sale of 17000 slips @ Rs.0.65/ rooted slips. From remaining field he has taken three cuts from guinea and produced 7.5 t DM/ha and two cuts from *Stylosanthes seabrana* gave 4.2 t DM/ha. The rejuvenation of old *desi* ber plantation through budding with improved cultivars *viz*., Gola, Banarasi, Karaka and Umran was carried out.

1.6. SOYBEAN PRODUCTION SYSTEM

1.6.1. INDORE

a. Agro-ecological setting

The Indore center is located in Central highlands (Malwa) Gujarat plain Kathiawar peninsula semi- arid ecoregion (AESR 5.1) and Malwa plateau in Madhya Pradesh. The climate is hot dry semi-arid, annual rainfall is 944 mm.

b. On-station experiments

During 2013, annual rainfall of 1532.7 mm was received which was excess by 678.2 mm compared to normal (854.5 mm) (Fig.36) during south-west monsoon (*kharif).* During north-east monsoon (October - December), 109.8 mm rainfall was received which was excess by 45.3 mm compared to normal (64.5 mm). During summer, 7.75 mm rainfall was received which was deficit by 22.9 mm compared to normal (30.6 mm). There was dry spell during 1-20 September coinciding with reproductive stages of *kharif* crops.

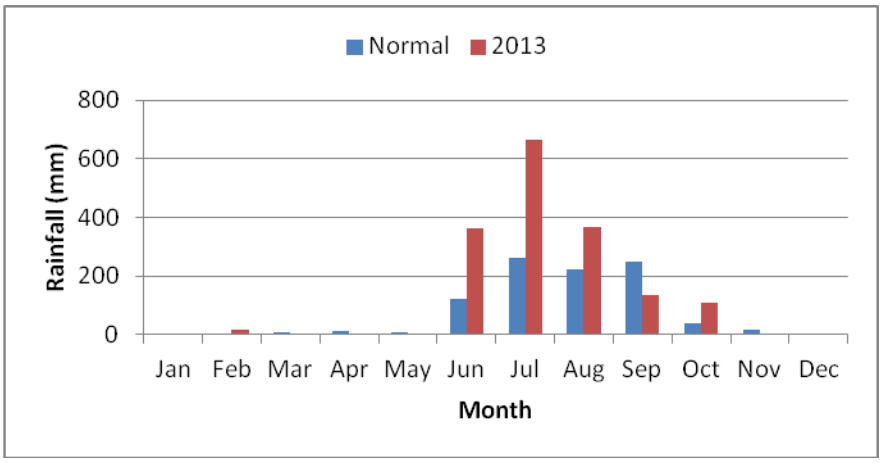


Fig.36: Normal and actual (2013) monthly rainfall at Indore

Real time contingency crop planning

The rainfall during June, July and August months was excess by 200%, 155.5% and 63.1% whereas September month was deficit by 45% compared to normal. One dry spell occurred during 1st - 20th September coinciding with podding and seed development stage of the crops. Seven high intensity rains occurred during crop growth period 23, 26, 27, 30, 31, 34 and 38 SMW (128, 150, 299, 198, 126, 187 and 120 mm, respectively). Under contingent crop planning, molybdenum was evaluated as seed treatment and foliar spray as a midseason correction measure to both soybean and chickpea in soybean – chickpea double cropping system. The seed treated with Mo @ 1 gm/kg gave highest seed yield of soybean (426 kg/ha) and chickpea (1141 kg/ha) with soybean equivalent yield of 1948 kg/ha while 2 foliar sprays of molybdenum @ 0.1% to soybean gave 412 kg/ha and chickpea gave 1096 kg/ha with SEY of 1794 kg/ha. The higher NMR (Rs.31939/ha) and B:C ratio (2.21) were obtained with seed treatment (Table-244).

Table-244: Foliar sprayof molybdenum on soybean (JS-95-60) and succeeding chickpea (JAKI –9218) for contingent crop planning

Treatment	Seed yield (kg/ha)		% increase in yield		SEY (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Soybean	Chickpea	Soybean	Chickpea				
Seed treated with Mo @ 1 gm/kg seed	426	1141	6.76	20.86	1948	26500	31939	2.21
Foliar application of Mo to soybean @ 0.1% 2 sprays	412	1036	3.25	9.74	1794	26500	27313	2.03
Untreated	399	944	-	-	1658	26500	23241	1.88

During *rabi* season, rainfall in October month was excess by 171.0%, whereas the rainfall during November and December months was deficit by 100, 66.2%, respectively compared to normal rainfall. The polythene mulching in soybean (cv.RVS 2001-04) and chickpea (cv.Jaki-9128) recorded higher seed yield of 1136 kg/ha and 839 kg/ha, respectively and the increase in yield was 9.67% in case of chickpea and 4.5% in case of soybean over no mulching. Further, poly-mulching gave higher NMR and B:C ratio in both soybean (Rs.25253 and 2.74) chickpea (Rs. 24525 and 2.82) (Table-245).

Table-245: Evaluation of polythene mulch for contingent crop planning

Treatment	Seed yield (kg/ha)	% increase in yield	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Soybean (RVS -2001-04)					
Polythene mulch	1136	4.5	14500	25253	2.74
No mulch	1086	-	13500	24525	2.82
Chickpea (Jaki-9128)					
Polythene mulch	839	9.67	13500	15881	2.176
No mulch	765	-	13500	13289	1.984

Different intercropping systems were evaluated for their performance under recommended fertilizer management of the region. Among different intercropping systems, maximum soybean equivalent yield of 2075 kg/ha, with net returns of Rs. 47794/ha and B:C ratio of 4.30 were attained by soybean (JS- 95-60) + pigeonpea (C-11) (4:2 row ratio) with the application of DAP @ 125 kg/ha followed by soybean (JS- 95-60) + pigeonpea (C-11) (4 :2 with IFFCO (20:16:0:13 kg NPKS/ha). The yield increased by 33.7 and 22.1% of DAP @ 125 kg/ha and IFFCO (20:16:0:13 kg NPKS/ha), respectively as compared to control. Soybean (JS-95-60) + maize (NK-6240) (4 :2 row ratio) with IFFCO (20:16:0:13 kg NPKS/ha) gave highest soybean equivalent yield of 1047 kg/ha, with net returns of Rs. 16922/ha and B:C ratio of 2.17 with the increase in yield by22.7% as compared to control (Table-246).

Table-246: Performance of intercropping systems for contingent crop planning

Treatment	Seed yield kg/ha	SEY kg/ha	Net return Rs/ha	B:C ratio
Soybean (JS- 95-60) + pigeon pea (C-11) (4 :2)				
DAP@ 125 kg/ha				
Soybean	432	2075	47794	4.30
Pigeonpea	987	-	-	-
20:16:0:13 kg NPKS/ha)				
Soybean	430	1766	38467	3.65
Pigeonpea	801	-	-	-
Control	409	1375	26751	2.84
Soybean (JS-95-60) + maize (NK-6240) (4 :2)				
DAP 125 kg/ha				

Soybean	420	971	14640	2.01
Maize	1103	-	-	-
20:16:0:13 kg NPKS/ha)				
Soybean	434	1047	16922	2.17
Maize	1227	-	-	-
Control	388	830	10399	1.72

Contingent crops planning

Under delayed onset of monsoon conditions, six *kharif* crops were tested with some prominent varieties *viz.*, maize (NK 6240 and Hy. 555-pionear Co.), soybean (JS 95-60), guar (HG 563), kidney bean (muth) (Local), horse gram (BK-1) and ragi (Local). Among these *kharif* crops, maize (Hy. 555 -pionear Co.) gave maximum seed yield of (1771 kg/ha) with net returns Rs.11062/ha and B:C ratio of 1.71 followed by maize (NK 6240) and horsegram (BK-1). Ragi (local) recorded the lowest yield of (134 kg/ha) with negative net returns of Rs.8965/ha and B:C ratio of 0.31 (Table-247).

Table-247: Evaluation of *Kharif* crops under delayed onset of monsoon conditions

Treatment	Seed (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Maize NK 6240	1412	21180	5680	1.37
Maize (Hy. 555 -pionear Co.)	1771	26562	11062	1.71
Soybean (JS 95-60)	257	7708	-6792	0.53
Guar (HG 563)	141	7060	-3940	0.64
Kidney bean (Muth) (Local)	150	9028	-1972	0.82
Horse gram (Kulthi) - (BK-1)	301	12037	1037	1.09
Ragi (Local)	134	4035	-8965	0.31

The rainfall during June, July and August months was excess by 200%, 155.5%, 63.1% whereas September month was deficit by 45% compared to normal. During *rabi* season rainfall in October month was excess by 171.0%, whereas the rainfall during November and December months was deficit by 100 and 66.2%, respectively compared to normal rainfall. One dry spell occurred during 1st - 20th September (podding and seed development stage). Seven high intensity rains occur during 23, 26, 27, 30, 31, 34 and 38 SMW (128, 150, 299, 198, 126, 187 and 120 mm, respectively). Contingent crop production practices under aberrant weather or delayed onset of monsoon condition under three sets of *kharif* crops were evaluated *viz.*, set-I crops: soybean (JS 95-60), sunflower (Moden), sesame (TKG-22), kulthi (local), maize (NK-6240), greengram (local) and urd (JU-89), Set-II crops: okra (Ankur-40), castor (Vestern-6), bajra (RVS-VH-23), mustard (JT-1), toria (RVM-2) and onion (Red bol)), Set-III crops chickpea (JG-16), mustard (RVM-2), chickpea (JG-130), toria (JT-1) and safflower (JSF-99). Among set-I crops, maize (NK-6240) gave the highest yield (1946 kg/ha) with the net returns of Rs. 13690/ha and B:C ratio of 1.88. In set-II, onion gave highest yield (5282 kg/ha) with the net returns of Rs. 20256/ha and B:C ratio of 1.92, and set-III, safflower (JSF-99) gave maximum yield (701 kg/ha) with the net returns of Rs. 20528/ha and B:C ratio of 2.42. (Table-248).

Table-248: Evaluation of contingent crop production practices under aberrant weather or delayed onset of monsoon condition

Crop	Variety	Seed yield (kg/ha)	Cultivation cost (Rs/ha)	Net return (Rs/ha)	B:C ratio
SET I *Kharif*-2013					
Soybean	JS 95-60	259	14500	-6744	0.53
Sunflower	Moden	275	14500	-739	0.95
Sesame	TKG-22	11	13000	-12222	0.06
Kulthi	Local	14	11000	-10583	0.04
Maize	NK-6240	1946	15500	13690	1.88
Greengram	Local	19	11000	-9832	0.11
Urd	JU-89	17	11000	-9999	0.09
Sowing date	11.08.2013				

SET II *Kharif*- 2013					
Okra	Ankur-40	389	25000	-17216	0.31
Caster	Vestern-6	667	14500	38876	3.68
Bajra	RVS-VH-23	751	11000	4012	1.36
Mustard	JT-1	234	11000	7682	1.70
Toria	RVM-2	183	11000	3678	1.33
Onion	Red bol	5282	22000	20256	1.92
Sowing date	31.08.2013				
SET III - 2013-2014					
Chick pea	JG-16	584	12000	11352	1.95
Mustard	RVM-2	183	11000	3678	1.33
Chickpea	JG-130	634	12000	13354	2.11
Toria	JT-1	167	11000	2344	1.21
Safflower	JSF-99	701	14500	20528	2.42
Sowing date :	03.10.2013				

One dry spell occurred during 1st - 20th September during pod and seed development stage sof the crop. Under contingent crop planning with aberrant monsoon to combat the abiotic stress, the effect of spraying of VAMC 50% SL @ 3.75 l/ha potassium solution @ 2% and thiourea @ 250 g/ha at the reproductive stage of the crop were studied on four crops *viz.*, soybean, maize, blackgram, and horsegram. The spraying of VAM-C 50% SL @ 3.75 l/ha recorded significantly higher seed yield, followed by spraying of potassium solution @ 2% as compared to the control *i.e.*, without spray. Spray of VAM-C 50% SL @ 3.75 l/ha on soybean, maize, blackgram and horsegram recorded 42.2, 19.8, 27.9 and 33.2% higher seed yield, respectively over control (no spray) (Table-249).

Table-249: Performance of rainfed *kharif* crops with foliar spray under aberrant monsoon situation

Treatment	Soybean (JS 95-60)	Maize (HQPM-1)	Blackgram (JU- 86)	Horsegram (HG 563)	Mean
Seed yield (kg/ha)					
Spray of VAM-C 50 % SL @ 375 ml/ha	737	3054	519	494	1201
Spray of potassium Solution @ 2%	564	2635	382	407	997
Spray of thiourea @ 250 g/ha	524	2607	379	388	975
Polythene mulch	628	3041	390	448	1127
Control	426	2449	374	330	895
Mean	576	2757	409	414	
Soybean equivalent yield (kg/ha)					
Spray of VAM-C 50 % SL @ 375 ml/ha	737	1527	1038	989	1073
Spray of potassium solution @ 2%	564	1317	763	814	865
Spray of thiourea @ 250 g/ha	524	1304	758	777	841
Polythene mulch	628	1521	780	896	956
Control	426	1224	747	660	764
Mean	576	1379	817	827	
Net return (Rs/ha)					
Spray of VAM-C 50 % SL @ 375 ml/ha	4713	30918	16239	14779	16662
Spray of potasium solution @ 2%	2049	27164	10538	12065	12954
Spray of thiourea @ 250 g/ha	691	26588	10225	10785	12072
Polythene mulch	1340	30619	8408	11873	13060
Control	1278	27734	13419	10787	13305
Mean	2014	28605	11766	12058	

B:C ratio					
Spray of VAM-C 50 % SL @ 375 ml/ha	1.27	3.08	2.09	1.99	2.11
Spray of potasium solution @ 2%	1.14	3.20	1.85	1.98	2.04
Spray of thiourea @ 250 g/ha	1.05	3.12	1.82	1.86	1.96
Polythene mulch	1.08	3.04	1.56	1.79	1.87
Control	1.11	4.08	2.49	2.20	2.47
Mean	1.13	3.30	1.96	1.96	

During *rabi* season, rainfall in October month was excess by 171.0%, whereas the rainfall during November and December months was deficit by 100 and 66.2%, respectively compared to normal rainfall. Different surfactants were demonstrated for coping with dry spells in chickpea. APSA–80 and Sampoo being statistically at par were superior as compared with control in terms of seed yield (kg/ha) and rainwater use efficiency (RWUE). Among the surfactants APSA–80 gave highest seed yield of 1624 kg/ha, 43% harvest index and 7.85 kg/ha-mm of RWUE followed by 1482, 42% and 7.16 with *Sampoo* and the lowest yield of 1209 kg/ha was found under control. The highest net return of 49266/ha and B:C ratio of 4.65 was provided by APSA-80 followed by Sampoo (45231/ha and 4.02). The lowest net returns of Rs. 35205/ha and 3.84 B:C ratio was recorded in control. The increase in yield was 25.6 and 18.5% by APSA-80 and Sampoo, respectively as compared to control (Table-250).

Table -250: Performance of surfactants on *rabi* chickpea

Surfactant	**Yield (kg/ha)**	**Harvest index (%)**	**RWUE (kg/ha-mm)**	**Cost of cultivation Rs/ha)**	**Net returns (Rs/ha)**	**B:C ratio**
APSA 80	1624.1	42.95	7.85	13500	49266	4.65
Sampoo	1482.9	41.55	7.16	12700	45231	4.02
Control	1208.8	40.45	5.84	12400	35205	3.84

Total 207 mm rainfall was received during crop season

Alternate land use system

To develop climate resilient alternative cropping systems, custard apple, guava, aonla, ber, drumstick and phalsa based agri-horti systems were introduced to educate farmers' that climate change is needed to be tackled with both short-term and long-term strategies. For crop diversification and higher returns, the rainfed crops viz., soybean, chickpea and soybean + pigeonpea (4:2) intercropping systems were introduced in the agri-horti systems. During 2013-14, the highest fruit yield was recorded by aonla (1312 kg/ha) with gross returns of Rs.26248/ha followed by guava (309 kg/ha and Rs.6175/ha) and phalsa (124kg/ha and Rs.7411/ha). The total net returns of Rs.44467/ha was received from selling of fruits. Sole pigeonpea recorded the highest soybean equivalent yield 1235kg/ha with net returns Rs. 22536/ha and soybean + pigeonpea (4:2) recorded soybean equivalent yield of 738 kg/ha and net return of Rs.7653/ha. The farmers are convinced to adopt this system, particularly medium and large farmers due to large land holdings (Table-251).

Table-251: Performance of custard apple, guava, phalsa, drumstick, aonla and ber based agri-horti systems

Crops	**Seed yield (kg/ha) under different systems (2012-13)**						**Mean fruit & seed yield (kg/ha)**
	Custard apple	**Guava**	**Phalsa**	**Drumstick**	**Aonla**	**Ber**	
Soybean – chickpea	218	235	227	220	257	236	232
	812	708	685	694	704	764	728
Soybean + pigeon pea (4:2)	79	93	74	73	69	93	80
	398	407	394	370	384	417	395
Sole pigeonpea	741	694	731	778	713	787	741

Crops	Soybean equivalent yield (kg/ha) under different horti-species						Mean SEY (kg/ha)
	Custard apple	Guava	Phalsa	Drumstick	Aonla	Ber	
Fruit yield	-	-	-	-	-	-	-
Soybean-chickpea	218	235	227	220	257	236	232
	1083	944	914	926	938	1018	971
Soybean + pigeon pea (4:2)	742	772	730	690	710	787	738
Sole pigeon pea	1235	1157	1219	1296	1188	1312	1235
Crops	**Net return (Rs/ha)**						**Mean Net return (/ha)**
	Custard apple	**Guava**	**Phalsa**	**Drumstick**	**Aonla**	**Ber**	
Soybean – chickpea	-7972	-7445	-7695	-7889	-6778	-7417	-7533
	17981	13833	12907	13277	13647	16055	14616
Soybean + pigeonpea (4:2)	7768	8648	7398	6198	6796	9110	7653
Sole pigeonpea	22536	20221	22073	24388	21147	24851	22536
Fruit plant /Crops	**B:C ratio**						**Mean B:C ratio**
	Custard apple	**Guava**	**Phalsa**	**Drum stick**	**Aonla**	**Ber**	
Sole soybean	0.45	0.49	0.47	0.46	0.53	0.49	0.48
Chickpea	2.24	1.95	1.89	1.92	1.94	2.11	2.01
Soybean + pigeonpea (4:2)	1.54	1.60	1.51	1.43	1.47	1.63	1.53
Sole pigeonpea	2.55	2.39	2.52	2.68	2.46	2.71	2.55
Fruit plants	**Custard Apple**	**Guava**	**Phalsa**	**Drum stick**	**Aonla**	**Ber**	**Total**
Fruit yield (kg/ha)	154	309	124	-	1312	-	
Gross income (kg/ha)	4632	6175	7411	-	26248	-	44467
Fruit yield eq. to soybean (kg/ha)	154	206	247		875		

C. On-farm experiments

Village profile

The program is being implemented by AICRPDA centre, Indore in Nignoti village, Indore district, Madhya Pradesh. The total cultivated area is 248 ha out of which 100 ha is rainfed. The mean annual rainfall is 954 mm with seasonal rainfall of 857 mm during *kharif* (June - September 2012). The major soil types are medium deep to deep black soils. The major rainfed crops during kharif are soybean, maize, sorghum, and wheat and chickpea during rabi season. The number of small, marginal and large farmers is 65, 47 and 137, respectively. The ground water table is 20 m. The sources of irrigation are open well, bore well, tube well, farm ponds, nallah etc., covering 60% of cultivated area.

Climate Vulnerability in General

In general, the climate in this agro-climatic zone is semi-arid. The south-west monsoon contributes 90–94%, north-east monsoon contributes 3-6% and summer contributes 3-4 % of the total annual average rainfall of 954 mm. The onset (southwest) of monsoon is during 24 SMW. The dry spells during crop season were experienced in September and at seed formation stage of soybean and maize. The onset of monsoon is normal or shifts about 8-10 days i.e., 26 SMW (June end) and the withdrawal is early (37 SMW). The data on normal and actual maximum and minimum temperatures follow the same trend from 19 SMW to 49 SMW. Thereafter, from 50 SMW to 20 SMW the actual values were lower than the corresponding normal values. Thus, the maximum and minimum temperatures have decreased for *rabi* crops. The extreme events like unusual and high intensity rainfall in short span had been

increasing between 22 SMW to 42 SMW with two peaks of more than 250 mm per week during 34 and 35 SMW. Further, there had been three peaks of more than 100 mm per week and these are 28, 30 and 32 SMW during *kharif* and no rains were received during rabi season. The region had been experiencing other extreme events like frost. There were four events of occurrence of frost that was on 14th, 15th, 22nd January and 9th February 2012. There had been considerable shift in the rainfall pattern and sowing window for soybean was from 23 SMW to 25 SMW. For the last eight decades (1930 to 2010), the maximum and minimum temperatures showed increasing trend, while decreasing trend of rainfall was observed for the same period at Indore.

Experienced weather conditions during the year - (2013-14)

During 2013, in Nignoti village, A rainfall of 1491 mm was received which was excess by 633.4 mm compared to normal (857.6 mm) (Fig.37) during south-west monsoon (*kharif).* During north-east monsoon (October-December), 109.2 mm rainfall was received which was excess by 60.2 mm compared to normal (48.2 mm). During summer, 32.5 mm of rainfall was received which was excess by 12.8 mm compared to normal (19.7 mm).

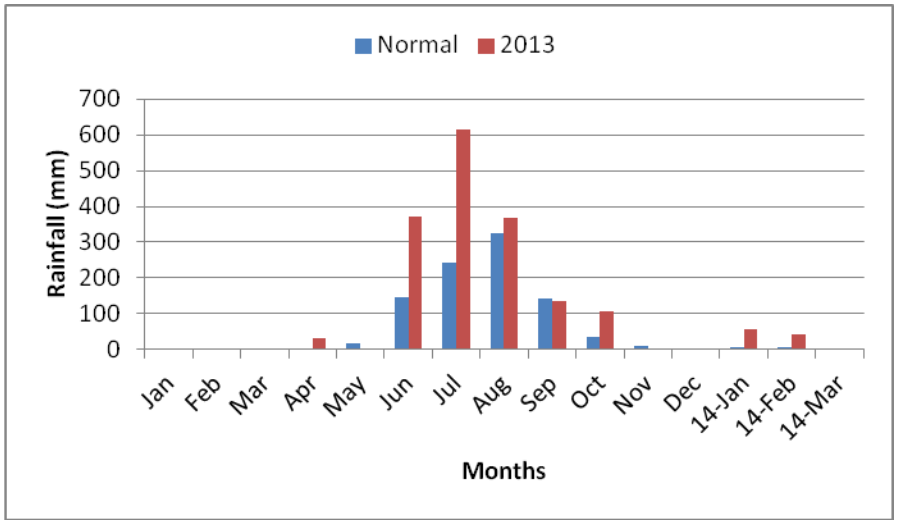


Fig.37: Normal and actual (2013) monthly rainfall at Nignotiwada

Interventions

The major on-farm interventions implemented included land configuration, crops or varieties/ cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 7.1.5 ha in 84 farmers' fields.

Real time contingency crop planning

The rainfall of 1491 mm was received which was excess by 633.4 mm compared to normal (857.6 mm) during south-west monsoon (*kharif*). During north-east monsoon (October-December), 109.2 mm rainfall was received which excess by 60.2 mm was compared to normal 48.2 mm. The rainfall during June, July and August months was excess by 152.7, 152.8 and 12.6% and September month was deficit by 3.5% compared to normal. The drought tolerant varieties of soybean (RVS 2001-04, JS 95-60 and local) during *kharif*, chickpea (Jaki-9218, JG-6, JG-226 and JG-16) and wheat (MP-1203, MP-1201and JW-1215) during *rabi* were introduced to cope up the rainfall variability of the region. The yield increase with soybean varieties was up to 10.8% with the harvest index of 53.06%, RWUE of 0.98 and B:C ratio of 2.76 over the local cultivar. Among soybean varieties, RVS 2001-04 gave maximum yield of 1355 kg/ha while JS 95-60 gave 1273 kg/ha with the crop seasonal rainfall of 1357 mm. During *rabi* season, rainfall in October month was excess by 208.4%, whereas the rainfall during November and December months was deficit by 100, 29.0%, respectively compared to normal rainfall. During rabi, drought tolerant varieties of chickpea and wheat were introduced for risk minimization in view of rainfall variability of the

region. Among 3 chickpea varieties, JG-6 gave maximum yield of 1958 kg/ha with net returns of Rs.50266/ha and B:C ratio of 5.05. Among wheat varieties, MP-1203 was superior with yield of 4494 kg/ha with harvest index of 45.2%, net returns of Rs. 46412/ha and B:C ratio of 3.81 (Table-252).

