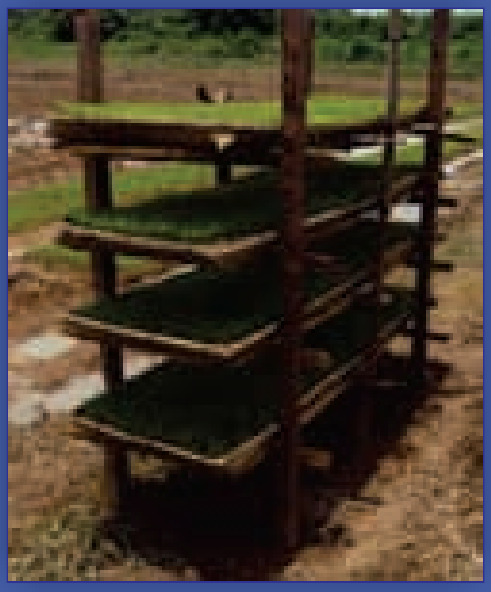
Managing Weather Aberrations
through Real Time Contingency Planning

AICRPDA - NICRA

Annual Report
2015-16



National Innovations on Climate Resilient Agriculture
All India Coordinated Research Project for Dryland Agriculture
ICAR-Central Research Institute for Dryland Agriculture
Hyderabad

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Release of Publications

Felicitation to Best Farmers

Field visit to On-station experiments

राष्ट्रीय जलवायु समुत्थान कृषि नवप्रवर्तन

National Innovations on Climate Resilient Agriculture

Managing Weather Aberrations

through Real Time Contingency Planning

वार्षिक प्रतिवेदन

Annual Report

2015-16



अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना

All India Coordinated Research Project for DrylandAgriculture

ICAR - Central Research Institute for DrylandAgriculture
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Preface

The agricultural production in rainfed areas in recent years is being more impacted due to climate variability, particularly delayed onset of south-west monsoon, in-season drought and other extreme events. Under National Innovations on Climate Resilient Agriculture (NICRA), the 23 AICRPDA network centres had been conducting, both on-station and on-farm, trials/demonstrations to identify or demonstrate risk resilient practices. Preparedness and implementation of real-time contingency measures implementation had been the focus. In NICRA adopted villages, various village institutions have been established to enhance adaptive capacity, for adoption and upscaling of climate resilient practices.

During 2015-16, the onset of monsoon was delayed by more than two weeks in NICRA villages located in Rajsamand and Solapur districts. Further, there were 4-6 dry spells at different stages of crops in NICRA villages Lakhimpur, Garhwa, Kandhamal, Vijayapur and Solapur districts. In general, the total rainfall during *kharif* season (June-September), 2015 was below normal in majority of the NICRA villages. During *kharif* 2015, resilient practices to cope with delayed onset of monsoon and early, mid season and terminal were demonstrated in 1050 farmers' fields covering about 400 ha in 33 villages representing diverse rainfed agro-ecologies in 24 districts across 15 states. This helped in coping with weather aberrations and enhancing the crop yields and income.

I compliment Dr. G. Ravindra Chary, Project Coordinator, AICRPDA and team of scientists from PC Unit and 23 AICRPDA centres for developing AICRPDA-NICRA technical program, for generating real-time data on impact of NICRA programme and bringing out this annual report. I thank Dr. T. Mohapatra, Secretary (DARE) & DG, ICAR and Dr. S. Ayyappan, Former Secretary (DARE) & DG, ICAR, Dr. A.K. Sikka, DDG (NRM), Dr. S.Bhaskar, ADG (AAF & CC), and Dr. B. Mohan Kumar, former ADG (AAF & CC), Principal Scientists at NRM Division for all the guidance and support to AICRDA from time to time. I profusely thank the participating farmers from 33 NICRA villages across the country for their participation, contribution and support.