Table-252: Performance of soybean, chickpea and wheat varieties (mean of 10)

Variety	Yield (kg/ha)	Duration (days)	Harvest index (%)	Net return (Rs/ha)	B:C ratio
Soybean					
RVS 2001-04	1355	108.4	53.06	25554	2.76
JS 95-60	1273	108.4	48.81	23706	2.63
Local	1209	108.4	43.06	24277	3.02
Chickpea					
Jaki-9218	1683	134.8	37.90	41466	4.34
JG-6	1958	134.1	39.64	50266	5.05
JG-226	1467	137.0	38.84	34533	3.78
JG-16	1467	133.8	39.27	34533	3.78
Wheat					
MP-1203	4494	112.6	45.2	46412	3.81
MP-1201	4056	133.2	40.6	40287	3.44
JW-1215	4387	129.4	44.7	44925	3.72

The rainfall during June, July and August months was excess by 152.7,152.8 and 12.6% and September month was deficit by 3.5% compared to normal. Application of molybdenum through seed treatment and foliar application were evaluated against farmers' practice in soybean. The highest average yield of 1307 kg/ha was recorded by ammonium molybdate with the crop seasonal rainfall of 1356.3 mm, RWUE of 0.96 kg/ha-mm, net return of Rs. 24727/ha and 2.70 B:C ratio. The yield increased by 4% as compared to farmers' practice (Table-253).

Table-253: Performance of molybdenum through seed treatment and foliar application on soybean (10 farmers)

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Ammonium molybdate	1307	0.96	24727	2.70
Farmers' practice	1255	0.92	25566	3.11

Nutrient management in wheat and soybean

The improved practice of balanced nutrition (24:64:32 N:P:K kg/ha) recorded 30.1% increase in seed yield over farmers' practice. The improved practice recorded soybean (JS-355) seed yield of 1729 kg/ha, with crop seasonal rainfall of 1360 mm, RWUE of 1.27 kg/ha-mm and B:C ratio of 3.58 as compared to the farmers' practice i.e., (9:23 0 N:P :K kg/ha) through 50 kg/ha DAP exhibited seed yield of 1209 kg/ha, RWUE of 0.88 kg/ha-mm, net return of Rs. 23803/ha and B:C ratio of 2.90 (Table-254).

Table-254: Performance of soybean with balanced nutrition

Treatment	Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Balanced fertilizers (24:64:32 N: P: K kg /ha) through IFFCO (12:32:16)	2001-04	1575	1.16	14500	32760	3.26
	JS-95-60	1516	1.11	14500	30990	3.14
	JS-355	1729	1.27	14500	37391	3.58
Farmers' practice	2001-04	1189.5	0.87	12500	23206	2.85
Farmers' practice (9:23:0 N: P: K kg/ha)	JS-95-60	1232	0.91	12500	26478	2.96
	JS-355	1209	0.88	12500	23803	2.90

During *rabi* season, rainfall in October month was excess by 208.4%, whereas the rainfall during November and December months was deficit by 100 and 29.0 %, respectively compared to normal rainfall. The wheat cv. Purna recorded 11.4% increase in seed yield over farmers' practice with the balanced nutrition (120:64:32 N P:K kg/ha). The improved practice recorded mean seed yield of 4594 kg/ ha with net return of Rs.54703/ha, B:C ratio of 4.30 as compared to the farmers' practice (110 N : 64 P : 0 K) through DAP and urea (Table-255).

Table-255: Performance of wheat cv. purna with balanced nutrition

Intervention	Seed yield (kg/ha)	Net return (Rs/ha)	B:C ratio
Balanced fertilizers (120:64:32 N:P:K kg/ha)	4594	54703	4.30
FP: 110:64:0 N: P: K/ha) through DAP and urea	4070	48094	4.2

Rainwater harvesting *(in situ* and *ex situ)* and its efficient use

A farm pond of size 30m x 24m x 4m (2144 m^3) was dug for efficient rainwater harvesting and recycling. Due to high intensity rainfall events sufficient runoff was generated resulting in filling of farm pond. A rainfall of 1491 mm was received which was excess by 633.4 mm compared to normal (857.6 mm) during south-west monsoon (*kharif).* During north-east monsoon (October-December), 109.2 mm rainfall was received which excess by 60.2 mm was compared to normal 48.2 mm. Potato cultivated through supplementary irrigation under farm pond on 3 farmers' fields gave highest yield of 15200 kg/ha with recommended variety (CHIPSONA-3) with net return of Rs.107000/ha and 3.38 B:C ratio (Table-256).

On-farm experiments were conducted in 5 farmers' fields, for onion cultivation through supplementary irrigation under farm pond. The maximum yield of 10650 kg/ha (var. Red-3) was recorded by recommended varieties with net return of Rs. 81500/ha and 4.3 B:C ratio followed by ALR. The yield increased by 2.8, 22.1% with ALR and Red-3, respectively as compared to control (own seed) (Table-256).

Table-256: Performance of onion through supplemental irrigation under farm pond

Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
ALR	8540	25000	60400	3.4
RED-3	10650	25000	81500	4.3
Own seed	8300	24000	59000	3.5

Efficient energy use and management

The improved implements *viz.*, reversible plough seed drill, power sprayer, knapsack hand sprayer were made available in the custom hiring centre. The improved implements gave higher output energy and crop yield compared to the normal implements. Sowing of wheat with improved seed drill gave higher energy output (59400 MJ/ha) with yield of 4400 kg/ha, net returns of Rs. 53700/ha and B:C ratio of 4.70 (Table-257).

Table-257: Input and output energy ratio and per cent energy use by various agricultural operations

Information	Quantity/ha	Total energy equivalent (MJ/ha)	% of energy use
Inputs			
1. Human labour (hrs)		1019.2	3.02
2. Machinery/ equipment (hrs)			
Primary tillage	tractor 3hr	2646	7.86
Secondary tillage	tractor 2 hr	1764	5.24
Sowing	tractor 3 hr	2646	7.86
Interculture operations	bullock pair 8 hr 3 hr	156.8	0.46
Seed	80 kg	1176	3.49
3. Diesel (litres)	30 litre		

4. Chemical fertilizers (kg)			
Nitrogen (N)	20	1212	3.60
Phosphate (P)	60	66	0.196
Potash (K)	20	134	0.39
Insecticides and weedicides	3.5	420	1.24
Irrigation (m^3)		22400	66.58
Total energy requirement (MJ)		33640	
Outputs			
Crop yield (kg)	4400		
Total energy output (MJ)		59400	
Output-input ratio		1.76	

Establishment of custom-hiring centre

Table-257 : List of implements available, work done and their rent at custom hiring centre

Farmers Name	Name of implement	Charge
Dharmendra Singh (1 ha.)	Deep ploughing with reversible plough	25 Rs/Bigha
Makhan Singh (1ha.)		
Bisankheda (2.5 ha.)		
Lakhan Singh	Seed drill	20 Rs/Bigha
Prakash Singh	Spiral Grader	25 Rs/day
Prakash Singh/Ranjeet Singh	Sprayer	6 Bigha = 60 Rs
Jeevan Singh/ Ranjeet Singh	Sprayer	2 Bigha = 20 Rs

Alternate land use / Farming systems for carbon sequestration and ecosystem services

To develop climate resilient alternative cropping systems, mango and guava seedlings were provided to selected farmers. Further, improved variety of berseem (Vardan) was demonstrated on 13 farmers' fields for enhancing fodder production. The highest green fodder yield of 22500 kg/ha was recorded on Preetam Singh's field followed by 22100 kg/ha by Ishwar Singh with the B:C ratio of 2.56 and 2.50, respectively (Table-258).

Table-258: Performance of berseem (13 farmers)

Farmers' Name	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Preetam Sing Tomar	22500	11000	17125	2.56
Ishwar Sing Mandloi	22100	11000	16500	2.50
Mean (13 farmers)	20000	11000	14000	2.27

1.6.2. REWA

a. Agro-ecological setting

Rewa centre is located in Keymore plateau and Satpura hill zone in Madhya Pradesh.

b. On-station experiments

During 2013, a rainfall of 1221.4 mm was received which was excess by 256.3 mm compared to normal (965.1 mm) during south-west monsoon (*kharif).* During north-east monsoon (October-December), 142.2 mm of rainfall was received which was excess by 92.1 mm compared to normal (50.1 mm). During summer, 46.6 mm of rainfall was received which was excess by 15.6 mm compared to normal (31 mm) (Fig.38).

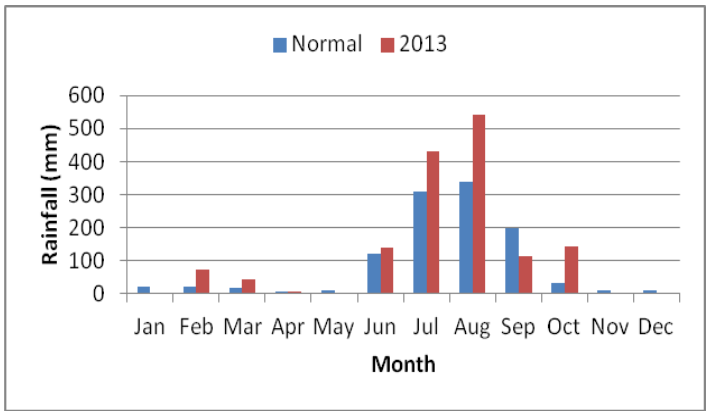


Fig.38: Normal and actual (2013) monthly rainfall at Rewa

Real time contingency crop planning

To cope with climate variability, chickpea + linseed intercropping systems with various row ratios were evaluated. Maximum chickpea equivalent yield of 1226 kg/ha was obtained in chickpea + linseed (4:2), compared to sole chickpea yield (856 kg/ha), with higher BC ratio (4.08) and higher net return of Rs. 30275/ha.

Intercropping system	Chickpea equivalent yield (kg/ha)	Net returns (Rs/ha)	BC ratio
Sole chickpea	856	22919	3.47
Chickpea + linseed (1:1)	1068	24921	3.41
Chickpea + linseed (2:1)	1067	28542	3.75
Chickpea + linseed (2:2)	1123	26459	3.57
Chickpea + linseed (4:2)	1226	30275	4.08
Chickpea + linseed (6:2)	1095	25966	3.68
Chickpea + linseed (6:4)	1199	29306	4.01
Chickpea + linseed (8:4)	1147	28266	3.84
Chickpea + linseed (mixed)	890	18378	3.11

A field experiment was conducted for optimization of plant population and planting method for soybean under set furrow cultivation in medium land situation. Among different seed rates, the soybean cv, JS 95-60 with 100 kg/ha seed rate gave highest yield (777 kg/ha), net income (Rs. 8537/ha), BC ratio (1.35) and RWUE of 0.84 kg/h-mm as compared to cv JS 93-05. Sowing of JS 93-05 with seed rate of 80 kg/ha was the next best treatment with seed yield of 750 kg/ha and net return of Rs 7792/ha (Table-259).

Table-259: Effect of seed rate and varieties of soybean on yield and economics

Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net income Rs/ha	B:C ratio	RUE (kg/ha-mm)
$S_1 V_1$	539	15422	1376	0.97	0.59
$S_1 V_2$	513	15422	2290	1.04	0.61
$S_2 V_1$	728	15669	7114	10.19	0.80
$S_2 V_2$	750	15669	7792	1.33	0.81
$S_3 V_1$	777	15937	8537	1.35	0.84
$S_3 V_2$	646	15937	4261	1.14	0.70

Seed rate: S_1: 70, S_2: 80, S_3: 100 kg/ha Variety: V_1: JS 95-60 V_2: JS 93-05

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use

In *kharif*, soybean gave 679 kg/ha yield with gross income of Rs.14938/ha and BC ratio of 1.5. In *rabi*, with irrigation, wheat recorded 3174 kg/ha of yield, while chickpea gave 3190 kg/ha of yield in case of no irrigation, wheat and chickpea gave yield of 2666 and 1587 kg/ha and 3.85 and 6.91 BC ratio, respectively (Table-260).

Table-260: Catchment-Storage-Command area relationship for increasing water productivity in micro-watershed

Treatments	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	BC ratio
***Kharif* crops**				
Soybean	679	9500	14938	1.57
***Rabi* crops**				
(A) Irrigation				
Wheat	3174	10300	43960	4.27
Chickpea	3190	9200	81030	8.81
(B) No irrigation				
Wheat	2666	9600	36924	3.85
Chickpea	1587	8500	58719	6.91

C. On-farm experiments

Village profile

The program is being implemented in the village Raura and Patauana, Block and Tehsil Raipur Karchulian in district Rewa (M.P.). The total cultivated area is 743.986 ha (477.785 ha + 166.201 ha) out of which 250.997 ha (129.210 ha + 21.787 ha) is rainfed. The mean annual rainfall is 1080 mm with seasonal rainfall of 943.2 mm during *kharif* (June-September). The major soil types are silty loam and silty clay loam. The major rainfed crops are rice, soybean, pigeonpea and blackgram in *kharif* season and wheat, chickpea, lentil and linseed in *rabi* season. The number of small, marginal, medium and large farmers are 347 (310+ 37), 192 (110 + 82) and 137 (127 +10) in Raura and Patauna villages, respectively. The ground water table is 30 m. The source of irrigation is bore wells covering 60% of cultivated area.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 85% and north-east monsoon 15% of the total annual average rainfall of 1080 mm. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 15-35% deficit of the average rainfall. The onset (south-west) of monsoon was during 25 SMW (standard meteorological week) and north-east monsoon is 47 SMW. The dry spells were experienced during the crop season for the past 10/15 years during August and September at flowering and grain formation stages of the major rainfed crops. The onset of the monsoon is normal. The soil moisture status is deficit during flowering and grain development stages of major rainfed crops.

Experienced weather conditions during the year 2013-14

During 2013, in Patauna village, a rainfall of 1122.0 mm was received which was excess by 178.8 mm compared to normal (943.2 mm) during south-west monsoon (kharif). The onset of monsoon was normal. During north-east monsoon (October-December), 153 mm of rainfall was received which was excess by 102.9 mm compared to normal (50.1 mm). During summer (March - May), 46.6 mm of rainfall was received which was excess by 21.6 mm compared to normal (25 mm). During the month of September 15 days (1 to 15th September) and 8 days (23 to 30th September, 2013) dry spells were observed at the time of maximum growth period and flowering stage of crops (Fig.39).

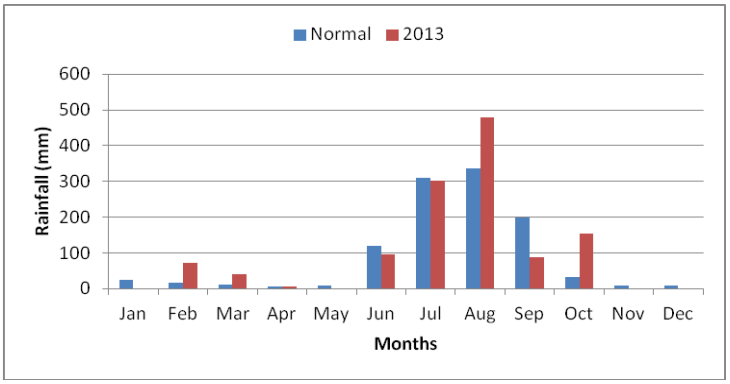


Fig.39: Normal and actual (2013) monthly rainfall at Patauna village

Interventions

The major on-farm interventions implemented included land configuration, crops or varieties/ cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 59.2 ha in 148 farmers' fields.

Land configuration

The land configuration included ridge furrow system and compartment bunding which facilitated runoff modulation/improved the drainage and enhanced in-situ moisture conservation. This resulted in mitigating dry spell in September and enhanced the crop yield of soybean, rice, blackgram, sesame, wheat, chickpea and lentil and rainwater use efficiency by 20-30% compared to farmers' practice (Table-261)..

Table-261: Performance of crops with land configuration

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	B:C ratio
		Improved practice	Farmers practice			
Soybean	JS 93-05	2300	2100	9.5	2.0	4.6
	JS 335	2200	1900	15.7	1.9	4.4
Blackgram	PU 30	950	700	35.7	0.8	4.7
	PDU-1	950	750	35.7	0.8	4.7
	LBG-20	950	650	46.1	0.8	4.7
Pigeonpea	Asha	2000	1900	5.2	1.7	8.0
	TJT-501	1800	1700	5.8	1.5	7.2
	ICPL 88039	2200	2000	10.0	1.9	8.2
Rice	Sahbhagi	2600	2300	13.0	2.2	2.1
	Danteshwari	2700	2100	38.5	2.3	2.2
	JR-201	2600	1800	44.4	2.2	2.1
Wheat	GW-273	3000	2500	20.0	59.7	4.2
Chickpea	JG-322	1800	1600	12.5	35.8	5.5
Lentil	JL-3	1500	1100	36.3	29.8	6.0

Real time contingency crop planning

The drought tolerant varieties, soybean (JS 93-05, JS-335), blackgram (LBG-20, PU-30, PDU-1), pigeonpea (Asha, TJT-501, ICPL 88039) and rice (Shahbhagi, Danteshwari, JR-201) were introduced to cope up with the rainfall variability.

Soybean: Two varieties of soybean were tested in farmers' fields under upland and mid land situations. The variety JS 93-05 recorded higher mean seed yield (1819 kg/ha) with RWUE of 1.47 kg/ha-mm, gross returns of Rs. 46235/ha and BC ratio of 3.97 under upland situation. While under midland situation, same soybean variety (JS 93-05) performed better and gave higher mean seed yield (1604 kg/ha) with 1.26 kg/ha-mm of RWUE, Rs.40890/ha of gross returns and BC ratio of 3.33 (Table-262).

Table-262: Performance of improved varieties of soybean under upland situation

Situation	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	B:C ratio
Upland	JS 93-05	1819	1.47	11933	46235	3.97
	JS 335	1727	1.41	11933	43953	3.74
Midland	JS 93-05	1604	1.26	11933	40890	3.33
	JS 335	1454	1.20	11933	36891	3.03

Blackgram: Three varieties of blackgram were introduced under upland and mid land situations. Blackgram cv. LBG-20 gave significantly higher yield (869 kg/ha) in upland situation with gross returns of Rs.33368/ha, BC ratio of 3.63 and RWUE of 0.68 kg/ha-mm. Under midland situation, same variety of blackgram (LBG-20) performed better and resulted in 727 kg/ha seed yield, 0.53 kg/ha-mm of RWUE, Rs.26492/ha of gross returns and BC ratio of 2.93 (Table-263). In general, the yields were less due to higher rainfall inAugust (480 mm) followed by two dry spells in September (1-15 September and 23-30 September).

Table-263: Performance of improved varieties of blackgram under upland and midland situations

Variety	Type of situation	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	B:C ratio
LBG-20	Upland	869	0.68	9500	33368	3.63
	Midland	727	0.53	9233	26492	2.93

Pigeonpea: Two varieties of pigeonpea were introduced under upland and mid land situations. Under upland situation, pigeonpea cv. ICPL- 88039 ws recorded higher mean seed yield (2100 kg/ha) followed by pigeonpea cv. Asha (1920 kg/ha) and TJT-501 (1790 kg/ha). While, higher RWUE (2.40 kg/hamm) and BC ratio (8.45) was recorded by pigeonpea cv. TJT-501 under upland situation (Table-264). Under midland situation, pigeonpea cv. ICPL- 88039 recorded higher mean seed yield (1950 kg/ha) with RWUE of 1.60 kg/ha-mm while, pigeonpea cv. Asha recorded higher gross return (Rs.88946/ha) with BC ratio of 8.03 (Table-264).

Table-264: Performance of improved varieties of pigeonpea under upland and midland situations

Situation	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	B:C ratio
Upland	Asha	1920	1.52	11017	93593	8.30
	TJT-501	1790	2.40	10500	90049	8.45
	ICPL-88039	2100	1.70	10000	84000	8.40
Midland	Asha	1819	1.47	11017	88946	8.03
	TJT-501	1618	1.25	10500	81576	7.65
	ICPL-88039	1950	1.60	10000	78000	7.80

Rice: Three rice varieties viz. Shahbhagi, Danteshwari and JR 201 were tested for their suitability in the farmers' fields under upland and midland situation. Variety Sahbhagi produced highest yield (2517 kg/ha and 3397 kg/ha under upland and midland situation, respectively). Dhanteshwari was the second best variety producing 2492 kg/ha and 2973 kg/ha (Table-265).

Table-265: Performance of improved varieties of rice under upland and midland situations

Variety	Type of situation	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	B:C ratio
Shahbhagi	Upland	2517	2.00	12800	27114	2.00
	Midland	3358	2.80	12800	34229	2.65
Danteshwari	Upland	2493	2.00	12800	26837	2.00
	Midland	2973	2.40	12800	30002	2.35
JR 201	Upland	2347	1.85	12800	25813	1.85
	Midland	2820	2.25	12800	30392	2.30

Wheat: During *rabi* season, in an assessment of wheat production, variety JW-3020 recorded significantly higher yield (2930 kg/ha) as compared to Lok-1 which gave the yield of 2756 kg/ha under partial irrigation. Higher BC ratio (3.75) as recorded by Lok-1 variety (Table-266).

Table-266: Performance of improved varieties of wheat

Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	B:C ratio
Lok - 1	2741	10500	39747	3.75
JW - 3020	2930	11000	43950	3.50

Chickpea: Three varieties of chickpea were tested on farmer`s fields. The variety JG-315 gave higher mean seed yield 1783 kg/ha with gross return of Rs. 64200/ha followed by JG 11 (1725 kg/ha, Rs.62950/ha) and JG 130 (1722 kg/ha, Rs. 625024/ha) (Table-267).

Table-267: Performance of improved varieties of chickpea

Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	BC ratio
JG – 11	1725	12600	62950	4.9
JG – 130	1722	13200	62024	4.6
JG - 315	1783	13200	64200	4.9

Lentil: Lentil variety JL 3 was introduced on farmers' fields which recorded 1364 kg/ha of seed yield with gross returns of Rs 45844/ha and BC ratio of 5.4.

Crops/varieties/cropping systems

Blackgram + pigeonpea (4:2), soybean + pigeonpea (4:2) and sesame + pigeonpea (4:2) intercropping systems were demonstrated to cope up with the rainfall variability both in upland and mid land situations. Maximum net returns of Rs. 131658/ha and BC ratio of 9.40 was recorded by soybean + pigeonpea (4:2) in upland situation (Table….) followed by sesame + pigeonpea (4:2) and blackgram + pigeonpea (4:2) with net returns of Rs. 103500 and Rs.96570/ha, respectively.

Under midland situation, green chilli + onion was recorded higher net return of Rs.267563/ha with 9.35 BC ratio followed by soybean + pigeonpea (4:2) intercropping system which recorded net returns of Rs.131658/ha and BC ratio of 9.40 (Table-268).

Table-268: Performance of intercropping systems in upland and midland situations

Situation	Intercropping system	Yield (kg/ha) (main crop + intercrop)	Net returns (Rs/ha)	RWUE (kg/ha-mm)	BC ratio
Upland	Blackgram + pigeonpea (4:2)	698 + 1700	96570	0.5 + 1.35	7.00
	Soybean + pigeonpea (4:2)	1683 + 2141	131658	1.3 + 1.7	9.40
	Sesame + pigeonpea (4:2)	712 + 1750	103500	0.5 + 1.05	12.2
Midland	Blackgram + pigeonpea (4:2)	7250 + 1712	116650	0.5 + 1.35	8.25
	Soybean + pigeonpea (4:2)	1680 + 1857	131658	1.3 + 1.45	9.40
	Sesame + pigeonpea (4:2)	788 + 1660	100538	0.6 + 1.3	7.25
	Green chili + onion	7513 + 17513	267563	6.15 + 14.20	9.35

Rainwater harvesting *(in-situ and ex-situ)* and its efficient use:

A farm pond of size 20 x 15 x 6 m (capacity 1800 m^3) was used for efficient rainwater harvesting and recycling. The stored water in the farm pond during this year was efficiently utilized for supplementary irrigation of 5 cm as pre-sowing irrigation for chickpea cv. JG-322. The supplemental irrigation resulted in higher yield (1867 kg/ha) of chickpea over no supplemental irrigation (1633 kg/ha). The per cent increase in yield over without supplemental irrigation was 14.3% chickpea cultivation with supplemental irrigation gave net return of Rs 56067/ha with B:C ratio of 5.3.

Timely operations through custom hiring centre

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements such as MB plough, cultivator, disk harrow, seed cum fertilizer drill, ridge seeder, raised bed seeder, hand wheel hoe, sprayer cum duster, hand operated sprayer and duster gave higher output energy and crop yield compared to normal implements. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period.

Alternate land use/farming systems for carbon sequestration and ecosystem services

Soybean based agri-horti system with soybean and chickpea crops were demonstrated in farmers' fields. Agro forestry, agro-horti and other carbon capture systems help in both adaption and mitigation. Hence, these interventions were made to educate farmers that climate change need to be tackled both short-term and long-term strategies. These interventions helped the farmers in the village during this excess rainfall year and farmers realized significantly higher yields by minimizing water logging problem. These systems are gradually attracting farmers' attention and more and more farmers are getting attracted to adopt such interventions to cope with climate variability in the region.

1.7. GROUNDNUT BASED PRODUCTION SYSTEM

1.7.1. ANANTAPUR

a. Agro-ecological setting

Anantapur is in Rayalaseema - Karnataka plateau (*AESR 3*). The climate is hot arid. Annual potential evapo-transpiration is 641 mm. Annual average rainfall is 615 mm. Length of growing period is 90-120 days. The drought occurs once in ten years. Anantapur is basically a groundnut region but to a little extent sorghum is grown. Groundnut is grown with pigeonpea as an intercrop in Anantapur. Water erosion is of high severity with moderate loss of top soil, affecting 51-100% area. The soils are deep loamy and clayey mixed red and black soils. The predominant soils are shallow red soils. Available water capacity is low to medium. The dominant rainfed crops during *kharif* are groundnut, pigeonpea etc.

b. On-station experiments

During 2013, the onset of monsoon was early by 6 days during (1st week of June), a rainfall of 380 mm was received which was excess by 27.9 mm compared to normal (352.1 mm) during south- west monsoon (*kharif*) (Fig.40). During north-east monsoon (October- December), 35 mm rainfall was received which was deficit by 109 mm compared to normal (144 mm) During summer, 11.6 mm of rainfall was received which was deficit by 59.9 mm compared to normal (71.5 mm). There were 12 dry spells during (09th July to 23rd July) at vegetative stage of groundnut.

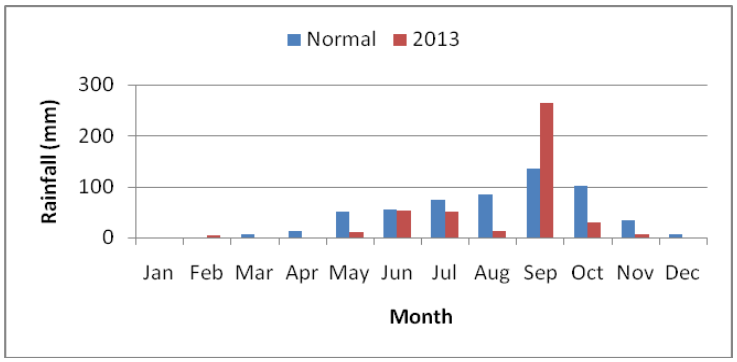


Fig.40: Normal and actual (2013-14) monthly rainfall at Anantapur

Real time contingency planning

Groundnut cv. K-9, recorded higher pod yield (538 kg/ha), haulm yield (1080 kg/ha), net return (Rs.3848 /ha), B: C ratio (1.16) and rainwater use efficiency (1.62 kg/ha-mm) followed by Vemana and K6 under normal onset of monsoon with dry spell during pegging and pod development stage. The performance of the varieties was shown to the farmers who visited the station regularly. One supplemental irrigation (10 mm) during pod development stage increased the pod yield by 32% with a B: C ratio of 1.5. During crop growth period,380.0 mm of rainfall was received in 14 rainy days during South west monsoon period out of which 129.6 mm (36%) was recorded during 3rd – 4th September, 2013 (two rainy days) against the normal rainfall of 351.6 mm which was 8.1% higher than the normal. During this period, 4 dry spells of 13 to 34 days duration (total 96 days) were experienced which mainly coincided with flowering, pegging and pod development stages (Table-269).

Table-269: Performance of improved varieties of groundnut

Variety	Pod yield (kg/ha)	Haulm yield (kg/ha)	RWUE (kg/ha–mm)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
Vemana	504	1061	1.52	25783	2387	1.10
ICGV-00308	276	759	0.83	15063	-8333	0.64
Abhaya	387	928	1.17	20398	-2998	0.87
Harithandhra	248	871	0.75	14536	-8860	0.62

Anantha	246	569	0.74	12856	-10540	0.55
Dharani	399	843	1.20	20428	-2968	0.87
K-6	497	985	1.50	25101	1705	1.07
TMV-2	427	871	1.29	21696	-1700	0.93
Greshma	427	748	1.29	21044	-2352	0.90
K-9	538	1080	1.62	27244	3848	1.16
Narayani	454	890	1.37	22877	-519	0.98

Pigeonpea cv.WRG-53 recorded higher seed yield (353 kg/ha), stalk yield (1952 kg/ha), gross return (Rs.13331/ha), net return (Rs.1285/ha), B:C ratio (1.11) and rainwater use efficiency (0.97 kg/ha-mm) followed by PRG-158 and PRG-100 with a seed yield of 330 and 304 kg/ha. The crop received 380.0 mm of rainfall in 14 rainy days during Southwest monsoon period. During the Northeast monsoon period crop received 35 mm in 5 rainy days against the normal rainfall of 146.4 mm. This was 76.1% less than the normal (Table-270).

Table-270: Performance of improved varieties of pigeonpea

Variety	Plant height (cm)	Pods/ plant	Seed/ pod	Test weight (g)	Pod yield (kg/ha)	Stalk yield (kg/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
PRG-100	163	209.4	3.4	10.2	304	1343	11312	-735	0.94	0.84
TTB-7	172	118.2	2.8	9.7	129	1636	5333	-6713	0.44	0.36
TRG-33	159	199.4	3.3	11.4	161	1160	6215	-5831	0.52	0.44
LRG-41	154	188.2	3.3	9.7	123	862	4736	-7310	0.39	0.34
LRG-30	165	211.6	3.5	8.5	156	1436	6178	-5868	0.51	0.43
PRG-158	162	231.0	3.2	9.3	330	1425	12263	217	1.02	0.91
WRG-53	181	260.2	3.3	8.6	353	1952	13331	1285	1.11	0.97
WRG-27	178	117.4	3.3	13.4	150	1878	6189	-5857	0.51	0.41
ICPL-85063	160	74.2	3.0	11.8	77	1554	3472	-8574	0.29	0.21
TRG-38	143	147.2	3.4	10.4	137	887	5239	-6808	0.43	0.38
TRG-59	148	70.8	3.2	12.2	80	828	3214	-8832	0.27	0.22
TRG-22	162	71.6	3.3	12.4	55	1211	2531	-9516	0.21	0.15
BRG-1	139	56.4	3.0	9.9	41	1281	2076	-9971	0.17	0.11
BRG-2	146	182.8	3.3	9.1	232	1594	8917	-3129	0.74	0.64

Groundnut sowing during July first fortnight gave higher pod yield (565 kg/ha), haulm yield (1209 kg/ha) and rainwater use efficiency (1.58 kg/ha-mm) with contingency measure of Leaf webber control by mass trapping and dead furrows at 3.6 m interval.(Table-271).

Table-271: Impact of contingency practices in groundnut

Date of sowing	Contingency measure	Yield (kg/ha)		Date of harvest	RWUE (kg/ha-mm)
		Pod	Haulm		
8-6-2013	Dead furrows at 3.6 m interval	427	1305	10-10-2013	1.23
8-7-2013	Leaf webber control by mass trapping, dead furrows at 3.6 m interval	565	1209	7-11-2013	1.58

Groundnut cv. K-6, with supplemental irrigation recorded higher pod yield (707 kg/ha), gross return (Rs.34686/ha) and net return (Rs.11390 /ha) compared to without supplemental irrigation, under normal onset of monsoon with dry spell during pegging and pod development stage. One supplemental irrigation (10 mm) during pod development stage increased the pod yield by 32% with a B: C ratio of 1.5 (Table-272).

Table-272.: Effect of supplemental irrigation on groundnut yield

Treatment	Pod yield (kg/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
With supplemental irrigation	707	34686	11390	1.5
Without supplemental irrigation	481	25240	1944	1.1
Increase	32%	9040		

Similarly pigeonpea cv. PRG-100, with supplemental irrigation recorded higher pod yield (523 kg/ha), gross return (Rs.18305/ha) and net return (Rs.6259/ha) compared to without supplemental irrigation. One supplemental irrigation (10 mm) of groundnut during pod development stage increased the pod yield by 72% with a B: C ratio of 1.52 (Table-273).

Table-273 : Effect of supplemental irrigation on pigeonpea yield

Treatment	Seed yield (kg/ha)	Gross eturn (Rs/ha)	Net return (Rs/ha)	B:C ratio
With supplemental irrigation	523	18305	6259	1.52
Without supplemental Irrigation	304	10640	-1406	0.88
Increase	72%	7665		

Supplemental irrigation to groundnut and pigeonpea with water stored in farm pond

During *Khari*f 2013, wet spell of 15 days either at flowering or pegging stage will reduce the groundnut pod yield slightly. The improved varieties of groundnut variety, K-6 and Narayani recorded higher pod yield during wet spells (Table-274).

Table-274: Effect of wet spell on yield of groundnut during *kharif* 2013

Treatments	D1 (8-6-2013)		D2 (29-6-2013)		D3 (22-7-2013)	
	K-6	Narayani	K-6	Narayani	K-6	Narayani
Rainfed	472	237	537	547	731	543
Irrigated	685	679	817	897	1635	1287
Wetspell Flowering	573	697	840	786	1504	1085
Wetspell Pegging	684	570	828	1256	1592	1228

Rainwater harvesting and recycling studies on roof rain water harvesting for crop production

About 800 m^2 roof area with a storage capacity of 16000 *lts* was established. During 2013, *kharif* a rainfall of 293 mm was received and 32.3 mm (11%) was utilized for vegetable cultivation. With this collected rainwater tomato produced yields of 4000 kg/ha (Table-275).

Table-275: Roof rainwater harvesting during *kharif*

Date	Rainfall (mm)	Volume of rain water collected (L)	Excess (L)
11.7.13	sowing		
24.7.13	3.0	2400	
16.8.13	5.0	4000	
3.9.13	61.6	49280	33280
4.9.13	68.0	54400	54400
8.9.13	11.0	8800	8300
9.9.13	6.2	4960	4960
11.9.13	59.4	47520	47520
15.9.13	8.6	6880	6380
16.9.13	32.4	25920	25920
17.9.13	13	10400	9900
18.10.13	Final harvest		
Total	293.2	214560	190660
Utilised		11%	89%

Efficient energy use and management /Timely operations through custom hiring centre

Groundnut is the major crop grown under rainfed condition in an area of about 8.5 lakh hectare in Anantapur district. The farmer has to perform timely field preparation, sowing of crop, intercultivation, spraying, harvesting and threshing of groundnut to save time and to get higher productivity. This is possible only when a farmer uses suitable farm machinery for performing the above said agricultural operations. Small and marginal farmers may not afford to purchase high cost machinery; thereby a custom hiring centre is a better solution to provide high cost machinery to small and marginal farmers on rent basis or custom hiring. Hence, a custom hiring centre was established at Agricultural Research Station, Anantapur during 2011-12 (Table-276).

Custom hiring center established at Agricultural Research Station, Anantapur

Table-276: Area and no. of farmers covered under custom hiring during 2013-14

Name of implement	Area (ha)	No. of farmers
Ananta planter	3918	950
Mould board plough	47	30
Duck foot cultivator	53	24
Fresh pod thresher	34	7
Dry pod thresher	45	12
Castor sheller/G.Nut decorticator	60	5
T.D levelling blade	7	6
Slim tyres	30	2

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA Centre, Anantapur in Aminabad and Girigetla villages in Thuggali Mandal, Kurnool district, Andhra Pradesh. The total cultivated area is 167.5 ha out of which 123.4 ha is rainfed. The mean annual rainfall is 620 mm with seasonal rainfall of 190.4 mm during *kharif* (June-September).

Climate Vulnerability in General

The climate in this agro-climatic zone is semi arid. Out of the total annual average rainfall of 342.9 mm, the south-west monsoon contributes 55.5%, north-east monsoon contributes 26 % and summer contributes 18.5%. For the past 15 years, the dry spells during crop season are experienced in August and October and at peg penetration, pod filling, pod development and harvesting stages of groundnut and flowering to reproductive stages in other crops. The onset of monsoon had been shifting (onset being in 25 SMW and withdrawal being 42-43 SMW).The soil moisture status was deficit during pod filling and pod development stages of groundnut.

Experienced weather conditions during (2013-14)

During 2013, in Aminabad village, onset of monsoon was delayed by 9 days during (3rd week of June), a rainfall of 482 mm was received which was excess by 52 mm compared to normal (430 mm) (Fig...) during south-west monsoon (*kharif*).

During north-east monsoon (October - December), 57 mm rainfall was received which was deficit by 76 mm compared to normal (133 mm) During summer, 22 mm of rainfall was received which was deficit by 31 mm compared to normal (53 mm). There were two dry spells during (28th July to 22nd August) i.e 26 days coinciding with vegetative and flowering stage and (6th to 26th September) i.e 21 days at pod development and pod maturity stage of groundnut crop during kharif season. In rabi season during (23rd November to 4th December) i.e 12 days coinciding with at pod development stage in chickpea and (7th to 31st December) i.e 25 days coinciding with pod maturity stage in chickpea. The deficit rainfall during August (-31%), September (-35%) and October (-51%) months coincided with flowering, pegging and pod development stages of groundnut crop and affected the crop yield (Fig.41).

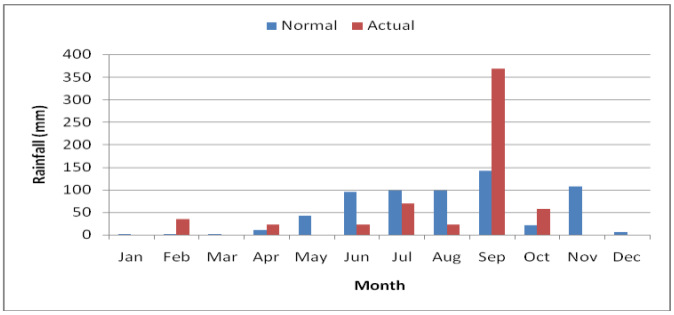


Fig.41: Normal and actual (2013-14) monthly rainfall at Aminabad

Interventions

The major interventions implemented were land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 258.4 ha in 510 farmers' fields.

Real time contingency crop planning

***In situ* moisture conservation**

The application of tank silt enhanced *in-situ* moisture conservation, ranging from 13.1 to 14.6% in red soils and 12.3 to 14.1% in black soils. The crop yield variation due to tank silt application was not significantly visible as the crop suffered due to middle and terminal drought during crop growing period (Table-277).

Table-277: *In-situ* moisture conservation with tank silt application

Crop	Variety	Rainfall from sowing to harvest (mm)	% increase in soil moisture over control	Yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Pearl millet	Local	459	13.1	387	0.84	2700	1.5
Chickpea	JG-11	77	14.1	600	7.7	9425	1.6
Castor	GCH-4	539	14.6	380	0.70	1400	1.1
Castor	GCH-4	539	12.3	415	0.76	2450	1.2

Application of tank silt

Chickpea in tank silt applied field

There was 17% improvement in yield with adoption of conservation furrows in groundnut where 462 kg/ha, net return (Rs.3591/ha), B:C ratio (1.2) and rainwater use efficiency (1.0 kg/ha-mm) compared to control (396 kg/ha).However, There was no difference in castor yield due to the formation of conservative furrows as prolonged dry spells occurred during capsule formation stage. The castor crop sown during June suffered due to moisture stress during reproductive stage and pod development and leading to small seed.(Table-278).

Table-278: Effect of in-situ moisture conservation through conservation furrow on groundnut and castor

Crop	No. of farmers	Rainfall (mm)*	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
			Treatment	control				
Groundnut	3	472	462	396	1.0	14875	3591	1.23
Castor	5	539	414	407	0.8	10000	2420	1.24

The drought tolerant varieties of groundnut (ICGV-9114, K-9 and Dharani), castor (PCH-111 and DCS-107), pigeonpea (PRG-158 and LRG-41), chickpea (JG-11 and KAK-2), setaria (Suryanandi and srilaxmi), bajra (ABH-1) and sorghum (NTJ-2 and NTJ-4) during *kharif* were demonstrated in the villages in general, the performance of all crops was poor due to uneven rainfall distribution and moisture at critical stages of crops. However, all improved varieties produced higher yields compared to local varieties (Table-279).

Table-279.: Performance of improved varieties of *kharif* rainfed crops

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	B:C ratio
		Improved practice	Local check		
Groundnut	ICGV-9114	532	396	34	1.4
Groundnut	K-9	449	396	13	1.2
Groundnut	Dharani	404	396	2	1.0
Castor	PCH-111	420	386	9	1.2
Castor	DCS -107	445	386	15	1.3
Sateria	Srilaxmi	878	800	9.7	1.7
Sateria	suryanandi	1006	800	12.9	2.0
Pearlmillet	ABH-1	394	375	5	0.5
Pigeonpea	LRG-41	172	125	27	0.5
Pigeonpea	PRG-158	198	125	36	0.5
Chickpea	KAK-2	183	140	30.7	0.4

Groundnut variety –Dharani

Sateria -Suryanandi

Pigeonpea variety –PRG-158

Castor variety -DCS-107

Pearl millet –ABH-1

Rainfed tomato

Performance of different improved varieties of *kharif* crops under rainfed conditions

Crops/ Varieties/Cropping system

The groundnut + pigeonpea intercropping system was introduced in farmer's fields with drought tolerant varieties of groundnut and pigenpea to cope up with rainfall variability and the system gave mean yield of 515 kg/ha and B:C ratio 2.6 with RWUE of 0.95 kg/ha-mm. There was a dry spell of 26 days from 19th July to 13th August 2013 during vegetative stage in groundnut and another dry spell of 22 days from 21st September to 12th October 2013 coinciding with pegging and seed development stages of groundnut during *Kharif* season. The deficit rainfall during July (-28%), August (-77%) during vegetative and flowering stages of groundnut and excess rainfall of 159% during September and October (+171%) over normal rainfall coincided with pegging and pod development stages of groundnut affected the crop (Table-280).

Table-280: Performance of groundnut + pigeonpea intercropping system

Intercropping system	Groundnut equivalent yield (kg/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Groundnut + pigeonpea	**515**	**10600**	**2.6**	**0.95**

Tomato transplanting was carried out during June last week to July second fortnight. Micronutrients namely Zinc (2%) and boron (1%) were sprayed at flowering and after 20 days of flowering. Mean tomato yield of 3963 kg/ha was recorded with spraying of micronutrients which was 8.9% higher than without spraying. Higher net return (Rs.17739/ha), B:C ratio (2.7) and rainwater use efficiency (7.3 kg/ha-mm) were recorded with micronutrients spray in tomato compared to control (Rs.15903/- per ha) (Table-281).

Table-281: Effect of micronutrient management in tomato

Treatment	Tomato yield (kg/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
Spraying of micronutrients	3963	27738	17738	7.3	2.7
Control	3558	24903	15903	6.6	2.7

Higher yield was recorded in tomato transplanted during second fortnight of July followed by first fortnight of July. Higher net return were recorded with 3rd date of transplanting due to higher prices which was due to damage of tomato crop transplanted during first week of June on receipt of 160 mm of rain on 2nd September 2013. Hence, it is better to go for staggered planting to cope up with the weather aberrations and price fluctuations (Table-282).

Table-282: Effect of date of translating on tomato yield and economics

Date of transplanting	Tomato yield (kg/ha)	RWUE (kg/ha-mm)	Rate (Rs/kg)	Gross return (Rsha)	Net return (R./ha)	B:C ratio
24.06.13	4000	7.6	7.50	30000	20000	2.0
12.07.13	4600	9.1	15.00	69000	59000	5.9
18.07.13	4800	9.8	35.00	168000	158000	15.8

In cotton, spraying of $ZnSO_4$ (2%), $MgSO_4$, Borax (1%) and 19-19-19 (1%) at the time of flowering and boll formation stage improved yield (362 kg/ha) by 9% ,gross return(Rs.13756/ha),net return(Rs.8256/ha), B:C ratio (2.5), rainwater use efficiency (0.67 kg/ha-mm) and reduced reddening of cotton leaves during moisture stress conditions (Table-283) .

Table-283: Effect of micronutrient management in cotton

Treatment	Cotton yield (kg/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
Spraying of micronutrients	362	13756	8256	0.67	2.5
Control	327	12426	7226	0.61	2.4

Demonstrations on soil test based fertilizer application were conducted at selected farmer's fields.Groundnut pod yield (451 kg/ha), net return (Rs.332/ha), B:C ratio(1.0) and rainwater use efficiency (0.9 kg/ha-mm) were higher with soil test based fertilizer application compared to farmer's practice (422 kg/ha) due to availability of balanced nutrients in the soil (Table-284).

Table-284: Performance of groundnut with site specific nutrient management

Farmer	Groundnut pod yield (kg/ha)		RWUE (kg/ha-mm)		Cost of cultivation (Rs/ha)		Net return (Rs/ha)		BC ratio	
	SSNM	Control	SSNM	Control	SSNM	Control	SSNM	Control	SSNM	Control
V.Ganganna	449	406	1	0.9	17902	18150	58	-1910	1	0.9
V.sanjanna	532	500	1.1	1.1	17682	18150	3598	1850	1.2	1.1
G.Parasuram	384	350	0.8	0.7	18302	18150	-2942	-4150	0.8	0.8
G.Rangaswamy	400	389	0.8	0.8	17682	18150	-1682	-2590	0.9	0.9
K.Basavaraju	425	410	0.9	0.9	17682	18150	-682	-1750	1.0	0.9
N.Veerendra	489	455	1.0	1.0	17282	18150	2278	50	1.1	1.0
Y.Srinivasuu	480	450	1.0	1.0	17502	18150	1698	-150	1.1	1.0
Mean	**451**	**422**	**0.9**	**0.9**	**17719**	**18150**	**332**	**-1236**	**1.0**	**0.9**

Botrytis problem in castor was observed against which carbendiazim spraying was taken up. The castor yield (445 kg/ha), net return (Rs.2923/ha), B:C ratio (1.3) and rain water use efficiency (0.8 kg/ha-mm) with the carbendiazim spraying was higher than control (400 kg/ha).Similarly application of pendimethalin resulted in effective control of weeds in groundnut and gave higher yields compared to control (Table-285).

Table-285: Performance of disease/weed management based on agro-advisories

Crop	Treatments	No.of farmers	Rainfall (mm) *	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
				Treatment	control				
Castor	Carbendizm	37	539	445	384	0.8	10000	2923	1.3
groundnut	Pendimethalin	5	472	403	390	0.9	13875	2269	1.2

Rainwater harvesting and recycling

A farm pond with size of 10 x 10 x 2.5 m with the capacity of 250 m^3 was dug for efficient rainwater harvesting and recycling. A rainfall of 160 mm was received on 2nd September 2013,and the farm pond as filled up. The stored water in the farm pond was efficiently used for irrigating to groundnut and chickpea.

Farm pond lining with red soil and cement (6:1 ratio)

Rainwater harvesting in farm pond

Efficient energy use and management

Custom hiring centre provided the implements on hire basis to the required farmers. The details of implements used on hire basis are given in the Table. The improved implements *viz.* tractor drawn Ananta planter, bullock drown automatic seed drill and groundnut wet pod thresher were made available which not only saved labour and facilitated timely sowing but also gave higher energy output and return compared to local implements. Sowing of groundnut with tractor drawn Ananta planter gave higher energy output and net return than the farmers' practice. Total energy requirement for sowing of groundnut with tractor drawn ananta planter was 2546 MJ/ha. Total energy output was higher with tractor drawn ananta planter (31162 MJ/ha). The net return with tractor drawn planter were Rs. 2613/ha . The diesel consumption for duck foot 5 row cultivator and groundnut wet pod thresher was 5 lt/hr while for sowing of groundnut with tractor drawn ananta planter was 4 lt/hr (Table-286).

Table-286: Details of implements used on hire basis

Implement	Area (ha)	No. of farmers / No. of demonstrations conducted
Duck foot 5 row cultivator	2.0	1
Ananta tractor drawn seed planter	8.8	9
Groundnut wet pod thresher	1.0	1
Thaiwan sprayer	2.0	2
Total	13.8	13

Total energy requirement for sowing of groundnut varieties with tractor drawn Ananta planter was ranged (2405 to 2808 MJ/ha). Total energy output for ICGV-91114 with tractor drawn Ananta planter (36700 MJ/ha), net return (Rs. 6405/ha) and B: C ratio (1.4) were higher compared to other varieties (Table-287).

Table-287: Performance of groundnut with improved implements

Variety	Farmer name	Yield (MJ/ha)	Total energy requirement (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Local	N.Laxminarayana	10000	2505	26560	14875	1125	1.0
Dharani	V.Eswarappa	10100	2405	31700	14875	1285	1.0
ICGV-91114	V.Ganganna	13300	2505	36700	14875	6405	1.4
Local	Y.Srinivas	10000	2808	29800	14875	1125	1.0
local	G.Balaramudu	11250	2505	31050	14875	3125	1.2

Alternate land use and Eco-system services

Pearl millet and sorghum are the second conventional crops in Girigetla micro-watershed area. Rajasri birds rearing were introduced with millet farming system. Gross return with pearl millet + pigeonpea + rajasri birds system were higher by 38% compared to pearl millet + pigeonpea system. Higher net return of Rs. 2700/ were recorded with rajasri birds in pearl millet + pigeonpea system (Table-288).