(Ch. Srinivasa Rao)
Director, ICAR-CRIDA

Contents

कार्यकारी सारांश

वर्ष 2011 से, अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना (एक्रीपडा) के 23 केंद्रों एवं खेतों दोनों पर निक्रा का प्रौद्योगिकी प्रदर्शन अवयव का कार्यान्वयन किया जा रहा है। वर्ष 2015–16 के दौरान, वर्षा जल संग्रहण (स्व–स्थाने एवं बहि–स्थाने) एवं बेहतर उपयोग, सूखा सहीष्णु फसलकिस्में, समुत्थान फसल प्रबंधन प्रक्रियाएं, बेहतर ऊर्जा प्रबंधन जैसे हस्तक्षेपों द्वारा मौसम प्रतिकूलताओं से जूझने के लिए सही समय की आकस्मिक फसल योजना कार्यान्वयन एवं तैयारियों पर महत्व दिया गया। वर्ष 2015 के खरीफ के दौरान, 15 राज्यों में फैले 24 जिलों के 33 गांवों में स्थित करीब 400 हेक्टेयर में फैले 1050 किसानों के खेतों में मानसून का देरी से आंरभ एवं मौसमी सूखा (आरंभिक, मध्य एवं अंतिम) से जूझने वाले हस्तक्षेपों का प्रदर्शन किया गया। राजसमंद एवं सोलापुर जिलों के निक्रा गांवों में मानसून के आरंभ में दो सप्ताहों से अधिक की देरी हुई। इसके अलावा, लखिमपुर, गढ़वाह, कंधमाल, विजयपुर एवं सोलापुर जिलों के निक्रा गांवों में फसलों के विभिन्न स्तरोंपर 4–6 शुष्क दौर चले।

प्रमुख उपलब्धियों का सार नीचे दिया गया है।

I. सही–समय की आकस्मिक योजना

मानसून का देर से आरंभ

कुंभी एवं बनखेता गांव (गढ़वा जिला झारखंड) में मानसून 13 दिन देर से आंरभ हुआ। स्थानीय किस्मों की तुलना में सूखा सहीष्णु एवं लघु अवधि की किस्में जैसेकि चावल की किस्म अरजिया तेज (3067 किलोग्राम प्रति हेक्टेयर, 35071 रुपए प्रति हेक्टेयर)य मक्का का किस्ष्म कंचन (3194 किलोग्राम प्रति हेक्टेयर, 19954 रुपए प्रति हेक्टेयर)य रांगी का किस्म ए–404 (1621 किलोग्राम प्रति हेक्टेयर, 11687 रुपए प्रति हेक्टेयर) य तिल का किस्म शेखर (487 किलोग्राम प्रति हेक्टेयर, 11867 रुपए प्रति हेक्टेयर) एवं उड़द का किस्म बिरसा उड़द–1 (1235 किलोग्राम प्रति हेक्टेयर, 44578 रुपए प्रति हेक्टेयर) से अधिक उत्पादन एवं लाभ प्राप्त हुआ।

एस.के. नगर में, मानसून के आरंभ में 31 दिनों की देरी के अंतर्गत, जीएचबी 538 (395 किलोग्राम प्रति हेक्टेयर) की तुलना में बाजरा संकर जीएचबी 558 से अधिक अनाज (445 किलोग्राम प्रति हेक्टेयर) एवं चारा (1215 किलोग्राम प्रति हेक्टेयर) उत्पादन सहित निवल लाभ (2070 रुपए प्रति हेक्टेयर) एवं बीरूसी अनुपात (0.25) प्राप्त हुआ। इसी प्रकार, मूंग किस्म जीएम–4 ने जीएम–3 की तुलना कम उत्पादन दिया लेकिन अधिक बीज एवं कड़बी का उत्पादन क्रमश 405 एवं 1030 किलोग्राम प्रति हेक्टेयर दिया।

रीवा में, मानसून के आरंभ में 10 दिनों देरी के अंतर्गत शीर्घ पकने वाली सोयाबीन किस्म जेएस 20–29 ने 29720 रुपए प्रति हेक्टेयर का लाभ, 1.18 का वर्षाजल उपयोग क्षमता (RWUE) एवं 2.85 का बीरूसी अनुपात सहित अधिक बीज उत्पादन (1016 किलोग्राम प्रति हेक्टेयर) दर्ज किया। इसकी प्रकार स्थानीय किस्मों की तुलना में उड़द की उन्नत किस्म (पीयू 30), मूंग (एचयूएम 1), तिल (टीकेजी 21) एवं अरहर (आशा) ने भी अधिक उत्पादन (क्रमश 632, 478, 350 एवं 1780 किलोग्राम प्रति हेक्टेयर) दिया।

आरंभिक मौसमी सूखा

कवलगी गांव (विजयपुर जिला, कर्नाटक) में, किसानों की प्रक्रिया (933 किलोग्राम प्रति हेक्टेयर) की तुलना में अरहर में निराई–गुड़ाई एवं निकौनी ने अधिक उत्पादन (1325 किलोग्राम प्रति हेक्टेयर), निवल लाभ (77922 रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (3.99 किलोग्राम प्रति हेक्टेयर–मिमी) दिया।