Table-288: Performance of rajasri birds in millet based system

Intervention	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
Pearl millet + pigeonpea system	8370	4570	2.2
Pearl millet + pigeonpea system + rajasri birds (10 birds)	11570	7270	2.6

Moisture conservation by conservation furrows

Tractor drawn Anantha groundnut planter

Bullock drawn groundnut planter

Rajsri birds for additional income

1.7.2. RAJKOT

a. Agro-ecological setting

Rajkot is located in Western plain, South Kachchh and north Kathiawar peninsular (AESR2.4). The climate is hot arid. Average annual rainfall is 590 mm.

b. On-station experiments

During 2013, the onset of monsoon was delayed by 5 days during (2nd week of June). A rainfall of 1000.8 mm was received which was excess by 442.7 mm compared to normal (557.9 mm) (Fig.42) during south-west monsoon (*kharif*). During north-east monsoon (October - December) 100.6 mm rainfall received which was excess by 76.12 mm as compared to normal (24.8) and summer there 26.2 mm rainfall received which was excess by 20.2 mm as compared to normal (6 mm).There were two dry spell were occurred (20th June to 4th July (14 days) and 19th August to 5th September (18 days) during season. The very heavy rainfall 300 mm was recorded on 26th September-2013.

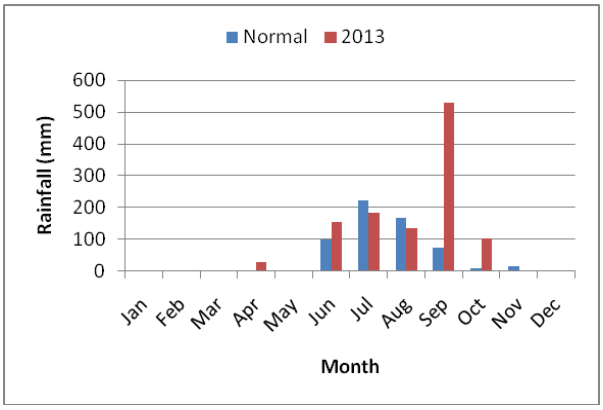


Fig.42: Normal and actual (2013) monthly rainfall at Rajkot

Real time contingency planning

At on station, during *kharif* 2013, the effect of drip and mulching was evaluated on the yield of various hybrids/varities of cotton (G.Cot Hybrid 6 BGII, G.Cot Hybrid 8 BGII and Bijdhan BGII). G. Cot Hy. 6 BGII 9 and G. Cot Hy. 8 BGII performed better and gave 11 and 9.6 % higher seed cotton yield compared to Bijdhan BGII. Seed cotton yield increased by 17.7 and 11.6 % under drip with groundnut shell mulching (4148 kg/ha) and plastic mulching (3932 kg/ha), respectively compared to no irrigation (3524 kg/ha).There were two dry spell were occurred (20th June to 4th July (14 days) and 19th August to 5th September (18 days) during season (Table-289).

Table-289: Effect of drip irrigation and mulching in cotton

Treatment	Seed cotton yield (kg/ha)				% increase in yield
	G.Cot Hy. 6 BGII	G.Cot Hy. 8 BGII	Bijdhan BGII	Mean	
Without irrigation	3502	3676	3396	3524	-
Drip irrigation	4074	3497	3508	3693	4.8
Drip irrigation + groundnut shell mulching	4232	4483	3729	4148	17.7
Drip irrigation + plastic mulching	4084	4031	3681	3932	11.6
Mean	3973	3922	3579	-	
% increase in yield	11.0	9.6	-		
	Variety	Irrigation & mulch			
S.Em	102	88			
LSD (P=0.05)	300	260			


Groundnut shell mulching


Plastic mulching

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use

On station trial was carried out to study the effect of drip irrigation on yield of castor var. GCH-7 during *kharif* 2013. The seed yield of castor was increased to the tune of 19.6 % due to drip irrigation and it also recorded higher net return compared to control .There were two dry spell were occurred (20th June to 4th July (14 days) and 19th August to 5th September (18 days) during season (Table-290).

Table-290 : Effect of drip irrigation on yield of castor

Treatment	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)
Drip irrigation	2750	26100	70150
Control	2300	22000	58500


Effect of drip irrigation on yield of castor

Addition of manure or *murrum* at 20 t/ha as an *in-situ* moisture conservation practice in groundnut recorded 14 and 12% higher pod (1910 kg/ha) and haulm yield (3470 kg/ha) compared to control. A rainfall excess by 442.7 mm compared to normal (557.9 mm) during south-west monsoon (*kharif*).There were two dry spell were occurred (20th June to 4th July (14 days) and 19th August to 5th September (18 days) during season. The very heavy rainfall 300 mm was recorded on 26th September-2013 (Table-291).

Table-291: Effect of different treatments on yield of groundnut (GG-20)

Treatment	Yield (kg/ha)	
	Pod	Haulm
Application of *murrum* @ 20 t/ha	1910	3470
Control	1670	3100

Cropping systems

Intercropping systems involving groundnut+ castor/blackgram performed better under both normal and delayed onset of monsoon conditions compared to sole cropping. Further, indicated that in case of normal onset of monsoon the maximum net return (Rs.71258) was obtained with groundnut + sesame intercropping system, while under delayed onset of monsoon higher net return of Rs. 55966/ha was recorded with castor + blackgram intercropping system. During 2013, the onset of monsoon was delayed by 5 days during (2nd week of June). (Fig.43).

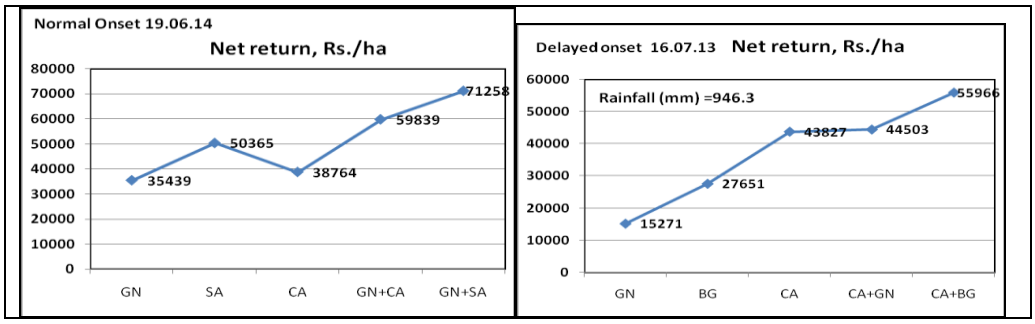


Fig.43: Groundnut + castor/blackgram based intercropping sytems

In another trail, among different intercropping systems, the maximum yield (1877 kg/ha), net return of Rs.111139 and B: C ratio of 5.94 was recorded under groundnut + sesame (2:1) followed by groundnut + cotton (3:1). A rainfall of 1000.8 mm was received which was excess by 442.7 mm compared to normal (557.9 mm) during south-west monsoon (*kharif*). There were two dry spell were occurred (20th June to 4th July (14 days) and 19th August to 5th September (18 days) during season. The very heavy rainfall 300 mm was recorded on 26th September-2013 (Table-292).

Table-292: Effect of various treatments on yields and economics of cropping systems

Treatment	Yield kg/ha		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Base crop	Inter crop			
Groundnut (sole)	2153	-	24500	56181	3.29
Groundnut +cotton (3:1)	1389	1606	30321	97831	4.23
Groundnut +castor (3:1)	1319	1651	25635	81289	4.17
Groundnut +sesame (2:1)	1847	764	22520	111139	5.94
Groundnut +blackgram (2:1)	1528	911	22520	84335	4.74

Groundnut + sesame (2:1)

Groundnut + castor (3:1)

Groundnut + cotton (3:1)

Alternate land use system

In guava based agri-horti system, the maximum yield (2342 kg/ha) and net return of (Rs.75279/ha) was recorded under cotton and followed by agri-horti system (Rs. 65511). In case of B:C ratio, the highest value of 4.47 was observed with sesame crop (4.47) followed by blackgram (3.70) and castor (3.42). However, the lowest value of B:C ratio (2.56) was observed under agri-horti system. During 2013, the onset of monsoon was delayed by 5 days during (2nd week of June). A rainfall of 1000.8 mm was received which was excess by 442.7 mm compared to

normal (557.9 mm) (Fig.) during south-west monsoon (kharif). There were two dry spell were occurred (20th June to 4th July (14 days) and 19th August to 5th September (18 days) during season. The very heavy rainfall 300 mm was recorded on 26th September, 2013. During north-east monsoon (October - December) 100.6 mm rainfall received which was excess by 76.12 mm as compared to normal (24.8) and summer there 26.2 mm rainfall received which was excess by 20.2 mm as compared to normal (6 mm) (Table-293).

Table-293: Effect of various treatments on yields and economics of agri- horti system

Crop	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Guava	4500	-	-	-
G nut	1025	-	-	-
Black Gram	480	-	-	-
Agri-horti	0	42000	65511	2.56
Groundnut (sole)	2153	24500	56181	3.29
Cotton (sole)	2342	36200	75279	3.08
Castor (sole)	2150	22000	53250	3.42
Sesame (sole)	972	18500	64120	4.47
Blackgram (sole)	1244	18500	49920	3.70

Agri-horti intercropping system

c. On - farm experiments

Village profile

The program is being implemented by AICRPDA centre, Rajkot in Pata meghpar village, Kalavad Taluka, Jamnagar district, Gujarat. The total cultivated area is 2793 ha out of which 1675 ha is rainfed. The mean annual rainfall is 585 mm with seasonal rainfall of 585 mm during *kharif* (June- September). The major soils types are medium black soils. The major rainfed crops during *kharif* are groundnut, cotton, sesame and during *rabi* are wheat, cumin, fenugreek and chickpea. The number of small, marginal, medium and large farmers are 28.7, 27.3, 27.8 and 16.1%, respectively. The ground water table is 19.5 m below the surface. The source of irrigation is open wells and bore wells covering 40.5% of cultivated area.

Climate vulnerability in general

The climate in this agro-climatic zone is semi- arid. Out of the total annual average rainfall of 585 mm, the south-west monsoon contributes 70-80%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 62.5% of the average rainfall. The normal onset of monsoon is during 26 SMW and withdrawal is during 39th SWM. However, for the past 10 years, the onset (south-west) of monsoon is during 27th SMW.

The dry spells are experienced during peg formation and pod development stages in groundnut, square and boll formation stages in cotton, and flowering and pod development stages in pulses. The maximum and minimum temperature (average) during crop season a 32.3 and 25ºC, respectively which have more or less remained similar during past 10 years. The extreme events like unusual and high intensity rainfall in short spans are increasing during in 32nd and 35th SMW of August during kharif season. Based on 53 years data, the probable extreme events like cold wave occur during 3rd SMW (January) and heat wave during 21st SMW (May) in the area. There has been a considerable shift in the rainfall pattern, in the past 10 years, with a rainfall of 895 mm which was excess by 67.5% as compared to normal of 585 mm in the area and crops experienced dry spells during 33rd - 34th SWM of August (mid-season) and 37th - 38th SMW of September (later season). The start of monsoon during 2001-10 was 27th SMW instead of 28th SMW during 1991-00. Similarly, the withdrawal of monsoon has also followed same trend.

Experienced weather conditions (2012-13)

The rainfall data of Rajkot centre (being the nearest agromet station) is taken for the analysis of weather conditions during the year 2013 at Pata Meghapar village. A rainfall of 1105 mm was received which was excess by 550.5 mm compared normal of 554.5 mm, during south-west monsoon (*kharif*). (Fig.44) during north-east monsoon (October - December) and summer there was no rainfall received. There were long dry spells during 17th August to 22nd September (36 days). 25th -26th September were the months with excess rainfall.

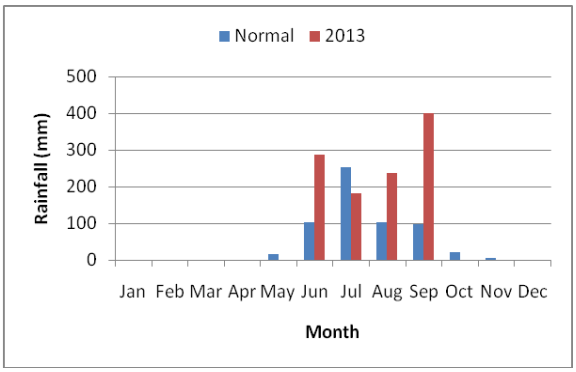


Fig.44: Normal and actual (2013) monthly rainfall at Pata Meghapar

Interventions

The major interventions that were implemented include *in-situ* moisture conservation, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center, and alternate land use and ecosystem services. These interventions covered an area of 52.4 ha in 131 farmers' fields.

Real time contingency plan

The seed cotton yield increased to the tune of 19 and 16 % with cotton varieties G. Cot. 6 BGII and G. Cot. 8 BGII in comparison different Bt cotton research varieties grown by the farmer. Improved practices recorded higher yield of both hybrids (2825 and 2644 kg/ha). It also recorded higher net returns (Rs.97670 & Rs.89043/ha), water use efficiency (2.56 & 2.39 kg/ha-mm) and B:C ratio (2.65 & 2.42) , respectively compared to farmer's practice .A rainfall of 1105 mm was received during the crop season. The cost of cultivation was lower with improved practices (Rs.36800/ha) compared to farmer's practice (Rs.37300/ha) (Table-294).

Table-294: Performance of cotton hybrids in farmer's fields

G. Cot. 6 BGII	Farmer	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of Cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
		IP	FP				
Variety trial	M P Kathiria	2750	2313	2.49	36800	94100	2.56
	D S Pambhar	2500	2375	2.26	36800	82200	2.23
	M M Kathiria	3063	2563	2.77	36800	108975	2.96
	R N Tarapra	2688	2125	2.43	36800	91125	2.48
	N M Khakhria	3125	2500	2.83	36800	111950	3.04

Improved practices		2825	-	2.56	36800	97670	2.65
Farmer practices		-	2375	2.15	37300	75750	2.03
G. Cot. 8 BGII	V P Kathiria	2875	2250	2.60	36800	100050	2.72
	R D Thumar	2406	2000	2.18	36800	77738	2.11
	M R Tarpara	2500	2188	2.26	36800	82200	2.23
	V P Molia	3000	2813	2.71	36800	106000	2.88
	K S Vasoya	2438	2125	2.21	36800	79225	2.15
Improved practices		2644	-	2.39	36800	89043	2.42
Farmer practices		-	2275	2.06	37300	70990	1.90

* IP: Improved practices; FP: Farmer's practice

In another trail on demonstration of improved chickpea variety, G-3 recorded higher seed yield (2502 kg/ha), net return (Rs. 56550/ha) and B: C ratio (3.06) in comparison to local var. Dahod Pila (Table-295).

Table-295: Performance of improved chickpea variety (G-3)

Farmer	Yield (kg/ha)		Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
	Improved practices	Farmer's practice			
R D Tarapara	2250	2150	67500	49000	2.65
B R Vasoya	2625	2350	78750	60250	3.26
G K Thesiya	2600	2200	78000	59500	3.22
G N Khakharia	2300	2050	69000	50500	2.73
P M Thesiya	2200	2100	66000	47500	2.57
P S Kamani	2850	2550	85500	67000	3.62
S M Hada	2575	2275	77250	58750	3.18
M S Kamani	2675	2400	80250	61750	3.34
D B Thummar	2300	2150	69000	50500	2.73
V D Thummar	2450	2225	73500	55000	2.97
V P Kathiriya	2625	2425	78750	60250	3.26
C R Kamani	2800	2625	84000	65500	3.54
N M Khakharia	2575	2300	77250	58750	3.18
H P Kamani	2200	1950	66000	47500	2.57
A P kamani	2500	2325	75000	56500	3.05
Improved practices	2502	-	75050	56550	3.06
Farmer practices	-	2272	68150	49650	2.68

Site specific nutrient management

Site specific nutrient management (SSNM) recorded higher wheat grain yield (4225 kg/ha), net return (Rs. 61365/ha) and B:C ratio (3.25) which were higher by 13.3 and 17.4 %, respectively compared to farmer practices (Table-296).

Table-296: Performance of wheat with site specific nutrient management

Farmer	Yield (kg/ha)		Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
	SSNM*	FP*			
V P Kathiriya	4750	4250	90250	71340	3.77
C R Kamani	4000	3375	76000	57090	3.02
N M Khakharia	4375	3750	83125	64215	3.40
H P Kamani	3750	3125	71250	52340	2.77
A P Kamani	3500	3375	66500	47590	2.52
D P Khakharia	4000	3500	76000	57090	3.02
P P Khakharia	4750	4400	90250	71340	3.77
P Thesiya	3500	3125	66500	47590	2.52

G Tarpara	5250	4375	99750	80840	4.27
J R Thummar	4375	4000	83125	64215	3.40
Improved practices	4225	-	80275	61365	3.25
Farmer practices	-	3728	70823	52263	2.82

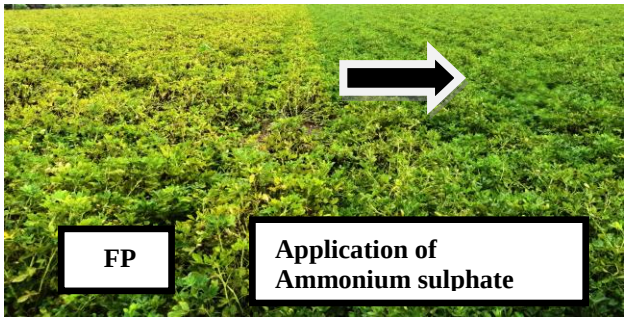
* SSNM: Site specific nutrient management; FP: Farmer's practice

In another trial on SSNM in groundnut recorded higher pod yield (2074 kg/ha), net return (Rs. 51921/ha) and B: C ratio (2.12) as well as water use efficiency (1.88 kg/ha-mm) which were higher by 6.6, 6.6 and 4.3 % compared to farmer practices (Table-297).

Table-297: Performance of groundnut with SSNM compared to farmers practices

Farmer	Pod yield (kg/ha)		RWUE (kg/ha-mm)	Gross returns (Rs/ha)	Net return (Rs/ha)	B:C ratio
	SSNM*	FP*				
N V Moliya	1960	1780	1.77	71890	47390	1.93
B S Hada	2120	1970	1.92	78130	53630	2.19
G B Gadhiya	1810	1710	1.64	66683	42183	1.72
A B Bhokhani	2350	2250	2.13	86638	62138	2.54
P M Tarapara	1920	1810	1.74	70760	46260	1.89
D B Deshay	2210	2010	2.00	81463	56963	2.33
N M Khakhariya	2360	2200	2.14	86950	62450	2.55
J M Rathod	1970	1890	1.78	72563	48063	1.96
A R Bhokhani	2250	2180	2.04	83193	58693	2.40
P B Rathod	1790	1660	1.62	65938	41438	1.69
Improved practices	2074	-	1.88	76421	51921	2.12
Farmer practices	-	1946	1.76	60813	38163	1.76

* SSNM: Site specific nutrient management; FP: Farmer's practice



In another trial, use of gypsum resulted in higher pod yield (1887 kg/ha) of groundnut , net return (Rs. 46706/ha) and B:C ratio (2.01) as well as water use efficiency (1.71 kg/ha-mm) which were higher by 11.1, 11.1 and 53.4 % in compared to farmer practices (Table-298).

Table-298: Performance of groundnut with SSNM compared to farmers practices

Farmer	Pod yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Gypsum application	Farmer's practice			
M S Moliya	2200	2050	1.99	58310	2.51
S M Hada	1500	1350	1.36	32375	1.40
B H Chirodiya	2110	1860	1.91	54976	2.37
R S Savsoya	2088	1790	1.89	54160	2.33

V V Rathod	2160	1900	1.95	56828	2.45
B R Vasoya	1500	1440	1.36	32375	1.40
K M Thesya	1860	1600	1.68	45713	1.97
P M Tarpara	1800	1720	1.63	43490	1.87
R N Vasoya	1500	1380	1.36	32375	1.40
C M Thesya	2150	1900	1.95	56458	2.43
Improved practices	1887	-	1.71	46706	2.01
Farmer practices	-	1699	1.54	30444	1.34

Improved practice

Farmer practice

Intercropping system

All the intercropping systems recorded higher yield and income as compared to respective sole crops. Among three intercropping systems, groundnut + castor performed better and gave additional income of Rs. 28000/ha followed by cotton + sesame (Rs.16490/ha). A rainfall was excess by 550.5 mm compared normal during south-west monsoon (*kharif*).There were long dry spells during 17th August to 22nd September (36 days).Which was coincides for flowering and pegging stage of groundnut, 25-26th September were the months with excess rainfall (Table-299).

Table-299: Performance of different intercropping systems

Sl. No.	Yield (kg/ha)			Net return (Rs/ha)	
	Sole crop	Intercropping		Sole crop	Intercropping
		Base crop	Inter crop		
Groundnut + castor (1:1)					
1	1980	1600	800	73475	87400
2	1850	1500	950	67213	87725
3	1800	1450	1400	66250	102313
4	2000	1600	1350	72300	105250
5	1750	1550	1000	65888	92438
Mean	**1876**	**1540**	**1100**	**69025**	**95025**
Cotton + green gram (1:1)					
1	2200	1750	700	104720	121800
2	2300	1600	630	109480	110810
3	2150	2000	650	102340	130950
4	2700	1650	800	128520	122540
5	2050	1500	700	97580	109900
Mean	**2280**	**1700**	**696**	**108528**	**119200**
Cotton+ sesame (1:1)					
1	1900	1400	550	90440	113390
2	2150	1650	500	102340	121040
3	2600	1950	480	123760	133620
4	2000	1500	530	95200	116450
5	2350	1750	450	111860	121550
Mean	**2200**	**1650**	**502**	**104720**	**121210**

Groundnut + castor

Cotton + green gram

Cotton + sesame

Relay cropping system

The results showed that the relay cropping system recorded higher income as compared to respective sole crop. Between two relay of cotton relay of chickpea was performed better and gave income of Rs. 128023/ha which was higher by 15.1 per cent in compared to sole cotton crop. A rainfall of 1105 mm was received which was excess by 550.5 mm compared normal of 554.5 mm, during south-west monsoon (*kharif*). There were long dry spells during 17th August to 22nd September (36 days). 25-26th September were the months with excess rainfall. During north-east monsoon (October – December) and summer there was no rainfall received chickpea cropping season the rainfall was deficit by 100 %. (Table-300).

Table-300: Performance of cotton and chickpea in relay cropping system

Farmer	Yield (kg/ha)			Net income (Rs./ha)	
		Relay cropping		Sole cotton	Relay cropping
	Sole cotton	Base cotton	Relay chickpea		
Cotton + chickpea (1:2)					
K. D. Tarapara	2400	1700	1500	114240	125920
K M Thesiya	2600	2000	1250	123760	132700
G S Kamani	2000	1650	1375	95200	119790
A R Bhokhani	2350	1800	1600	111860	133680
Mean	**2338**	**1788**	**1431**	**111265**	**128023**

Relay cropped chickpea in cotton

Nutrient management

Integrated nutrient management (INM) recorded higher pod yield (2190 kg/ha) of groundnut, net return (Rs.52458/ha), B:C ratio (2.12) and water use efficiency (1.98 kg/ha-mm) which were higher by 12.5, 14.3 and 12.5 % compared to farmer practices (Table-301).

Table-301: integrated nutrient management in groundnut

Farmer	Pod Yield (kg/ha)		RWUE (kg/ha-mm)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Integrated nutrient management	Farmer's practice				
J R Thumar	2090	1680	1.89	73673	48923	1.98
D T Thesia	2075	1910	1.88	73144	48394	1.96
G B Tarapra	2220	1760	2.01	78255	53505	2.16
V S Tarpra	2208	2105	2.00	77832	53082	2.14
J M Kamani	2210	1880	2.00	77903	53153	2.15
T P Kathiria	2310	2175	2.09	81428	56678	2.29
C R Kamani	2175	2070	1.97	76669	51919	2.10
V S Tarpara	2085	1840	1.89	73496	48746	1.97
P N Kathiria	2335	2205	2.11	82309	57559	2.33
T M Thesia	2195	1820	1.99	77374	52624	2.13
INM practices	2190	-	1.98	77208	52458	2.12
Farmer practices	-	1945	1.76	68544	45894	2.03

In another study, INM recorded higher seed cotton yield (2541 kg/ha),net return (Rs. 83634/ha), B:C ratio (2.24) and water use efficiency (2.3 kg/ha-mm) which were higher by 24.1, 34.4 and 24.3% compared to farmer practices (Table-302).

Table-302: Integrated nutrient management in cotton

Farmer	Seed cotton yield (kg/ha)		RWUE (kg/ha-mm)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
	Integrated nutrient management	Farmer's practice				
R B Chirodia	2750	2125	2.49	130900	93600	2.51
C M Thesia	2500	1750	2.26	119000	81700	2.19
V P Kathiria	2813	2094	2.55	133875	96575	2.59
G R Tarapara	2688	1875	2.43	127925	90625	2.43
D D Thesia	2250	1500	2.04	107100	69800	1.87
R A Vasoya	2563	2250	2.32	121975	84675	2.27
V V Rathod	2156	2000	1.95	102637	65337	1.75
G P Tarapara	2250	1938	2.04	107100	69800	1.87
V P Tarapara	3000	2813	2.71	142800	105500	2.83
D P Khakhria	2438	2125	2.21	116025	78725	2.11
INM practices	2541	-	2.30	120934	83634	2.24
Farmer practices	-	2047	1.85	97431	62231	1.77

Foliar application

Foliar application of potassium nitrate @ 2 % at square formation & boll development stage recorded higher seed cotton yield (2646 kg/ha), net return (Rs.88650/ha), B:C ratio (2.38) and water use efficiency (2.39 kg/ha-mm) which were higher by 18.2, 18.2 and 26.1% in compared to farmer practices (Table-303).

Table-303: Performance of cotton with foliar fertilization

Farmer	Seed cotton yield (kg/ha)		RWUE (kg/ha-mm)	Gross return (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Foliar application	Farmer's practice				
K. D. Tarapara	2800	2450	2.53	133280	96480	2.62
B C Vasoya	2650	2125	2.40	126140	89340	2.43
J B Thesia	2813	2094	2.55	133899	97099	2.64

J P Pambhar	2570	2375	2.33	122332	85532	2.32
G N Khakhriya	2400	2150	2.17	114240	77440	2.10
Foliar spray	2646	-	2.39	125950	88650	2.38
Farmer practices	-	2238	2.03	106529	70329	1.94

In a similar trial involving foliar application of KNO_3 in wheat ,the grain yield (4031 kg/ha) of wheat increased to the tune of 10.6% due to foliar application of potassium nitrate @ 1% at milk and dough stage compared to farmer practices. It also recorded higher net return (Rs.57794) and B:C ratio (3.07) (Table-304).

Table-304: Performance of wheat with foliar application

Farmer	Yield (kg/ha)		Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Foliar application	Farmer's practice			
V P Kathiriya	4125	3875	78375	59575	3.17
C R Kamani	3800	3575	72200	53400	2.84
N M Khakharia	3825	3550	72675	53875	2.87
H P Kamani	4375	3700	83125	64325	3.42
A P Kamani	4000	3500	76000	57200	3.04
Foliar spray	4031	-	76594	57794	3.07
Farmer practices	-	3675	69825	51265	2.76

Integrated pest management

Integrated pest management (IPM) recorded higher seed cotton yield (2473 kg/ha), net return (Rs. 80815/ha) and B:C ratio (2.16) as well as water use efficiency (2.24 kg/ha-mm) which were higher by 7.2, 16.1 and 27.9 % in compared to farmer practices (Table-305).

Table-305: Performance of cotton with IPM compared to farmer's practices

Farmer	Seed cotton yield (kg/ha)		RWUE (kg/ha-mm)	Gross returns (Rs/ha)	Net return (Rs./ha)	B:C ratio
	Integrated pest management	Farmer's practice				
G N Tarpara	2180	1875	1.97	103768	66468	1.78
L M Hada	2100	1950	1.90	99960	62660	1.68
K S Thesia	2800	2325	2.53	133280	95980	2.57
B K Thesia	2580	2100	2.33	122808	85508	2.29
D K Akabari	2030	1650	1.84	96628	59328	1.59
N J Akabari	2970	2700	2.69	141372	104072	2.79
J R Tarpara	3050	2550	2.76	145180	107880	2.89
V P Bhut	2350	1950	2.13	111860	74560	2.00
D M Thesia	2020	1800	1.83	96152	58852	1.58
M B Bharvad	2650	2400	2.40	126140	88840	2.38
Improved practices	2473	-	2.24	117715	80415	2.16
Farmer practices	-	2130	1.93	101388	62888	1.73

In another trial, IPM recorded higher seed yield (1220 kg/ha) of cumin, net return (Rs. 99600/ha) and B:C ratio (6.11) compared to farmer practices (Table-306).

Table-306: Performance of cumin with IPM compared to farmers practices

Farmer	Yield (kg/ha)		Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Integrated pest management	Farmer's practice			
J R Thummar	1025	950	97375	81075	4.97
R D Thummar	1300	1375	123500	107200	6.58

P D Thummar	1350	1150	128250	111950	6.87
K S Kamani	1200	1050	114000	97700	5.99
V D Thummar	1125	975	106875	90575	5.56
S M Thesiya	1150	875	109250	92950	5.70
B R Bharvad	1275	1200	121125	104825	6.43
M M Khavas	1225	1100	116375	100075	6.14
M A Jesadiya	1375	1250	130625	114325	7.01
S S Thesiya	1175	1050	111625	95325	5.85
Improved practices	1220	-	115900	99600	6.11
Farmer practices	-	1097	104263	88413	5.58

The pod yield of groundnut was increased 8.5% due to spraying of thiourea @ 2 per cent as compared to farmer practices. It also recorded higher water use efficiency (1.74 kg/ha-mm), net return (Rs. 46843) and B: C ratio (1.98).A long dry spell of 36 days was experienced during crop season (17th Agust-22nd September) (Table-307).

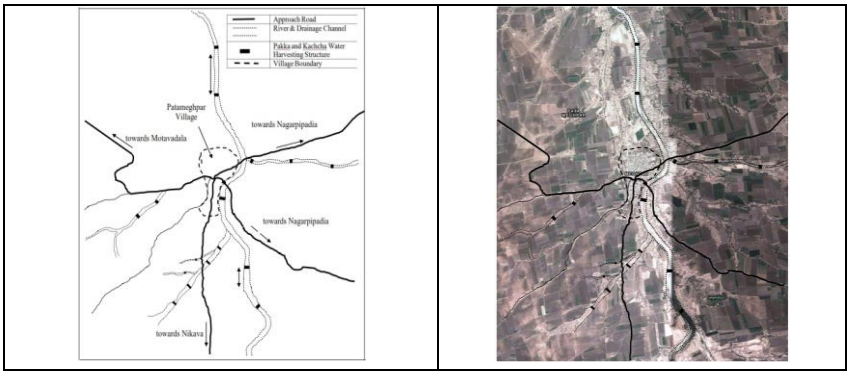
Table-307: Drought management in groundnut

Farmer	Pod yield (kg/ha)		RWUE (kg/ha-mm)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Integrated pest management	Farmer's practice				
V S Tarpara	2010	1850	1.82	73813	50113	2.11
M P Kathiria	1920	1790	1.74	70400	46700	1.97
G B Tarapra	1630	1450	1.48	59738	36038	1.52
J P Pambhar	1950	1920	1.76	71538	47838	2.02
G S Kamani	2100	1830	1.90	77225	53525	2.26
Improved practices	1922	-	1.74	70543	46843	1.98
Farmer practices	-	1768	1.60	64490	41840	1.85

Spraying of Thiourea @ 2 %

Farmer's practice

Rainwater management



Rainwater harvesting during 2013 at NICRA village

Pucca Structure

Kacha Structure

Farm ponds

View of rainwater harvesting structures in NICRA village

***In-situ* moisture conservation**

The results showed that opening of dead furrows between two rows for *in-situ* moisture conservation in cotton recorded higher seed cotton yield (2628 kg/ha) which was higher by 20.4 % in compared to farmer practices. It also recorded higher water use efficiency (2.35 kg/ha-mm), net return (Rs. 87775/ha) and B: C ratio (2.35).The rainfall of 1105 mm was received which was excess by 550.5 mm compared normal of 554.5 mm, during south-west monsoon (*kharif*), there were long dry spells during 17th August to 22nd September (36 days). 25-26th September were the months with excess rainfall during north-east monsoon (October - December) (Table-308).

Table-308: Effect of dead furrow on cotton yield and economics

Farmer	Seed cotton yield (kg/ha)		RWUE (kg/ha-mm)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Improved practices	Farmer's practice				
K P Kathiria	2888	2475	2.61	137445	100145	2.68
P P Khakhria	2613	2269	2.36	124355	87055	2.33
D P Khakhria	2723	2131	2.46	129591	92291	2.47
S M Thesia	2475	2338	2.24	117810	80510	2.16
S M Hada	2915	2365	2.64	138754	101454	2.72
M B Gadhia	2544	1925	2.30	121083	83783	2.25
K D Tarpara	2489	1994	2.25	118465	81165	2.18
J L Thesia	2269	1856	2.05	107993	70693	1.90
L K Thesia	2613	2338	2.36	124355	87055	2.33
G D Thesia	2750	2131	2.49	130900	93600	2.51
Improved practices	2628	-	2.38	125075	87775	2.35
Farmer practices	-	2182	1.97	103869	66869	1.81

Addition of manure or *murrum* for *in-situ* moisture conservation in groundnut recorded higher pod (2228 & 2175 kg/ha) by 22 and 17% as compared to farmer practices, respectively. The treatments also recorded higher water use efficiency (2.02 & 1.97 kg/ha-mm), net return (Rs.59615 & 56317) and B:C ratio (2.62 & 2.35) , respectively (Table-309).

Table-309: Effect of manure and *murrum* application on groundnut yield and economics

Treatment	Pod yield (kg/ha)	RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
Manure @ 5t/ha	2228	2.02	59615	2.62
Manure @ 10t/ha	2175	1.97	56317	2.35
Farmer practices	1841	1.67	45487	2.00

Manure @ 5t/ha

Murrum @10t/ha

Efficient energy use and management

Primary tillage by using reversible plough (in summer) recorded higher seed cotton yield (2731 kg/ha) which was higher by 19.7% in compared to farmer practices. It also recorded higher water use efficiency (2.47 kg/ha-mm), net return (Rs.88396) and B:C ratio (2.12) (Table-310).

Table-310: Effect energy use and management through custom hiring

Farmer	Seed cotton yield (kg/ha)		RWUE (kg/ha-mm)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
	IP	FP				
B.R. Vasoya	2800	2450	2.53	133280	91680	2.20
M.M. Gamara	2650	2125	2.40	126140	84540	2.03
V.S. Tarpara	2813	2094	2.55	133899	92299	2.22
D.B. Cirodiya	2570	2375	2.33	122332	80732	1.94
M.A. Jesadiya	2800	2250	2.53	133280	91680	2.20
R..K. Akbari	2750	2300	2.49	130900	89300	2.15
D.A. Bokhani	2400	2150	2.17	114240	72640	1.75
Improved practices	2731	-	2.47	129996	88396	2.12
Farmer practices	-	2282	2.07	108623	72423	2.00

* IP: Improved practices summer tillage using reversible plough; FP: Farmer's practice summer tillage using local plough

Tillage with reversible plough (in summer)

1.8. COTTON BASED PRODUCTION SYSTEM

1.8.1. AKOLA

a. Agro-ecological setting

Akola is in Eastern Maharashtra of Deccan Plateau, hot semi-arid eco-region (AESR 6.3). The climate is hot moist semi-arid. Average annual rainfall is 825 mm. Length of growing period is 120-150 days.

b. On-station experiments

During 2013, the onset of monsoon was during second week of June i.e 11-17th June (24th MSW). a rainfall of 821.7 mm was received which was excess by 133.7 mm compared to normal (688 mm) during south-west monsoon (*kharif*) (Fig.45). During north-east monsoon (October - December), 86.3 mm of rainfall was received which was excess by 4.3 mm compared to normal (82 mm). During summer (March - May), 4 mm of rainfall was received which was deficit by 18.8 mm compared to normal (22.8 mm). There were two dry spells of 10 days (June 20th to 29th coinciding with germination and emergence of soybean, sorghum, pigeonpea and cotton) and another 10 days dry spell (September 23rd to 2nd October coinciding with pod filling stage of soybean, flowering stage of sorghum, late vegetative stage of pigeonpea and flowering stage of cotton).

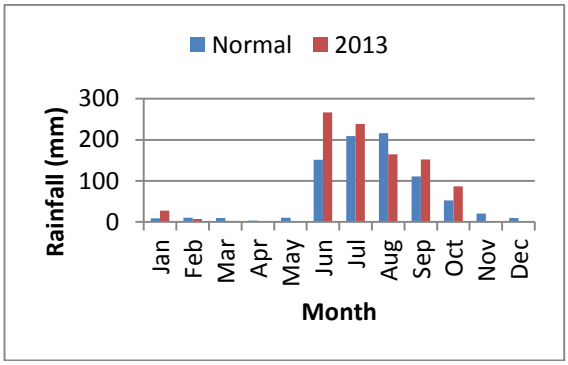


Fig.45: Normal and actual (2013) monthly rainfall at Akola

Alternate land use systems

During *kharif* 2013, custard apple based agri-horti-systems were demonstrated. Maximum net monetary returns (Rs.3930/ha), B:C ratio of 1.46 and rainwater use efficiency (0.94 kg/ha-mm) was recorded in custard apple + greengram intercropping system. The rainfall in June month was excess by 75.9%, 14.1% in July and 36.7% in September, whereas the rainfall during August month was deficit by 23.9% compared to normal rainfall (Table-311.).

Table-311: Performance of custard apple based agri-horti system

Treatment	Rainfall (mm)	Yield (kg/ha) Y1+Y2	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Custard apple	-	298.5	3250	500	1.15
Custard apple + greengram	324.2	125	8542	3930	1.46

Simislarly, hanuman phal based based agri-horti-systems were demonstrated. Maximum net monetary returns (Rs.5065/ha), B:C ratio of 1.59 and rainwater use efficiency (0.59 kg/ha-mm) was recorded in hanuman phal + greengram intercropping system. There were two dry spells of 10 days (20th to 29th June coinciding with germination and emergence of greengram) and another 10 days dry spell (September 23rd to 2nd October coinciding with pod filling stage of greengram) (Table-312).

Table-312 : Performance of hanuman phal based agro- horti system

Treatment	Rainfall (mm)	Yield (kg/ha) Y1+Y2	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Hanuman phal	-	337	3250	1700	1.52
Hanuman phal + greengram	324.2	165	8542	5065	1.59

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA Centre, Akola in Varkhed (Bk) village, Barshi Takali Taluka, Akola district, Maharashtra. The total cultivated area is 275 ha out of which 252 ha is rainfed. The mean annual rainfall is 796.0 mm with seasonal rainfall of 743 mm during *kharif* (June -September). The major soil types are shallow, medium deep and very deep black soils. The major rainfed crops during *kharif* are cotton, soybean, greengram, sorghum and pigeonpea and during *rabi* is chickpea. The number of small, marginal, medium and large farmers are 84, 84, 29 and 1, respectively. The groundwater table is 7.8 m below ground. The source of irrigation is open wells and bore-wells covering 8.36% of cultivated area.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 818 mm, the south-west monsoon contributes 84%, post-monsoon contributes 9%, winter contributes 3% and summer contributes 4%. The historical rainfall data (last 30 years) indicated that the variability in rainfall during south-west monsoon was deficit with -16**%** of the average rainfall. The onset (south-west) of monsoon is during 24th SMW and post monsoon rains were uncertain. For the past 10-15 years, dry spells are being experienced during July, August and September coinciding with the vegetative or reproductive stages of the major rainfed crops. The onset of the monsoon was sometimes delayed up to 25th SMW and 26th SMW and early withdrawal observed during 39th SMW. The soil moisture status was often deficit during the reproductive stages of major rainfed the crops, particularly cotton and pigeonpea.

The maximum/minimum temperature during crop season showed insignificant increasing trend of maximum (+ 0.05^{0}C/year) and minimum (+0.08^{0}C/year) for kharif season and insignificant decreasing trend of maximum (0.02^{o}C/year) and increasing trend of minimum temperature (+0.1^{o}C/year) for *rabi* season for the past 10 years. The extreme events like unusual and high intensity rainfall in short span were decreasing during *kharif* and *rabi* seasons.

The area has also been experiencing other extreme events like cold wave normally during the second fortnight of December to first fortnight of January. There has been a shift in the rainfall pattern with decadal trend showing a decrease in June and July rainfall in the last two decades and increase in September rainfall during the same period.

Experienced weather conditions during the year (2013-14)

The onset of monsoon was during second week of June i.e 11-17th June (24th MSW). The rainfall dates of Barishthakli station, (nearest rain gauge station i.e 12 km from Warkhed watershed)was taken for the analysis of weather conditions during the year 2013 at Barishthakli village. A rainfall of 1365 mm was received which was excess by 698.7 mm compared to normal (666.3 mm) (Fig.) during south-west monsoon (*kharif*).

During north-east monsoon (October - December), 210 mm rainfall was received which was excess by 143.2 mm compared to normal (66.8 mm). During summer, 30 mm of rainfall was received which was excess by 6.7 mm compared to normal (23.3 mm). There were two dry spells during 28th July to 22nd August i.e 26 days coinciding with vegetative and flowering stage and 6th to 26th September i.e 21 days at pod development and pod maturity stage of groundnut crop during kharif season. In *rabi* season dry spells were recorded during (23rd November to 4th December i.e 12 days coinciding with pod development stage in chickpea, and 7th to 31st December i.e 25 days coinciding with pod maturity stage in chickpea (Fig.46).

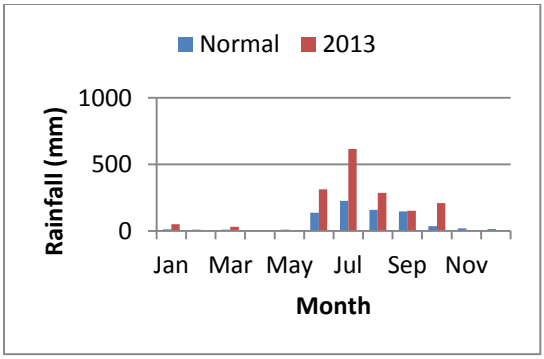


Fig.46: Normal and actual (2013) monthly rainfall at Barishthakli

Real time contingency crop planning

Under this programme, sorghum hybrids CSH-9, CSH-14 and Bhagyalaxmi-296 were demonstrated on six farmers' fields. Among the three varieties, Bhagyalaxmi-296 gave highest mean yield of 1337.8 kg/ha, net return (Rs.11975/ha), and rainwater use efficiency (1.80 kg/ha-mm) with mean B:C ratio of 1.92. During north-east monsoon (October - December), 210 mm rainfall was received which was excess by 143.2 mm compared to normal (66.8 mm). There was excess rainfall in October (493.2%) followed by no rainfall in November and December. Two dry spells were recorded during 23rd November to 4th December i.e 12 days coinciding with flowering in sorghum and during 7th to 31st December i.e 25 days coinciding with dough stage.

Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
CSH-9	1012	1.45	12191	5884	1.44
CSH-14	1129	1.53	12191	7914	1.62
Bhagyalaxmi-296	1337	1.80	12191	11975	1.92

During *kharif*, soybean varieties JS-335, JS-93-05 and JS-95-60 were demonstrated on ten farmers' fields. Among all the three varieties, JS - 335 gave highest mean yield of 2183 kg/ha, net returns (Rs.51153.9/ha), and rainwater use efficiency (3.00 kg/ha-mm) with mean B:C ratio of 3.20 compared to over two varieties. A rainfall of 1365 mm was received which was excess by 698.7 mm compared normal (666.3 mm) during south-west monsoon (kharif). There were two dry spells during 28th July to 22nd August i.e 26 days coinciding with vegetative and flowering stage and 6th to 26th September i.e 21 days at pod development and pod maturity stage of soybean during *kharif* season (Table……..).

Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
JS-335	2183	3.00	22700	51153	3.20
JS-93-05	1422	1.90	19650	28469	2.40
JS-95-60	1724	2.30	20600	37745	2.80

Different intercropping systems were demonstrasted onfarmers' fields to cope with rainfall variability during *kharif* season. During *kharif* 2013, a rainfall of 1365 mm was received which was excess by 698.7 mm compared normal (666.3 mm) during south-west monsoon (*kharif*). There were two dry spells during 28th July to 22nd August i.e 26 days coinciding with vegetative and flowering stage and 6th to 26th September i.e 21 days at pod development and pod maturity stage of soybean, pigeon pea and sorghum during *kharif* season. The cotton, greengram and soybean based intercropping systems were demonstrated on thirty one farmers' fields. Among all cotton + sorghum + pigeonpea + sorghum (3:1:1:1) gave highest mean yield of 2166 kg/ha and rainwater use efficiency (2.89 kg/ha-mm) whereas cotton + soybean + pigeonpea + soybean (3:2:2:2) gave higher net return (Rs.51162/ha) and soybean + pigeonpea (4:2) gave higher B:C ratio of 3.21 followed by cotton + soybean + pigeonpea + soybean (3:2:2:2) with B:C ratio of 3.00 (Table-313).

Table-313: Performance of intercropping systems on fasrmers' fields

Intercropping system with row proportion	Yield (kg/ha) Y1+Y2	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Soybean + p.pea (4:2)	1858	2.50	20747	46960	3.21
G.gram + p.pea (4:2)	1290	1.70	23788	26530	2.0
Cotton + p.pea (6:2)	1417	1.89	26310	31052	2.15
Cotton + gram (1:1)	1346	1.78	20288	32593	2.58
Cotton + soybean + pigeon pea + soybean (3:2:2:2)	1933	2.60	25550	51162	3.00
Cotton + sorghum + pigeon pea + sorghum (3:1:1:1)	2166	2.89	22500	44820	2.99
Cotton + sorghum + pigeon pea + sorghum (6:1:2:1)	1450	1.93	20000	25076	2.25

Rainwater harvesting and recycling

During 2013, There were four dry spells during 28th July to 22nd August i.e 26 days coinciding with vegetative and flowering stage and 6th to 26th September i.e 21 days at pod development and pod maturity stage of groundnut crop during *kharif* season. In *rabi* season during 23rd November to 4th December and September 23rd to 2nd October. To facilitate runoff modulation and enhance in-situ moisture conservation, introduced furrow opening at 30 days in between rows of cotton. This resulted in mitigating the dry spells and gave yield of 1397 kg/ha (15.89% increase) compared to without furrow opening with rainwater use efficiency of 3.49 kg/ha-mm. It gave B:C ratio of 3.02 as compared to a B:C ratio of 2.91 in case of without furrow opening (Table-314). Similarly, furrow opening at 30 days in between rows of soybean resulted in mitigating the dry spells and gave yield of 2566 kg/ha (38.46% increase) compared to without furrow opening with rainwater use efficiency of 3.49 kg/ha-mm. It gave B:C ratio of 3.46 as compared to a B:C ratio of 2.71 in case of without furrow opening (Table-314).

Table-314: In- situ moisture conservation with opening furrow at 30 DAS in cotton and soybean

Intervention	**Rainfall (mm)**	**Duration of crop**	**Yield (kg/ha)**	**RWUE (kg/ha-mm)**	**Cost of cultivation (Rs/ha)**	**Net return (Rs/ha)**	**B:C ratio**
Sole cotton							
Furrow opening	768.1	215.6	1397	1.82	19100	38738	3.02
Without furrow opening	750.8	219.5	1175	1.56	21550	41288	2.91
Sole soybean							
Furrow opening	737.3	101.8	2566	3.49	24981.25	61627	3.46
Without furrow opening	734.1	100.6	1579	2.15	19658	34058	2.71

Efficient energy use and management/ Timely operations through custom hiring center

During 2013-14, custom hiring services significantly contributed to alleviate the labour shortage during peak demand period. Multipurpose thresher was introduced for threshing of soybean which reduced the soybean harvesting time, labour cost by 33.3% and also reduced the cost of harvesting (Table-315). About 39 farmers wre benefitted and 15.6 ha area was harvested by using multi thresher.

Table-315: Performance of multithresher in soybean

No. of farmers	**Area covered (ha)**	**Total produce threshed (q)**	**Expenditure on threshing (Rs/qt)**	
			Multipurpose thresher under custom hiring	**Manual threshing**
39	15.6	628	Tractor fare (driver +Diesel): Rs. 40 Labour charges Rs. 50 Custom hiring charges: Rs. 10	Labour charges Rs. 150
			Total: Rs. 100	**Rs. 150**

1.8.2. KOVILPATTI

a. Agro-ecological setting

Kovilpatti is in Tamil Nadu uplands and leeward flanks of South Sahayadris and Deccan (Karnataka) plateau (*AESR 8.1*). The climate is hot semi-arid. Potential evapo-transpiration is 812 mm. Rainfall is 728 mm. Length of growing period is 90-120 days. The frequency of drought is once in ten years. Water erosion is medium severe with slight loss of top soil, affecting 26-50% area. The soils are moderately deep to deep, loamy to clayey and mixed red and black . Available water capacity is medium. Soil reaction is neutral to slightly alkaline, medium in organic 'C' and 'P' and high in 'K' content. Deficient nutrients are sulphur, calcium, zinc etc.

b. On-station experiments

During 2013, a rainfall of 43.6 mm was received which was deficit by 106.6 mm compared to normal (150.2 mm) during north-east monsoon (October - December) 252.8 mm of rainfall was received which was deficit by 138.1 mm compared to normal (390.9 mm) (Fig.47). During January, February and March,2013, 73 mm of rainfall was received which was excess by 4.5 mm compared to normal (68.5 mm).

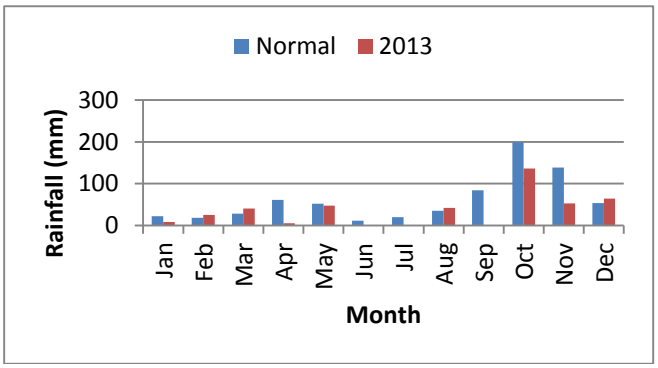


Fig.47: Normal and actual (2013) monthly rainfall at Kovilpatti

Real time contingency crop planning

The improved varieties of rainfed crops *viz.*, cotton, maize and pearlmillet were evaluated.

Cotton : Among the four Bt cotton hybrids, Jackpot hybrid recorded higher yield (866 kg/ha), B:C ratio (1.21) and rainwater use efficiency of 3.19 kg/ha-mm followed by Chiruta (845 kg/ha). During the growth period of cotton, the rainfall (272 mm) was deficit by 35%. The rainfall in October was normal which coincided with vegetative stage of the crop. But the rainfall was deficit by 65% in November which coincided with squaring, flowering and boll formation stages of the crop resulting is poor crop growth and yield (Table-316).

Table-316: Performance of Bt cotton under deficit rainfall conditions

Hybrid/ variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Jadoo	838	3.09	30000	5196	1.17
Jackpot	866	3.19	30000	6372	1.21
Chiruta	845	3.11	30000	5490	1.18
Mallika Bt 2	551	2.03	30000	-6858	0.77

Maize: Maize hybrid NK 6240 recorded highest grain yield (1995 kg/ha) followed by TNAU hybrid COH(M)6 (1975 kg/ha). The B:C ratios of these two hybrids were on par. During the growth period of maize in *rabi* 2013, the rainfall (259 mm) was deficit by 47%. The rainfall received during vegetative stage was 127.4 mm (deficit by 58%). In flowering and fertilization stage the rainfall was normal (38.8 mm) and 40.6 mm was received during grain filling and maturity stage (24% deficit). Due to the poor distribution of rainfall, moisture stress occurred during the critical growth stages resulting in stunted crop growth and poor yields (Table-317).

Table-317: Performance of maize varieties/hybrid

Hybrid/variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
NK 30	1914	7.39	25000	-118	1.00
900 M Gold	1908	7.37	25000	-196	0.99
COH(M) 6	1975	7.63	25000	678	1.03
NK 6240	1995	7.71	25000	941	1.04

Pearlmillet: Among the pearl millet hybrids, the pioneer hybrid recorded highest yield of 3111 kg/ha, net returns (Rs.37332), B:C ratio (1.66) and rainwater use efficiency (21.15 kg/ha-mm) followed by the TNAU hybrid CO (Cu) 9 (2667 kg/ha). The length of panicle was higher in CO Cu 9 hybrid. During the cropping season, the rainfall was deficit by 41%. During this period a total of 271.9 mm of rainfall was received in 16 rainy days against the normal of 459 mm in 25 rainy days (Table-318).

Table-318: Performance of pearlmillet varieties/hybrid

Hybrid/ variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Pioneer 80 M 32	3111	21.15	22500	14832	1.66
KH 301	2507	17.04	22500	7584	1.34
CO (Cu) 9	2667	18.13	22500	9504	1.42
Co 9	2396	16.29	22500	6255	1.28

Mitigation of in-season dry spells

Foliar spray of pink pigmented facultative methanotrophs (500 ml/ha) recorded higher seed cotton yield (296 kg/ha) than control (255 kg/ha) followed by foliar spray of 1% KCl , which was on par with 100 ppm salicylic acid. Foliar spray of pink pigmented facultative methanotrophs recorded 16 % yield increase over the control. During the growth period of cotton, the rainfall was deficit by 35%. The rainfall in October was normal which coincided with vegetative stage of the crop. But the rainfall was deficit by 65% in November which coincided with squaring, flowering and boll formation stages of the crop resulting in poor crop growth and yield (Table-319).

Table-319: Performance of foliar application during in-season dry spells/droughts

Treatments	Plant height (cm)	No of monopodial branches	No of sympodial branches	Boll weight (g/boll)	Seed cotton yield (kg/ha)
KCl (1%)	74	1	14	4.32	290
Salicylic acid (100 ppm)	73	2	13	4.21	288
Thio urea	75	1	13	4.63	255
Pink pigmented facultative methanotrophs (500 ml/ha)	85	1	14	4.78	296
$ZnSo_4$ (0.5%) + Boric acid (0.3%) + $FeSo_4$ (0.5%) + Urea (1%)	86	1	15	4.31	267
Control	70	1	10	4.12	255
CD (P=0.05)	12.8	NS	2.2	NS	25.7

Evaluation of different intercropping systems

Due to deficit rainfall (272 mm) during the cropping season, all the intercropping systems failed to bring significant improvement in cotton equivalent yield. However, even with deficit rainfall, the intercrops such as cluster bean (1079 kg/ha) and onion (1221 kg/ha) recorded higher yield which resulted in higher cotton equivalent yield, B: C ratio (1.29 & 1.42) and rain water use efficiency (3.97 & 4.50 kg/ha-mm) ,respectively than other intercropping systems (Table-320).

Table-320: Performance of different cotton based intercropping systems

Intercropping system with row ratios (1:2)	Cotton equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	LER	MAI
Bt cotton (sole)	330	1.22	32000	-18140	0.43	-	-
Bt cotton + cluster bean	1079	3.97	35000	10318	1.29	1.71	1242
Bt cotton + radish	566	2.08	34200	-10428	0.70	1.84	107
Bt cotton + onion	1221	4.50	36000	15282	1.42	2.13	885
Bt cotton + coriander	619	2.28	33150	-7152	0.78	1.83	136

Rainwater harvesting (*in-situ and ex-situ*) and efficient use

Adoption of broad bed furrows (BBF) technique for in-situ moisture conservation resulted in 15.7 , 13.9 and 18.2 % higher yield in green gram, pearl millet and maize , respectively due to increased moisture levels in broad bed furrow treatment compared to ridges and furrow in maize and flat sowing of green gram and pearl millet. During the cropping season the rainfall was deficit by 44 %. During this period a total of 281 mm of rainfall was received in 20 rainy days against the normal of 501.3 mm in 26 rainy days (Table-321).

Table-321: Performance of crops under *in-situ* moisture conservation practices

Crop	Rain-fall (mm)	*In-situ* conservation technology	Percent increase in yield over flat sowing	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation	Net return (Rs/ha)	B:C ratio
Maize (NK 30)	35.7	Broad bed furrows	325	1818	7.37	15000	-9475	0.37
		Ridges and furrows	275		9.97	14000	-6525	0.53
Greengram (CO 6)	221.7	Broad bed furrows	575	1573	1.24	23000	5750	1.25
		Flat sowing	425		1.47	22000	-750	0.97
Pearlmillet - II (Pioneer)	57.7	Broad bed furrows	205	1388	3.85	15000	-4750	0.68
		Flat sowing	180		7.42	14000	-5000	0.64

CD (p=0.05) : Maize-38; Green gram-150; Pearlmillet-44

During *rabi* 2013 - 14, four runoff events occurred during the month of October 2013. The intensity of the runoff causing rainfall was 40 mm/hr. The total volume of water stored in farm pond was 408 m^3. The test crops of Bt cotton and hybrid maize were raised in an area of 0.2 ha each. The stored water was reused for giving supplemental irrigation using a raingun with nozzle diameter of 1.5" and wetting radius of 15 m. Supplemental irrigation to a depth of 2.2 cm was given during 45^{th} week (11.11.2013) when the cotton and maize crops were in vegetative phase. Since irrigation was given during vegetative phase and there was prolonged drought during the flowering and reproductive stages significant yield difference was not recorded (Table-322).

Table-322: Water storage details in farm pond

Date of runoff event	Intensity of rainfall (mm/hr)	Amount of rainfall (mm)	Depth of water in farm pond (mm)	Volume of water stored (m^3)
17.10.2013	40	37.2	150	60
19.10.2013	40	25.6	470	188
21.10.2013	40	26.2	300	120
22.10.2013	40	16.8	100	40
			Total	**408 m^3**

Alternate land use for carbon sequestration and ecosystem services

In aonla based intercropping systems, the intercrops, cowpea, green gram and cluster bean were sown in the interspaces, of aonla. Among the three crops , green gram recorded highest yield of 233 kg/ ha. In custard apple based intercropping systems, the intercrops, green gram, horse gram and moth bean were sown in the interspaces of custard apple. Among the three crops, green gram recorded highest yield of 266 kg/ ha . In sapota based intercropping systems, bhendi, bengal gram and coriander were sown in the interspaces of sapota. Among the three crops, bhendi recorded highest vegetable yield of 288 kg/ ha. The crop establishment was satisfactory during October and subsequently due to failure of monsoon rains during November and December, the crop growth was affected severely. A total rainfall of 421.3 mm was received with 28 rainy days. The tree seedlings *viz*., aonla, custard apple and sapota were pot watered during moisture stress condition. Deficit rainfall resulted in low intercrop yield and less income. The net income showed a negative trend and the B:C ratio was also less than one in all the systems (Table-323).

Table-323: Performance of aonla, custard apple and sapota based agri-horti systems

Crop/variety	Intercrop	Yield (kg/ha)	Crop duration (days)	Cost of cultivation (Rs/ha)	Net Return (Rs/ha)	B:C ratio
		Crop				
Aonla (Krishna & NA-7)	Sole	-	perennial	3000	0	0
	Cowpea (P 152)	173	75	12500	-4700	0.62
	Green gram (CO 6)	233	70	15000	-4500	0.70
	Cluster bean (PNB)	222	90	12000	-2000	0.83
Custard apple (APK-1)	Sole	-	perennial	4000	0	0
	Green gram (CO 6)	266	75	15000	-3000	0.80
	Horse gram	133	90	8000	-2000	0.75
	Moth bean	100	70	8000	-3500	0.56
Sapota (PKM-1)	Sole	-	perennial	3200	0	0
	Bhendi	288	90	17500	-4500	0.74
	Bengal gram	110	90	8000	-3000	0.63
	Coriander (local)	88	60	10000	-6000	0.40

The results soils under different land use systems were found to be poor in nutrient status with low available N (56 to 95 kg/ha), P (1.9 to 9.2 kg/ha) and medium K (142 to 281 kg/ha). Organic carbon content varied from low to medium (0.11 to 0.74%) (Table-324).

Table-324: Soil properties under land use systems

Crop	Soil depth (cm)	pH	EC (dS/m)	Available nutrients (kg/ha)			OC (%)
				N	P	K	
Aonla	0-15	8.25	0.32	76	5.0	263	0.43
	15-30	8.12	0.29	62	8.3	211	0.21
	30-45	8.06	0.43	56	10	228	0.11
Custard apple	0-15	8.23	0.29	73	9.2	281	0.38
	15-30	8.06	0.54	62	8.3	217	0.19
	30-45	8.08	0.52	87	1.9	173	0.62
Sapota	0-15	8.39	0.36	62	8.3	193	0.23
	15-30	8.28	0.48	95	6.7	181	0.74
	30-45	8.21	0.41	78	9.2	142	0.48

c. On-farm experiments

Village: Nakkalamuthanpatti, Taluk: Kovilpatti, District: Thoothukudi, Tamil Nadu

Village profile

The program is being implemented by AICRPDA centre, Kovilpatti in Nakkalamuthanpatti village, Kovilpatti Taluk, Thoothukudi district, Tamil Nadu. The total cultivated area is 578.83 ha out of which 342 ha is rainfed. The mean annual rainfall is 783.1 mm with seasonal rainfall of 305.1 mm during *rabi* 2012 (October - December). The major soil types are medium deep to deep black soils and red soils. The major rainfed crops during *rabi* are maize, greengram, blackgram, cotton and sunflower. The number of small, marginal and large farmers are 111, 368 and 69 respectively. The ground water table is 800 cm. The source of irrigation is open dug wells, covering 15% of cultivated area.

Climate vulnerability

The climate in this agro-climatic zone is semi-arid and north-east monsoon season is the main cropping season under rainfed conditions in this zone. Out of the total annual average rainfall of 737.8 mm, the south-west monsoon contributes 20.1%, north-east monsoon contributes 53.1% and summer contributes 20.6%. The historical rainfall data indicates that the variability in rainfall during south-west monsoon season (in the last 30 years from 1972 to 2011) is 17.6% surplus compared to the average rainfall from 1901 to 1971. While comparing the same periods, it was found that rainfall during north-east monsoon season is 5.9% surplus. The onset of south-west monsoon was during 22nd SMW (1st June) and north-east monsoon was during 42nd SMW (20th October) in the state. The length of growing period spans from 38th SMW to 47th SMW. The dry spells during cropping season are experienced in the months of December and January (from 49th SMW to 4th SMW) for the past 10 years which coincided with grain maturity stages of the major rainfed crops. The onset of the south- west monsoon (SWM) and north-east monsoon (NEM) in the last ten years is normal with a maximum deviation of ± 9 days. The soil moisture status was deficit during grain maturity stages of major rainfed crops.

Maximum temperature during SWM and NEM season did not change in the last ten years (2002 – 2011) compared to the previous ten years (1992 – 2001); while comparing the same periods, it was found that minimum temperature increased by 2.4˚C in both the seasons. The extreme events like unusual and high intensity rainfall in short span did not show any change during kharif and rabi seasons. No other extreme event was experienced in this area. There has been no shift in the rainfall pattern and sowing window during NEM season; the sowing week is 37th SMW for the dominant rainfed crops.

Weather conditions during 2013-14

During 2013, in Muthukri shnapuram village, onset of monsoon was early by 1 day during 3rd week of October. A rainfall of 19.7 mm was received which was deficit by 130.5 mm compared to normal (150.2 mm) during north-east monsoon (October - December) 267.1 mm was received which was deficit by 123.8 mm compared to 390.9 mm During months of (January and February -2014) 4.2 mm of rainfall was received which was deficit by 36.4 mm compared to normal (40.6 mm). There were no dry spells during the cropping season (Fig.48).

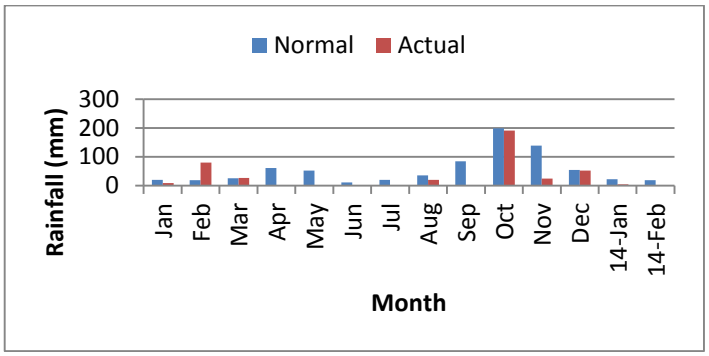


Fig.48: Normal and actual (2013) monthly rainfall at Muthukrishnapuram village

Interventions

The major interventions that were implemented include land configuration, crops or varieties; timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 7.1 ha in 32 farmers' fields.

Real time contingency crop planning

Under this component improved varieties of rainfed crops viz., cotton, maize, and pearl millet were introduced to cope with rainfall variability in the village.

Cotton: Among the Bt hybrids, Jackpot recorded highest seed cotton yield of (644 kg/ha), gross returns (Rs. 27048/ha),BC: ratio of (0.77) and rainwater use efficiency of (2.95 kg/ha-mm) followed by Jadoo (630 kg/ha). During the cropping season of cotton in 2013, the rainfall (218 mm) was deficit by 49%. The rainfall received during establishment to squaring (58 days) was 215 mm (34% deficit), squaring to blooming was 52 mm (18% deficit) and blooming to boll opening was 24 mm (91% deficit). Due to this moisture stress during the critical growth stages, crop showed wilting symptoms, squaring and flowering were affected and crop yield was reduced (Table-325).

Table-325: Performance of Bt cotton hybrids at farmers' fields

Hybrid/ variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Jadoo BG II	630	2.89	35000	-8540	0.76
Jackpot BG II	644	2.95	35000	-7952	0.77
Chiruta BG II	604	2.77	35000	-9632	0.72
Mallika BG II	562	2.57	35000	-11270	0.68

Maize : Among the four maize hybrids, the NK 30 hybrid registered highest grain yield of 1490 kg/ha ,gross returns (Rs.19370/ha),B:C ratio (0.77) and rain water use efficiency of (6.83 kg/ha-mm) followed by NK 6240 (1439 kg/ha). During the cropping season of maize in 2013 the rainfall was deficit. During this period a total of 271 mm of rainfall was received in 16 rainy days against the normal of 418 mm in 20 rainy days. The rainfall received during vegetative stage was 215 mm (34% deficit), the same during flowering and fertilization was 32 mm (111% deficit) and grain filling and maturity was 24 mm (56% deficit). Due to this, crop showed wilting symptoms and poor yield was recorded (Table-326).

Table-326: Performance of maize varieties/hybrids at farmers fields

Hybrid/variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
NK 30	1490	6.83	25000	-5630	0.77
900 M Gold	1360	6.23	25000	-7320	0.71
COH(M)6	1280	5.87	25000	-8360	0.67
NK 6240	1439	6.60	25000	-6293	0.75

Pearlmillet: Among the four pearl millet hybrids, Pioneer 80M32 produced higher grain yield (2613 kg/ha) followed by KH301 (2272 kg/ha). The RWUE and B:C ratio was higher with pioneer hybrid. The lowest yield was recorded in C0 9 hybrid. During the cropping season the rainfall was deficit by 41%. During this period a total of 271.9 mm of rainfall was received in 16 rainy days against the normal of 459 mm in 25 rainy days. The rainfall received during the months of October, November and December was 191, 24 and 52 mm against the normal of 198, 138 and 53 mm, respectively. The rainfall in October was normal which coincided with vegetative stage of the crop. But the rainfall was deficit by 82% in November which coincided with flowering and grain filling stages of the crop resulting in poor crop yield (Table-327).

Table-327: Performance of improved varieties/hybrids of pearlmillet at farmers' fields

Hybrid/variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Pioneer 80 M 32	2613	45.50	18750	12606	1.67
KH 301	2272	39.56	18750	8514	1.45
CO (Cu) 9	2210	38.48	18750	7770	1.41
Co 9	2028	35.31	18750	5586	1.30

Intercropping systems

Due to failure of monsoon all the intercropping systems showed negative trend on the net income. The Bt cotton + radish resulted in higher cotton equivalent yield of 867 kg/ha followed by Bt cotton + onion (783 kg/ha). All the intercropping systems recorded B:C ratio less than one. However Bt cotton + onion system registered higher B:C ratio (0.94) than other intercropping systems. During the cropping season n in 2013, the rainfall was deficit by 49%. The rainfall received during establishment to squaring (58 days) was 215 mm (34% deficit), squaring to blooming was 52 mm (18% deficit) and blooming to boll opening was 24 mm (91% deficit). Due to this moisture stress during the critical growth stages, plants showed wilting symptoms, squaring and flowering were very much affected and crop yield was reduced (Table-328).

Table-328: Performance of cotton based intercropping systems in farmer's fields

Intercropping system with row ratios (1:1)	Cotton Equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	LER	MAI
Bt cotton (sole)	625	2.87	32500	-6250	0.81	-	-
Bt cotton + cluster bean	694	3.18	36000	-6852	0.81	1.34	126
Bt cotton + radish	867	3.97	52750	-16336	0.69	1.54	44
Bt cotton + onion	783	3.59	35000	-2114	0.94	1.41	51
Bt cotton + coriander	638	2.92	34375	-7579	0.78	1.14	17

Rainwater harvesting (*in-situ and ex-situ*) and efficient use

Maize: Sowing maize (Var.NK 30) on broad bed furrows enhanced the soil moisture content (10 %) resulting in 24.8% increased yield (1902 kg/ha), gross returns of (Rs. 22824/ha), net returns of (Rs.324/ha), rain water use efficiency (8.56 kg/ha-mm) and B:C ratio (1.01) over flat sowing with tractor drawn *gorrus*. During the cropping season of maize in 2013, the rainfall was deficit; a total of 271 mm of rainfall was received in 16 rainy days against the normal of 418 mm in 20 rainy days. The rainfall received during vegetative stage was 215 mm (34% deficit), the same during flowering and fertilization was 32 mm (111% deficit) and grain filling and maturity was 24 mm (56% deficit) resulting in partial wilting and poor yield (Table-329).

Table-329: Performance of maize under *in-situ* moisture conservation practices

Type of *in-situ* conservation technologies	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Broad bed furrows	1902	8.56	22500	324	1. 01
Flat sowing	1523	6.86	22500	-4224	0.81

Greengram: Adoption of broad bed furrows resulted in 6 % soil moisture and 12 % increased yield (280 kg/ha), gross returns of Rs. 14000/ha and rainwater use efficiency (1.28 kg/ha-mm) of green gram (CO6) over flat sowing. During the cropping season of greengram in 2013, the rainfall was deficit; total of 267 mm of rainfall was received in 15 rainy days against the normal of 397 mm in 19 rainy days. The rainfall received during vegetative stage was normal but the same during flowering was 0 mm (100% deficit) and pod formation and maturity was 70 mm (30% deficit). Due to this moisture stress during the critical growth stages, plants showed wilting symptoms, flowering and pod formation were affected and crop yield was reduced (Table-330).

Table-330: Performance of green gram under *in-situ* moisture conservation practices

Variety	Type of *in-situ* conservation technologies	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)
CO 6	Broad bed furrows	280	1.28	21000	-7000
	Flat sowing	250	1.15	20000	-7500

Blackgram: Adoption of broad bed and furrows resulted in 8.1 % increased yield (200 kg/ha), gross returns of Rs. 10000/ha and rainwater use efficiency (0.92 kg/ha-mm) of black gram (Nirmal) over flat sowing. During the cropping season of blackgram in 2013, the rainfall was deficit; a total of 217.9 mm of rainfall was received in 15 rainy days against the normal of 397 mm in 19 rainy days. The rainfall received during vegetative stage was normal but the same during flowering was 0 mm (100% deficit) and pod formation and maturity was 70 mm (30% deficit).Hence plants showed wilting symptoms, flowering and pod formation were affected and crop yield was reduced (Table-331).

Table-331: Performance of black gram under *in-situ* moisture conservation practices

Rainfall (mm) from sowing to harvest	Type of *in-situ* conservation technologies	per cent increase in soil moisture over control	Yield (kg/ha)	RWUE (kg/ha-mm)
217.9	Broad bed furrows	-	200	0.92
	Flat bed sowing		185	0.85

Efficient energy use and management

During *rabi* 2013, wheel hoes and power weeders were used by the farmers on paying hiring charges of Rs.100/day for wheel hoes and Rs. 200/day for power weeders to the custom hiring centre. The revenue generated was Rs.1300. Due to mid season and terminal droughts, the weeders were used for taking up one weeding only (Table-332).

Table-332: Establishment of a custom hiring centre at Nakkalamuthanpatti village

Equipment	Nos.	Unit cost (Rs)	Total (Rs)
TNAU Power weeder	1	56100	56100
Hand operated sprayer	2	4150	8300
Power sprayer	1	6604	6604
Wheel hoe	10	1000	10000
Mini weeder	2	-	55150
Diesel pump set (1.5 HP)	1	15740	15740
Ferti seed drill	2	-	129990
Rotavator	1	73630	73630
Tractor mounted boom sprayer	1	125000	125000
Total			**4,80,514**

Establishment of custom hiring centre

Alternate land use and eco-system services

In aonla based intercropping system, green gram, cowpea and cluster bean were intercropped. The intercrops as well as the tree seedlings dried due to the drought. In acid lime based intercropping system, the crops cotton, pearl millet and maize were tested as inter crops. Among the three crops maize recorded highest yield of 1250 kg/ha.In sapota based intercropping system, bhendi, chickpea and coriander were intercropped. Among the three crops, coriander recorded highest yield of 125 kg/ha .The biometric observations on the height and girth of the seedlings were measured periodically in aonla, acidlime and sapota and they indicated no significant variation. The total rainfall received during the *rabi* 2013 was 222.1 mm .The crop establishment was satisfactory during October and subsequently due to failure of monsoon rains during November and December, the crop growth was affected severely. Deficit rainfall resulted in low intercrop yield and less income. The net income showed a negative trend and the B:C ratio was also less than one in all the systems (Table-333).

Table-333: Performance of aonla, acid lime, sapota based agri-horti systems

Farmer	Crop	Inter-crop	Yield (kg/ha)		Crop duration (days)	No. of tree prunings	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
			Main crop	Inter crop							
Mr. Subburaj	Aonla (Krishna)	Sole	In aonla based intercropping system the crops of green gram, cowpea and cluster bean were intercropped. The intercrops as well as the tree seedlings dried due to drought.								
Mr. Lingaraj	Acid lime (PKM 1)	Cotton (Jadoo)	-	600	160	Pre bearing stage	2.70	35000	27000	-8,000	0.77
Mr. Singarayar		Pearl millet (Pioneer)	Due to failure of rainfall during November and December, the crops failed.								

Mr. Selvaraj		Maize (NK30)	-	1250	110	-	5.62	30000	14375	-15,625	0.48
Mr. Subburaj		Sole	The Acid lime tree seedlings dried, because of insufficient rainfall during the years 2012-13 and 2013-14.								
Mr. Ravi	Sapota (PKM 3)	Bhendi (Arka anambika)	-	40	90	Pre bearing stage	0.18	10000	1250	-8,750	0.13
		Bengal gram (Local)	-	80	80	-	0.36	12000	10000	-2,000	0.83
		Coriander (PKM 1)	-	125	60	-	0.56	10000	9000	-1,000	0.90
Mr. P.Venkidasamy		Sole	The Sapota tree seedlings dried, because of insufficient rainfall during the years 2012 -13 and 2013-14.								

A field experiment was conducted to reduce the risk in agriculture due to the climatic variability. Horticultural tree crops *viz*., Aonla, sapota and acid lime were introduced to mitigate climate change through to enhanced soil carbon sequestration. During the reporting period soil samples were analyzed for the nutrient status of the soil. The results revealed that the soils were poor in nutrient status with low available N ranges from (56 to 108 kg/ha),P (3.8 to 13.3 kg/ha) and low to medium K (33 to 328 kg/ha).Organic carbon content varied from low to medium (0.19 to 0.92%). The change in carbon status are being studied by taking profile samples and the biomass carbon from fruit trees will also be calculated periodically at the end of the experiment (Table-334).

Table-334: Soil properties under land use systems

Farmer	**Crop**	**Soil depth (cm)**	**pH**	**EC (dS/m)**	**Available nutrients (kg/ha)**			**OC (%)**
					N	**P**	**K**	
Mr. Ravi	Sapota	0-15	8.39	0.58	108	12.5	150	0.92
		15-30	8.20	0.60	56	10	93	0.19
		30-45	8.19	0.41	56	3.75	33	0.19
Mr. Lingaraj	Acid lime	0-15	7.90	0.37	56	8.3	294	0.19
		15-30	7.79	0.26	56	9.2	294	0.19
		30-45	8.09	0.32	62	5.8	138	0.21
Mr. Selveraj	Acid lime	0-15	8.41	0.50	70	10	328	0.35
		15-30	8.49	0.25	76	13.3	244	0.43
		30-45	8.41	0.50	76	3.8	177	0.44
Mr. Subburaj	Acid lime	0-15	8.08	0.49	84	7.5	192	0.33
		15-30	8.08	0.49	70	4.4	222	0.19
		30-45	8.15	0.84	87	3.8	233	0.60

1.8.3. PARBHANI

a. Agro-ecological setting

Parbhani centre is located in Central and Western Maharashtra plateau eco-sub-region. The climate is hot moist semi-arid. Annual normal rainfall is 901 mm.

b. On-station experiments

During 2013, the onset of monsoon was delayed by 11 days (1st week of July). A rainfall of 1014.7 mm was received which was excess by 214.2 mm compared to normal (800.5 mm) during south-west monsoon (kharif) (Fig…49). During north-east monsoon (October - December), 157.9 mm of rainfall was received which was excess by 47.4 mm compared to normal (110.5 mm). During summer (March - May), 19.8 mm of rainfall was received which was deficit by 16.7 mm compared to normal (36.5 mm). There was one dry spell of 16 days 2nd to 18th August). However, dry spells of short duration upto eight days were regularly observed during the entire growing season.

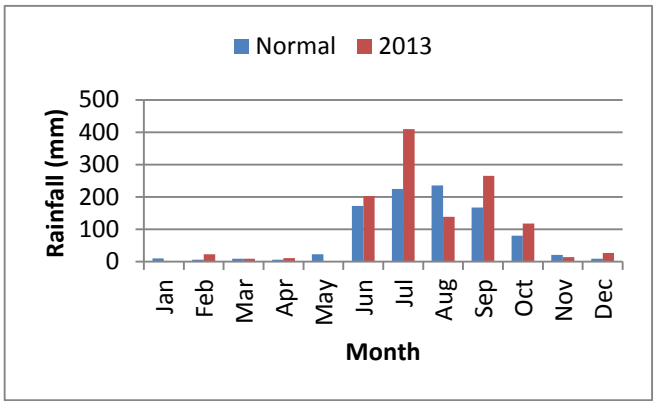


Fig.49: Normal and actual (2013) monthly rainfall at Parbhani

c. On-farm experiments

Village profile

The program is being implemented by AICRPDA Centre, Parbhani, in Pangri village in Jintur Taluka, Parbhani district, Maharashtra. The total cultivated area is 951.06 ha out of which 880.00 ha is rainfed. The mean annual rainfall is 835 mm with seasonal rainfall of 637 mm during *kharif* (June-September). The major soil types are medium deep to deep black soils. The major rainfed crops during *kharif* are soybean, sorghum, cotton, pigeonpea, greengram, blackgram and during *rabi* are sorghum, safflower and linseed. The number of small and medium, marginal and large farmers are 374, 75 and 25, respectively. The ground water table is 50 m below surface. The source of irrigation is wells covering 5% of cultivated area.

Climate vulnerability in general

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 835 mm, the southwest monsoon contributes 80 to 85%, north-east monsoon contributes 10 to 15 % and summer rainfall contributes about 5%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 10 - 15% deficit of the average rainfall. The onset (south-west) of monsoon is during 22 – 23 SMW. For the past 15 years, the dry spells during crop season were experienced during August and at vegetative or reproductive stages of the major rainfed crops. The onset of monsoon was normal. The soil moisture status was deficit during maturity stages of major rainfed crops. The maximum and minimum temperature during crop season are 41˚C and 21˚C respectively. The extreme events like unusual and high intensity rainfall in short span were increasing during kharif and rabi seasons. There had been a considerable shift in the rainfall pattern and it is observed that during last 5 years the onset of effective monsoon was in the 1st fortnight of July instead of last week of June. Hence, normal sowing period during *kharif* was delayed.

Experienced weather conditions during the year (2013-14)

The rainfall data of nearest station (Parbhani) were considered for planning of different interventions and interpretation of results. During 2013, in Pangri village, the onset of monsoon was delayed by 11 days during (1st week of July). A rainfall of 1014.7 mm was received which was deficit by 214.2 mm compared to normal (800.5 mm) during south-west monsoon (*kharif*) (Fig.50).

During north-east monsoon (October - December), 157.9 mm of rainfall was received which was excess by 47.4 mm compared to normal (110.5 mm). During summer (March - May), 19.8 mm of rainfall was received which was deficit by 16.7 mm compared to normal (36.5 mm). There was one dry spells of 16 days (2nd to 18th August). However, dry spells of short duration up to eight days were regularly observed during the entire growing season.

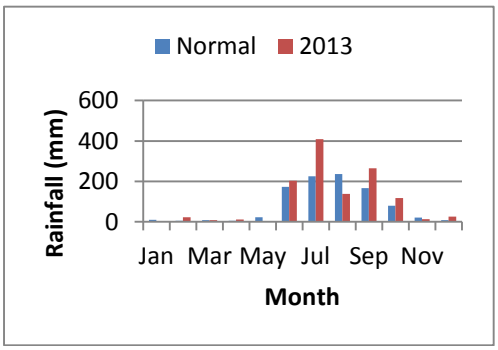


Fig.50: Normal and actual (2013) monthly rainfall at Pangri

Interventions

The major interventions implemented in the village include land configuration, crops or varieties/ cropping systems, timely operations through custom hiring centre and alternate land use and ecosystem services. These interventions covered an area of 27.2 ha in 68 farmers' fields.

Real time contingency crop planning

The rainfall of 1014.7 mm was received which was excess by 214.2 mm compared to normal (800.5 mm) during south-west monsoon (*kharif*) (Fig...). There was one dry spell of 16 days (2nd to 18th August). However, dry spells of short duration up to eight days were regularly observed during the entire growing season. The rainfall during June, July and September months was excess by 17.5, 81.9 and 58.3%, while the rainfall deficit in August by 41.4% compared to normal rainfall. During the *Kharif* 2013, improved verities of soybean MAUS 71, MAUS 81 and MAUS 158 were sown on 18 farmers' fields to cope up with the rainfall variability. Among the varieties MAUS 71 and MAUS 158 recorded plant height of 63 and 65 cm and seed yield of different varieties was between 15 to 16 q/ha. The variety MAU-81 recorded higher seed yield (16 q/ha) and rainwater use efficiency (1.64 1.64 kg/ha-mm) with 101 days to maturity and exhibited maximum number of pods/plant (72 pods/plant) while MAUS-71 and MAUS-158 recorded seed yield (15 q/ha) (Table-335).

Table-335: Yield and yield contributing characters of soybean varieties at NICRA village

Variety	Days to maturity	No. of pods/ plant	Height of plant (cm)	yield (q/ha)	100 seed weight (g)	RWUE (kg/ha-mm)
MAUS-71	101	70	63	15	12.1	1.57
MAUS-81	101	72	64	16	12.3	1.64
MAUS-158	101	70	65	15	12.1	1.58

Field demonstration of green gram varieties BM 2002-1, BM 2003-2 and BM 4 were conducted on 7 farmers' fields. Among the varieties the highest grain yield of 6.5 q/ha, B:C ratio (2.20) and rainwater use efficiency (6.8 kg/ha-mm) was recorded by BM 2002-01 followed by BM-4 (6.0 q/ha) (Table-336).

Table-336: Performance of greengram varoetoes

Variety	Days to maturity	No of pods/ plant	Height of plant (cm)	Yield q/ha	100 seed weight (g)	B:C ratio	RWUE (kg/ha-mm)
BM-4	65	11.75	65	6.0	5.1	2.03	6.3
BM2002-1	69	13	64	6.5	4.6	2.20	6.8
BM2003-2	64	11.5	65	5.2	5.25	1.77	5.5

Two varieties of blackgram i.e. BDU-1 and TAU-1 were demonstrated on four farmers' fields. Seed yield of 6.1 q/ha, B:C ratio (2.06) and rainwater use efficiency (6.3 kg/ha-mm) was obtained in variety BDU-1 compared to TAU-1 on farmers' fields (Table-337). Pearlmillet variety ABPC 4-3 was demonstrated on five farmers' fields. The variety gave a grain yield of 11 q/ha and matured in 85 days.

Table-337: Yield and yield contributing characters in black gram

Variety	Days to maturity	No of pods/ plant	Height of plant (cm)	Yield (q/ha)	Stalk yield q/ha	Harvest Index (%)	B:C ratio	RWUE (kg/ha-mm)
BDU-1	70	20	51.4	6.1	14.72	41.42	2.06	6.3
TAU-1	71	23	51.7	6.0	12.25	48.54	2.01	6.2

Three pigeonpea varieties *viz* BDN 708, BDN 711, BSMR 736 were demonstrated on 14 farmers' fields. Seed yield ranges from 9 to 12.3 q/ha. In general, BSMR- 853 performed better on farmer's field as compare to BDN 708 and BDN 711 (Table-338).

Table-338: Performance of pigeonpea varieties in farmers' fields

Variety	Days to maturity	No. of pods/ plant	Height of plant (cm)	Yield (q/ha)	RWUE (kg/ha-mm)
BDN -711	158.4	68.2	108.88	9.0	0.9
BDN -708	178	81.7	119.62	9.2	0.96
BSMR-853	181.6	84.6	121.13	12.3	5.53

The rainfall during October and December months was excess by 45.9% and 189.% , respectively whereas rainfall was deficit in November by 33.0% compared to normal rainfall. Two demonstrations of safflower variety PBNS 12 were conducted on farmers' fields. The mean seed yield of 9.70 q/ha was recorded for PBNS 12 variety and the variety matured in 146 days. (Table……..). Eight field demonstrations were conducted with Vijay, Digvijay and Akash varieties of chickpea. The highest mean grain yield of 14.20 q/ha was recorded in Akash variety as compared to Vijay and Digvijay (Table-339).

Table-339: Performance of chickpea varieties in farmers' fields

Variety	Days to maturity	No of pods/ plant	Height of plant (cm)	100 Seed Weight (g)	Yield (q/ha)
Vijay	131.3	81.3	56.63	19.46	11.39
Digvijay	127	73.5	51.97	21.17	11.98
Akash	118	160	54.9	21.2	14.20

Demonstrations of *rabi* sorghum varieties viz., Parbhani moti, Jyoti and M-35-1 were taken on farmers' fields. The highest grain yield was recorded by Jyoti (14.56 q/ha) followed by Moti (14.16 q/ha) (Table-340).

Table-340: Performance of *rabi* sorghum varieties

Variety	Days to maturity	Height of plant (cm)	100 Seed weight (g)	Yield (q/ha)
Moti	131.5	152.5	3.8	14.16
Jyoti	133.3	157.6	4.1	14.56
M-35-1	136.5	162.2	4.3	12.31

Crops and cropping system

Soybean + pigeonpea (4:2) intercropping was demonstrated on five farmers field. Shri. Pardhe manchak shankarrao recorded highest soybean equivalent yield (10.35 q/ha) of soybean + pigeonpea (4:2). Gross monetary return, net monetary returns and B:C ratio as compared to other farmers (Table-341).

Table-341: Seed yield and monetary returns in soybean+ pigeonpea (4:2) intercropping system

Name of farmer	Yield (q/ha)		Soybean equivalent yield (q/ha)	Net return (Rs/ha)	B:C ratio
	Soybean	Pigeonpea			
Manchak Shankarrao Pardhe	16.0	8.43	10.35	61132.00	3.50
Munja Pandit Pardhe	16.7	8.13	9.98	62532.00	3.56
Varad Rameshrao Dalve	16.5	8.29	10.18	62392.00	3.55
Shivaji Vasantrao Dalve	14.5	7.32	8.99	51997.00	3.13
Dnyanoba Venkatrao Korpe	14	6.9	8.47	48777.00	3.00

Cotton *Bt* + green gram (1:1) was demonstrated on single farmers field. Farmer Pardhe bharat narayanrao recorded higher cotton equivalent yield of intercrop cotton *Bt* (6.17 q/ha), higher gross monetary (Rs.105570), net monetary returns (Rs.71894) and B:C ratio (3.13) as compared to other farmers.

Different intercropping systems were demonstrated as an insurance against rainfallvariability. The rainfall was excess by 45.9% in October and 189.1% in December. However, the rainfall was deficit by 33% in November. Sorghum + safflower (4:2) intercropping was demonstrated on three farmers' fields. Farmer Munja pandit pardhe recorded higher yield of sorghum + safflower intercropping, higher gross monetary returns (Rs.21318/ha), net monetary returns (Rs.8254/ha) and B:C ratio (1.63) as compared to other farmers (Table-342).

Table-342: Grain yield and monetary returns of sorghum + safflower (4:2) intercropping system

Name of farmer	Yield (q/ha)		Sorghum equivalent yield (q/ha)	Net return (Rs/ha)	B:C ratio
	Sorghum	Safflower			
Meghaji Manikrao Pardhe	7.03	4.05	18.82	5772	1.44
Munja Pandit Pardhe	7.24	5.30	24.94	8254	1.63
Balasaheb Ramrao Maske	6.69	3.79	17.83	4752	1.36

Similarly, bengalgram + safflower (4:2) intercropping was demonstrated on four farmers' fields. Farmer Ramkishan Ganpatrao Pardhe recorded higher yield of Bengal gram + safflower intercropping, bengalgram equivalent yield (9.45 q/ha), gross monetary returns (Rs.61695/ha), net monetary returns (Rs.51171/ha) and B:C ratio (5.86) as compared to other farmers' (Table-343).

Table-343: Seed yield and monetary returns of bengal gram + safflower (4:2) intercropping system

Name of farmer	Yield (q/ha)		Bengal gram equivalent yield (q/ha)	Net return (Rs/ha)	B:C ratio
	Bengalgram	Safflower			
Ramkishan Ganpatrao Pardhe	8.39	5.32	9.45	51171	5.86
Nomaji Kishanrao Pardhe	7.34	4.89	8.69	44511	4.22
Girish Manikrao Pardhe	8.21	5.10	9.06	49371	4.69
Kishan Mohan Dalve	7.43	5.00	8.88	45411	4.31

Rain water harvesting (*in situ* and *ex situ*) and efficient utilisation

The rainfall was excess by 17.5% in June, 81.9% in July and 58.3% in September but was deficit by 41.4% in August. Demonstrations on *in-situ* moisture conservation were conducted to cope with rainfall variability.

Two demonstrations of *in-situ* moisture conservation techniques (opening of furrow) were undertaken in sole pigeonpea crop. The highest seed yield of 16.1 q/ha was recorded in variety BSMR-853 & BDN 708 with opening of furrow compared to seed yield of 12.1 q/ha in without opening of furrow. In varieties MAUS 71 & MAUS 81 seed yield of 16.0 q/ha was recorded with opening of furrow and 15.1 q/ha in without opening of furrow (Table-344).

Table-344: Effect of *in-situ* moisture conservation on pigeonepa yield

Variety	Days to maturity	No of pods/ plant	Plant height (cm)	Yield (q/ha) with furrow	Yield q/ha without furrow
BSMR 853 & BDN 708	180	87	119.35	16.1	12.1
MAUS 71 & MAUS 81	107	83	65.5	16.0	15.1

Demonstration on efficient recycling of harvested rainwater in farm ponds through drip irrigation in cotton was conducted on five farmers' fields. The highest yield of 29.27 q/ha and rain water use efficiency (4.59 kg/ha-mm) was recorded in variety Brahma with protective irrigation through farm pond water whereas without micro-irrigation yield of Bt cotton was 15.25 q/ha.

Intervention	Cotton	Yield (q/ha)	RWUE (kg/ha-mm)	B:C ratio
Introduction of drip irrigation as protective irrigation through farm pond water for cotton with use of liquid fertilizer No of farmers : 05 Area covered: 02 ha	Malika	24.85	3.90	3.90
	Malika	24.32	3.81	3.55
	Malika	20.67	3.24	2.79
	Brahma	29.27	4.59	4.32
	Brahma	27.42	4.30	3.96
Without intervention (without micro-irrigation system) No of farmers : 05 Area covered: 02 ha	Bt	15.25	2.39	2.02

2. NICRA- Strategic Research

Adaptation Strategies through Cropping Systems at Selected Soil benchmark sites

At Warkhed watershed, Akola district, Maharashtra, during south-west monsoon (June -September) 2013, a rainfall of 1265 mm was received which was excess by 598.7 mm compared to normal (666.3 mm) and during *rabi* season,(October to December), a rainfall of 210 mm was received which was excess by 143.2 mm compared to normal (66.8 mm) (Fig.51).

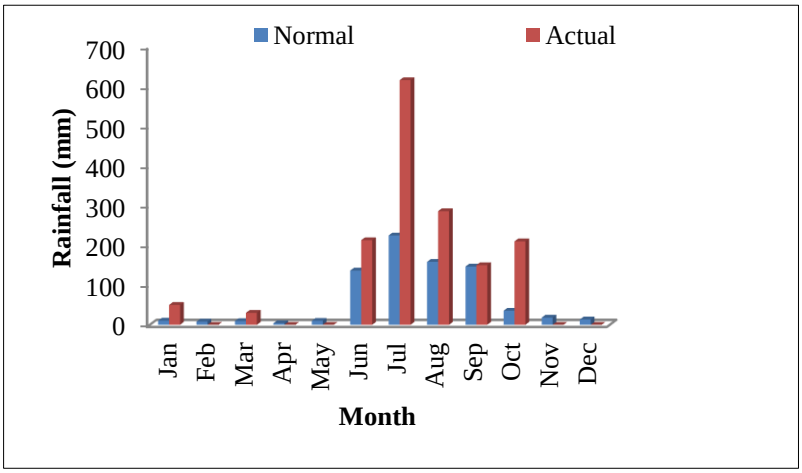


Fig.51: Normal and Actual (2013) monthly rainfall at Warkhed watershed

The excess and continuous rainfall accounting to 662 mm during 15th July to 3rd August affected soybean, blackgram, greengram and sorghum which were at vegetative/reproductive stages. In general, the crops were more affected in deep to very deep black soils (Vertic Ustochrepts and Typic Haplusterts) occurring on the middle sector and valley floor of the watershed due to imperfectly drained conditions which resulted in yield reduction up to 30%. However, these crops performed relatively better due to moderately well to well drained conditions in shallow, non-calcareous soils (Typic Ustorthents) occurring on the upper sector of the watershed. As a real time contingency measure, the excess water was drained out from the crop fields. The long duration crops (cotton and pigeonpea) in intercropping systems *viz*. cotton+ greengram (1:1), cotton + greengram + pigeonpea (1:1*6):2), soybean + pigeonpea (4:2) performed better due to ideal soil moisture/drainage conditions during reproductive stages in deep to very deep black soils. This resulted in increased yields up to 26% and higher rainwater use efficiency (RWUE) up to 1.44 kg/ha-mm, particularly in Vertic Ustochrepts as compared to shallow Typic Ustorthents.

29th August 2013

1st October 2013

Shallow black soils (Fine, non-calcareous Typic Ustorthens)

Deep black soils (Very fine, smectitic, calcareous Vertic Ustochrepts)

Very deep black soils (Very fine, smectitic, calcareous Typic Haplusterts)

Performance of cotton + greengram + pigeonpea (1:1*6):2) in various soil types

3. NICRA - Other Activities

3.1. Village Institutions

3.1.1. Village Climate Risk Management Committee (VCRMC)

VCRMC is selected through a meeting of gram sabha and is expected to actively participate and manage the various activities of the NICRA project. Further, VCRMC has a greater role in identifying and facilitating implementation of interventions and smooth functioning of the NICRA programmes. During 2013-14 in NICRA villages, the VCRMCs played a greater role in identifying and implementation of need based climate risk resilient interventions such as renovation and or establishing new farm ponds/percolation tanks/ other water harvesting structures for creation of water assets for drought proofing, crop, land and soil based interventions, establishing and efficient functioning of custom hiring centers etc. The initial learning experiences indicate VCRMCs in future are likely to participate, identify, innovate and implement risk resilient interventions in a participatory mode, further in sensitization and building the adaptive capacity of the farmers in AICRPDA-NICRA villages.

3.1.2. Custom Hiring Centre (CHC)

Custom Hiring Centre (CHC) was established in each NICRA village and the need based farm implements were purchased based on decisions of VCRMCs and Custom Hiring Management Committees (CHMCs) (Annexure-I). The need based implements purchased after the decision as well as approved by VCRMCs in adopted village, is made available for facilitating the hiring of implements as per the rates decided by CHMC. The money incurred from the custom hiring is maintained and used for repair of the implements. The list of custom hiring committees and details of registration of CHC in NICRA villages, are given in Annexure-I. The list of implements available at CHCs in some NICRA villages are given in Annexure-I.

Farmer using sprayer for plant protection

Farmer using power tiller for secondary tillag

Custom hiring center established at Agricultural Research Station, Anantapur

3.1.3. Village Seed Bank

Maintaining a seed bank is one of the mitigation strategies to tackle the adverse situations arising due to occurrence of extreme weather events. In NICRA village *i.e.* Chamua Narayapur, Lakhimpur district, Assam, an effort was made to establish a seed bank of the rice varieties of different duration which are suitable for aberrant weather situations like flood and drought. The farmers of the NICRA village were trained and a seed production progarmme of 22 improved varieties and more than 30 local varieties was undertaken with the guidance from the scientists of AICRPDA, centre, Biswanath Chariali. The seed stock of 11 rice varieties are available in the seed bank in Chamua Narayanpur village (Table-345).

Table-345 : seed bank of chamua Narayanapur village, Biswanath Chariali

Duration /S.No.	Variety	Yield (kg/ha)
Short duration variety		
1	Luit	2692
2	Kolong	2734
3	Lachit	3137
4	Dishang	4170
Medium duration variety		
5	Mohan	4020
6	Mulagabharu	5047
7	TTB-404	5250
Long duration variety		
8	Ranjit	5418
9	Mahsuri	3332
10	Gitesh	5278
11	Jalkunwari	3612

Seed production in Chamua Narayanapur village

3.1.4. Fodder Bank

It is essential for giving high priority for ensuring availability of enough fodder and forage on a continuous basis especially during drought years. One of the viable strategies for achieving this is to establish "Fodder Bank" at strategic locations in the region and utilize the stored material for supply to places of deficit. The community lands provide for fodder production during drought/ flood and improved fodder/ feed storage methods, availability of the fodder within purchase limit of poor farmers, and efficient feed management for livestock during aberrant weather situations. In such efforts, Phule Jaywant was introduced in NICRA village by Solapur (Fig.). Similarly, the introduction, production and availability of berseem locally helped in increased milk production (Table-346) in NICRA village adopted by Indore center (Fig.), A community fodder bank is maintained in NICRA village (Kochriya village) by Arjia center.

Table-346: Improved forage crop (Berseem) cultivation for enhancing milk production of milch animals at Indore

Farmer's Name	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Preetam Singh Tomar	22500	11000	17125	2.56
Bhagwat Singh/ Badrilal	20000	11000	14000	2.27
Ellam/ Ranjeet Singh	21500	11000	15875	2.44
Ishwar Singh Mandloi	22000	11000	16500	2.50
Jual Singh Solanki	21000	11000	15250	2.39
Gyan Singh Patel	21500	11000	15875	2.44
Pyar/ Gulzzar Singh	18000	11000	11500	2.05
Gabbar Singh Patel	19500	11000	13375	2.22
Ranjan Singh Patel	19500	11000	13375	2.22
Makhan Singh Solanki	18500	11000	12125	2.10
Mahendra Singh Mukati	19500	11000	13375	2.22
Dharmendra Solanki	20000	11000	14000	2.27
Jugraj Singh Tomar	16500	11000	9625	1.88
Mean	20000	11000	14000	2.27

Community fooder bank in Kochriya village, Arjia

Fodder production with Phule Jaywant - Solapur

3.2. Training / Field days etc., organized

3.2.1. Trainings organized

Centre & Topic	No. of beneficiaries	Date
Anantapuramu		
Importance of soil test based fertilizer application in groundnut	34	06.07.13
Integrated farming systems	26	06.07.13
Presowing training programme including improved dryland technologies, mechanization in groundnut and contingent crops	32	12.07.13
Demonstration on sowing of groundnut with ananta automatic tractor drawn mechanical seed drill in Girigetla Village	45	15.07.13
Package of practices of groundnut and importance of soil conservation measures	36	18.07.13
Mechanization In groundnut	40	27.01.14
Tips in cotton harvesting	29	27.01.14
Importance of lining in farm ponds	35	29.01.14
Value addition In groundnut and redgram	40	29.01.14
Importance of implements for preparatory cultivation	40	03.04.14
Importance of summer ploughings	38	03.04.14
Importance of nutrients on growth and yield of different crops	33	15.04.14
Exposure visit to RARS, Nandyal in the eve of ZREAC and 4 farmers participated in the interacrtion meeting with Scientists, Departmental officials and other farmers	--	25.04.14 to 26.04.14
Arjia		
Pre-seasonal training on improved dryland technology of *kharif* season	65	30-06- 2013
One day pre-seasonal training in NICRA project	98	26-06-2014
One day pre-seasonal training in NICRA project	76	27-06-2014
Pre- seasonal training on improved dryland technology of *kharif* season	72	03-07-2014
Biswanath chariali		
Agromet advisory services for village level climate managers	17	27-06-2013
operation and maintenance of agricultural implements and machines		05-03-14 to 07-03-14
Chianki		
Field visit cum *Krisak Gosthi* programme on *kharif* crops	25	18-4-2013
Training cum seed distribution	218	20-06-2013
Management of upland *kharif* crops	45	17-07-2013
Fertilizer distribution and their management on *kharif* crops	218	30-07-2013
Management of late sown transplanted rice	111	16-09-2013
Scientific cultivation of gram and mustard cum seed distribution	95	28-10-2013
Value addition of farm produce for woman's	45	30-10-2013
Scientific cultivation of wheat cum seed distribution programme	118	16-11-2013
Empowering women through skill based trainins: Sewing Training Centre	30	Three months training, starting on 03-02-2013
Rajkot		
Methods of *in-situ* moisture conservation	45	16-04-2013
Integrated pest management and fertilizer application in *kharif* crops	75	08-07-2013
Production technology of *rabi* Crops	51	22-10-2013
Pest management in *rabi* crops	47	16-01-2014
Recycling of cotton stalks	51	03-02-2014
Rakh Dhiansar		
Training on different aspects of seed production for *rabi* crops	15-20	01-01-14 & 06-02-14
Technologies for enhancing crop production in rainfed areas.	13 Undergraduate students	12-03-2013
Solapur		
Kharif pre-seasonal training at Village Narotewadi	40	01.07.2013

Training for village level climate managers – Biswanath chariali

Training on operation and maintenance of agricultural implements and machines

3.2.2. Field days organized

Centre & Topic	No. of beneficiaries	Date
Arjia		
Improved technology of pasture land development and water harvesting structure	80	04-05-2013
Improved technology of groundnut + sesame (2:2) intercropping system	70	07-09-2013
Effect of improved dryland technology of *kharif* (FLD on horsegram)	75	21-09- 2013
Improved maize + blackgram (6:2) intercropping system	80	26-09-2013
Improved dryland technologies	228	25-10-2013
Improved technologies of mustard, gram and taramira production	93	03-01-2014
Improved pasture land development	78	28-03-2014
Improved technology of pasture land development and water harvesting structure	80	04-05-2013
Improved technology of groundnut + sesame (2:2) intercropping system	70	07-09- 2013
Ballowal Saunkhri		
One day farmers' awareness camp at village Nainwan		25-07-2013
Kisan mela		04-09-2013 and 10.03.2014
Project Coordinator interaction with the farmers of NICRA and ORP villages.		18-09-2013 to 20-09-2013
Importance of oilseed crops and their potential in the area	35	12-2-2014
Impact of climate change on agriculture	150	21-03-2014
Processing of fruits, vegetables and milk products		18-06-2014
Hisar		
One day formal interactive session on recommended dryland technologies	70	2.9.2013
Rakh Dhiansar		
Diversification from field crops to growing of vegetable crops for enhancing socio-economic status under kandi belt of Jammu region	15	25-02-2014


Field day – Rakh Dhiansar


Farmers of the NICRA village releasing fish fingerlings in NICRA village pond – Ballowal Saunkhri


Dr.Ch Srinivasarao, Project Coordinator, AICRPDA, interacting with farmers and visiting the demonstrations at NICRA village Nainwan and Achalpur

3.3. Agro-advisories

Weather forecasting is a most important factor for planning and management of crops in dryland agriculture. It helps to prevent the crop damage due to aberrant weather i.e. drought/heavy rain, chilling injury, heavy fog, dew and heat wave. It provides the very useful information to farmers i.e. weather condition, insects, plant diseases and their control measures etc. Weather based Agromet Advisory is sent to farmers community by SMS through farmer portal (A website of Ministry of Agriculture) on need base. The aim of advisory is to help the farmers for timely management of their crops. In collaboration of Integrated Agromet Advisory Services, Agromet Advisories are given to farmers of the NICRA village twice in a week i.e. on Tuesday and Friday.

S.No	Advise through SMS	Impact
1	**Advisory Date :** 30 August, 2013 Rajkot, Jamnagar,Amreli ane Surendranagar Jillama agami panch divas mate varsadni agahi nathi. Halka ane Madhyam potvali jaminma vavel Kapas, Magfali ane Shakbhaji pakone purak piyat apvu. From: DFRS, JAU, Targhadia	During 2013, 705 mm rainfall was received up to August in NICRA village; There was sufficient water in the wells because of the watershed program. During 1st fortnight of September, there was possibility of dry spell as per the forecast. Therefore, farmers were advised to provide life saving irrigation to crops to mitigate the dry spell.
2	**Advisory Date :** 25 September, 2013 Rajkot, Amreli, Jamnagar ane surendranagar Jillama tarikh 25 thi 29 September-13 daramyan halavathi bhare varsadni shakyata che. Jethi magafali upadavanu kam mulatvi rakhavu. Temaj chomasu pak puro thayel khali kkhetarma chana gujarat-2 athava-3, tal purva-1 athva ajama gujarat-1 athva-2 athva juvar gundarinu pasandgi mujab vavetar karavu. From:DFRS,JAU, Targhadia	In NICRA village, harvesting of bunch groundnut was started by the farmers during 3rd week of September, 2013. But as per the forecast by Integrated Agromet Advisory Services, there was possibility of heavy rain in last week of September, 2013. Therefore farmers were advised to postpone the harvesting of groundnut to avoid yield losses. Special advise was given to farmers who had harvested short duration crops to sow *rabi* crops.
3	**Advisory Date :** 28 September, 2013 Saurashtrama vadhu varsadna karane kapasna pakma para wilt namano sukarano updrav hovathi tena niyantran mate, 1 vighe 10 kilogram uria khatar apvu ane palar pani utarvu. jo shakya hoy to uriani sathe amonium sulfet khata 5 kilogram prati vighe apavu. From: DFRS, JAU, Targhadia	Due to heavy rain during 3rd week of September, 2013, there was possibility to initiate parawilt in cotton crop. Therfore farmers were advised to apply urea or ammonium sulphate the cotton crop to control parawilt. In addition to this, it is suggested to apply light irrigation for better aeration.
4	**Advisory Dates : 2**1 January, 2014 5:13:12 Agami panch divas HAVAMAN Jillama thandu,suku ane tarikh 22 ane 26 roj anshatah vadala thavani agahi chhe. Jethi Jiruna Pakma kali charamino updrav thaya nahi te mate MENCOZEB 40gram/pamp mujab chhantkav karavo ane piyat mulatvi rakhavu. From: DFRS, JAU, Targhadia	January 2014, Next five days, climate remain cold and dry and slightly cloudy during January 22 to 26, 2014 in Rajkot, Jamnagar, Amreli and Surendranagar districts of zone, there is possibility. There is possibility to occurrence of Alternaria Blight in Cumin**.** Special advise was given to farmers to postpone irrigation and spraying of Mancozab 40 g/15 litre.

Weather forecast based agrometeorological advisories prepared by Agromet Advisory Services, Sonitpur have been given and displayed in the NICRA village regularly. Farmers of the village are being immensely benefited from the advisories.

Medium range weather forecast and Agromet advisories displayed in Chamua village

The medium range weather forecasts along with weather based agro-advisories are displayed in NICRA village (hamua Narayanpur) adopted by Biswanath Chariali. Agromet Advisory bulletin prepared by Agromet Services Unit, Sonitpur of BN College of Agriculture is regularly displayed at the office in the NICRA village and such advisories are also displayed in NICRA villages adopted by Ballowal Saunkhri.

In Chikkamaranahalli village adopted by Bangalore, the agro-advisories through ICTs (information kiosks) combining the village level weather data linked to district advisory issued by the IMD/SAU. Agro advisory messages are issued twice in a week by Agro-meteorology Dept. UAS, Bengaluru and IMD.

In NICRA village adopted by Kovilpatti center during the cropping season in 2013-14 a total of 58 weather bulletins were disseminated to the farmers through SMS and All India Radio. The bulletins were also sent to all the government officers including the Block Development Officers (BDOs) and Tashildars. The bulletins were also displayed in the village notice board. Advisories covering selection of varieties, soil and moisture conservation methods, integrated weed management, integrated nutrient management, pest & disease management and other agronomic practices were included.

Integrated Agro-met Advisory Services Project, running in AICRIPDA, College of Agriculture Indore is sponsored by MoES, IMD, Govt. of India, New Delhi. The eight districts covered for providing Agro-advisories are Indore, Ujjain, Dewas, Shajapur, Mandsure Ratlam, Neemach and Rajgarh. For this purpose the weather forecast is received and every Tuesday and Friday from IMD, Pune. On the basis of forecast, agro-advisory is prepared by the scientists at college of Agriculture, Indore and disseminated to the farmers of the region. The dissemination of agro-advisories is made through all modes of diffusion like Door Darshan, Akashvani, KVKs, Department of Farmers Welfare and Agriculture Development, Newspapers, SMS, NGOs, and through the Extension Scientists of the College. The Scientists associated with NICRA Project also informed who in turn provide the information to the adopted farmers under NICRA at Nignoti village, Indore.

3.4. Soil Heath Cards

In NICRA villages, the soil health cards for individual farmers were issued. Sample copies of the soil health cards given to the farmers in NICRA villages are shown below.

Soil Health cards of village Nainwan and Achalpur (Ballowal Saunkhri)

Biswanath chariali

Soil Health Cards Anantapur

3.5. Publications

a) Research papers/abstracts

Chianki

Ekhlaque Ahmad, D.N. Singh, Munish Kumar Singh, A. Paul, A. Sah, A.M. Ansari and M.S. Yadava (2014). Evaluation of drought tolerant rice genotypes for rainfed upland situation. *National Seminar on Breeding for Abiotic Stresses : Problems & Prospects.*

Ekhlaque Ahmad, D.N. Singh, Munish Kumar Singh, A. Paul, A. Sah, A.M. Ansari and M.S. Yadava (2014). Evaluation of drought tolerant linseed genotypes under rainfed condition of Jharkhand. *National Seminar on Breeding for Abiotic Stresses : Problems & Prospects.*

Arjia

C.M. Yadav and R.K. Sharma (2013). Crop-Livestock Integrated Farming System for the marginal farmers of rainfed regions of Bhilwara district in Rajasthan. *Indian Journal of Dryland Agricultural Research and Development* 28 (1): 74-76.

M. L. Jat, S.K. Sharma, A.K. Kothari, R.K. Sharma, K. Pareek and Monika Kumari (2013). Moisture conservation practices in blackgram for pulse security in semi-arid tropics. *Indian Journal of Soil Conservation,* 41(2): 158-162.

b) Reports

Annual Report -2012-13. National Initiative on Climate Resilient Agriculture, Dryland Farming Research Station, (Maharana Pratap University of Agriculture and Technology, Udaipur), Bhilwara, Rajasthan Indian Council of Agriculture Research, Hyderabad – 500 059, Andhra Pradesh, India.

Characterization of soils of Nignoti village, Indore Bulletin RVSKVV Publication No. 45/2014.

c) TV Talks

Topic	Scientist/Technical Staff	Name of channel	Date of recording
SRI vidhi se dhan ki unnat kheti	Munish Kr. Singh, SRF	Daltonganj Doordarsan	04/05/2013
Bhoomi ke adhar par kismo ka chayan	Munish Kr. Singh, SRF	Daltonganj Doordarsan	04/05/2013
Agaat barsati sabjiyon ki vaigyanik kheti	A.M. Ansari	Daltonganj Doordarsan	29/05/2013
Aam ki vaigyanik bidhi se bagwani	A.M. Ansari	Daltonganj Doordarsan	29/05/2013
Tanr jamin mein dhan ki kheti	A. Paul	Daltonganj Doordarsan	30/05/2013
Til ki vaigyanik kheti	A. Paul	Daltonganj Doordarsan	30/05/2013

SRI cultivation	Akhilesh Sah	Daltonganj Doordarsan	19/07/2013
Contingent crop plant	Akhilesh Sah	Daltonganj Doordarsan	31/07/2013
Kusum ki vaigyanik kheti	Munish Kr. Singh	Daltonganj Doordarsan	10/10/2013
Barsha ritun mein sabjiyon ki parbandhan	A.M. Ansari	Daltonganj Doordarsan	10/10/2013
Tissi ki vaigyanik kheti	Ekhlaque Ahmad	Daltonganj Doordarsan	10/10/2013
Ban brichon ki dekhbhal	Anil Kumar	Daltonganj Doordarsan	10/10/2013
Garma moong ki vaigyanik kheti	Munish Kr. Singh	Daltonganj Doordarsan	28/01/2014
Ganne ki vaigyanik paddati se kheti	Ekhlaque Ahmad	Daltonganj Doordarsan	28/01/2014
Poly house mein sabji ki kheti	Pramod Kumar	Daltonganj Doordarsan	28/01/2014
Rabi fasal ka prabandhan	Akhilesh Sah	Daltonganj Doordarsan	28/01/2014
Garma bhindi ki vaigyanik kheti	Munish Kr. Singh	Daltonganj Doordarsan	28/01/2014
Garma faslo ka prabandhan	Akhilesh Sah	Daltonganj Doordarsan	01/05/2014
Rabi faslo ka sangrahan	A. Paul	Daltonganj Doordarsan	01/05/2014
Urd ewam Makaa ki vaigyanik kheti	Munish Kr. Singh	Daltonganj Doordarsan	12/05/2014
Arhar ewam uprao Dhan ki kheti	Akhilesh Sah	Daltonganj Doordarsan	12/05/2014
Samajik vaniki	Anil Kumar	Daltonganj Doordarsan	12/05/2014

d) Radio Talks

Topic	Scientist/Technical Staff	Name of channel	Date of recording
May-June, maah ki kheti Karya	M.S. Yadav	Akashvani Daltonganj	07/05/2013
Fal bagan lagane ki krishi takneek	A.M. Ansari	Akashvani Daltonganj	07/05/2013
Khadi faslo ki dekh-rekh	M.S. Yadav	Akashvani Daltonganj	13/02/2014
Garma bhindi ki kheti	Munish Kr. Singh	Akashvani Daltonganj	13/02/2014
Der se boi gai rabi faslon ka prabandhan	Akhilesh Sah	Akashvani Daltonganj	13/02/2014
Uprao jameen mein Dhan ki Kheti	Munish Kr. Singh	Akashvani Daltonganj	22/05/2014

3.6. Linkages Developed

The AICRPDA, centers have developed linkages with ICAR Institutes, Central Government schemes / state Government programmes for implementation of NICRA programmes and state line departments, KVKs, ATMA and NGOs for capacity building of various stakeholders.

4. Project Team of AICRPDA-NICRA

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Rice based production system

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Acronyms

AAU	Assam Agricultural University	MJ	Mega Joules
ADG	Assistant Director General	MM	Millimeter
AICRPAM	All India Coordinated Research Project on Agrometeorology	MPKV	Mahatma Phule Krishi Vidyapeeth
AICRPDA	All India Coordinated Research Project for Dryland Agriculture	MPUA&T	Maha Rana Pratap University of Agriculture & Technology
ANGRAU	Acharya NG Ranga Agricultural University	NBSS & LUP	National Bureau of Soil Survey and Land Use Planning
ARS	Agricultural Research Station	NDUAT	Narendra Dev University of Agriculture & Technology
ATMA	Agricultural Technology Management Agency	NICRA	National Initiative on Climate Resilient Agriculture
BC ratio	Benefit Cost ratio	NMR	Net Monetary Return
BHU	Banaras Hindu University	NRM	Natural Resource Management
CAZRI	Central Arid Zone Research Institute	ORP	Operational Research Project
CCSHAU	Chaudhury Charan Singh Haryana	OUAT	Orissa University of Agriculture &
CHC	Custom Hiring Centre	PAU	Punjab Agricultural University
CHMC	Custom Hiring Management Committee	PC Unit	Project Coordination Unit
CRIDA	Central Research Institute for Dryland	PDKV	Dr. Panjabrao Deshmukh Krishi
DARE	Department of Agricultural Research and Education	RDF	Recommended Dose of Fertilizer
DAS	Days After Sowing	REY	Rice Equivalent yield
DDG	Deputy Director General	RRS	Regional Research Station
DG	Director General	RWUE	Rain Water Use Efficiency
FAD	Focused Group Discussion	SAU	State Agricultural University
GEY	Grain Equivalent Yield	SEY	Soybean Equivalent Yield
GMR	Gross Monetary Return		
HW	Hand Weeding	SK Nagar	Sardarkrushi Nagar
ICAR	Indian Council of Agricultural Research	SKDAU	Sardar Krushinagar Dantiwada Agricul-
IGKV	Indira Gandhi Krishi Vidyapeeth	SKUAS&TJ	Sher-e-Kashmir University of Agricultural Science & Technology, Jammu
IGFRI	Indian Grassland and Fodder Research Institute	SMW	Standard Metrological Week
IMD	Indian Meteorological Department	TNAU	Tamil Nadu Agricultural University
JAU	Junagadh Agricultural University	UASB	University of Agricultural Sciences
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya	UASD	University of Agricultural Sciences, Dharwad
MAU	Marathwada Agricultural University	VCRMC	Village Climate Risk Management Committee
MEY	Maize Equivalent Yield		

Annexure-I

1. Village Climate Risk Management Committee (VCRMC)

The committee was formed with the following farmers from Aminabad and Girigetla villages of Thuggali mandal, Kurnool district.

1a. VCRMC – Anantapuramu :

S.No	Name of the farmer	Village
1	Sri.B.Diwakar Chowdary	**Aminabad**
2	Sri.V.Venkata Reddy	,,
3	Sri.P.Narayana Swamy	,,
4	Sri.Kunduri Ramesh S/O Rangaiah	,,
5	Sri.J.Umapati	,,
6	Sri.Jaragala Sarat Babu S/O Vivekananda Chowdary	,,
7	Sri.G.Siddaiah S/O Anjanaiah	,,
8	Sri.B.Omkarappa S/O Bajarappa	,,
9	Sri.M.Venkateswarlu	,,
10	Sri.T.Gopal S/O Timmappa	,,
11	Sri.Gose Balaram S/O Parasuramudu	**Girigetla**
12	Sri.Karanji Chandrasekhar S/O Veerabhadrappa	,,
13	Sri.Balachandra Kaladar Reddy S/O Seetarami Reddy	,,
14	Sri.Arava Basappa S/O Chinna Basappa	,,
15	Sri.Sola Rangaswamy	,,
16	Sri.M.Gangadaraiah	,,
17	Sri.Bola Venkatesh S/O Ranganna	,,
18	Sri.G.Ramakrishna S/O Anjaneyulu	,,

1b. VCRMC - Hisar

S.No	Name of the farmer	Village
1	Bir Singh	Balawas
2	Mai Ram	,,
3	Raj Kumar	,,
4	Sultan	,,
5	Subhash	,,
6	Harphool	,,

2. Custom Hiring Management Committee (CHMC)

Name of Farmers	Fathers Name	Designation
Agra		
Sri Gurudayal Singh	Sri Aneg Singh	President
Sri Nanigram	Sri Samanta Singh	Secretary
Sri Makhan Singh	Sri Charan Singh	Member
Sri Janak Singh	Sri Ramnarayan Singh	Member
Sri Raghuveer Singh	Sri Daujiram Singh	Member
Sri Bijendra Singh	Sri Angad Singh	Member
Sri Shyamveer Singh	Sri Harishankar Singh	Member
Sri Rajveer Singh	Sri Kishan Lal	Member
Sri Bhoop Singh	Sri Bhoori Singh	Member
Sri Nihal Singh	Sri Antram	Member

Anantapuramu		
Sri.B.Diwakar Chowdary		President
Sri.Y.Ekambaram		Treasurer
Sri.V.Venkata Reddy		Member
Sri.P.Narayana Swamy		Member
Sri.Kunduri Ramesh	Sri Rangaiah	Member
Sri.J.Umapati		Member
Sri.Jaragala Sarat Babu	Sri Vivekananda Chowdary	Member
Sri.G.Siddaiah	Sri Anjanaiah	Member
Sri.B.Omkarappa	Sri Bajarappa	Member
Sri.M.Venkateswarlu		Member
Sri.T.Gopal	Sri Timmappa	Member
Sri.Gose Balaram	Sri Parasuramudu	Member
Sri.Karanji Chandrasekhar	Sri Veerabhadrappa	Member
Sri.Balachandra Kaladar Reddy	Sri Seetarami Reddy	Member
Sri.Arava Basappa	Sri Chinna Basappa	Member
Sri.Sola Rangaswamy		Member
Sri.M.Gangadaraiah		Member
Sri.Bola Venkatesh	Sri Ranganna	Member
Sri.G.Ramakrishna	Sri Anjaneyulu	Member
Ballowal Saunkhri		
Sri Harmesh Singh	Sri Hawail Singh, Nainwan	President
Sri Paramjit Lal S	Sri. Amar chand, Achalpur	Member
Sri Darshan Singh	Sri. Anurudh Singh, Nainwan	Member
Sri. Avinash Kumar	Sri. Bishan Das, Achalpur	Member
Sri. Rajinder Singh	Sri. Sheetal singh, Nainwan	Member
Sri. Purshotam singh	Sri . Anant Ram, Achalpur	Member
Smt Deepo W/o	Sh .Mohan Singh, Nainwan	Member
Smt Manjeet Kaur	W/o Sri. Satnam Singh, Achalpur	Member
Sri. Sohan singh	Sri. Hari Das, Nainwan	Member
Sri. Harmesh Lal	Sri. Kartar Chand, Achalpur	Member
Sri. Agya Ram	Sri. Anant Ram, Nainwan	Member
Sri. Gurdas Singh	Sri. Babu Ram, Achalpur	Member

3. List of implements under the NICRA Custom Hiring Centre, Ballowal Saunkhri and revenue generated

Sr. No.	Name of Implement & Rates	Number	Revenue generated (Rs /year)
	Ballowal Saunkhri		**4500**
1	Rotavator (Rs 100/acre)	1	
2	Maize Planter (Rs 80/acre)	1	
3	Iron Planker (Rs 40/acre)	2	
4	Seed drill (Rs 80/acre) (wheat, soil seed)	1+1	
5	Bund former (Rs 40/acre)	1	
6	Ridger (Rs 800/acre)	1	
7	Wheel hand hoe (Rs 20/acre)	5	
8	Knapsack sprayer (Rs 40/acre)	8	
9	Maize Sheller (Rs 100/acre)		
10	Water Lifting pump (Rs40/hr)	1	

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