महकापल, तंडपल एवं गुमियापल गांवों (बस्तर जिला, छत्तीसगढ़) में, बिना कूंड़ निर्माण (1202 किलोग्राम प्रति हेक्टेयर) की तुलना में देसी हल से चावल के खेतों में कूंड़ों के निर्माण ने 10763 रुपए प्रति हेक्टेयर का निवल लाभ, 1.67 का बीरूसी अनुपात एवं 3.26 किलोग्राम प्रति हेक्टेयर–मिमी सहित 2230 किलोग्राम प्रति हेक्टेयर का अधिक अनाज उत्पादन दिया।

बुधाधनी गांव (कंधमाल जिला ओडिशा) में, मेढ़ रहित (2100 किलोग्राम प्रति हेक्टेयर) किसानों की प्रक्रिया की तुलना में चावल की खेतों में मेढ़ की ऊंचाई बढ़ाने से स्व–स्थाने नमी संरक्षण से अधिक उत्पादन (2400 किलोग्राम प्रति हेक्टेयर), निवल लाभ (11000 रुपए प्रति हेक्टेयर) एवं बीरूसी अनुपात (1.84) हुआ।

निगनोती गांव (इंदौर जिला, मध्यप्रदेश) में बिना निकौनी (980 किलोग्राम प्रति हेक्टेयर) की तुलना में

निकौनीनिराई–गुड़ाई से सोयाबीन किस्म जेएस 93–05 ने 17920 रुपए प्रति हेक्टेयर का निवल लाभ एवं 2.12 का बीसी अनुपात सहित के बीज उत्पादन में 8 प्रतिशत (1060 किलोग्राम प्रति हेक्टेयर) की वृद्धि हुई।

वन्नेदोड्डीपल्ली गांव (अनंतपुर जिला, आंध्र प्रदेश) में, बिना संरक्षण कूंडों (1510, 460, 676, एवं 470 किलोग्राम प्रति हेक्टेयर) की तुलना में स्व–स्थाने नमी संरक्षण कूंडों की खोदाई से मूंगफली (5 प्रतिशत), अरंड़ (11 प्रतिशत), अरहर (9 प्रतिशत) एवं कपास (6 प्रतिशत) के उत्पादन में वृद्धि हुई। किसानों की प्रक्रिया की तुलना में संरक्षण कूंड़ों के निर्माण से अरंड़, अरहर एवं कपास में क्रमश 820 रुपए, 4650 रुपए एवं 1350 रुपए प्रति हेक्टेयर का अतिरिक्त निवल लाभ प्राप्त हुआ।

राजकोट में, बिना कूंड की तुलना में कपास में वनस्पतिक स्तर पर स्व–स्थाने नमी संरक्षण के लिए कूंड (45 सेंटीमीटर चौड़ा) खोदने से कपास के बीज उत्पादन (1850 किलोग्राम प्रति हेक्टेयर) में 17 प्रतिशत की वृद्धि हुई। बिना कूंड की तुलना में इससे अधिक निवल लाभ (58575 रुपए प्रति हेक्टयर), बीरूसी अनुपात (2.00) एवं वर्षाजल उपयोग क्षमता (3.15 किलोग्राम प्रति हेक्टेयर–मिमी) भी दर्ज हुआ।

बबुलगांव (परभनी जिला, महाराष्ट्र) में, नियंत्रण (435 किलोग्राम प्रति हेक्टेयर) की तुलना में सोयाबीन में 2 प्रतिशत की दर से KNO_3 के पर्ण छिड़काव से 11 प्रतिशत अधिक बीज उत्पादन (484 किलोग्राम प्रति हेक्टेयर), निवल प्रतिफल (5544 रुपए प्रति हेक्टेयर), बीरूसी अनुपात (1.44) एवं वर्षाजल उपयोग क्षमता (1.69 किलोग्राम प्रति हेक्टेयर) दर्ज हुआ।

मध्य मौसमी सूखा

कवलगी गांव (विजयपुर जिला कर्नाटक) में, बिना पर्ण छिड़काव के मूंग एवं अरहर का क्रमश 275 एवं 788 किलोग्राम प्रति हेक्टेयर की तुलना में शुष्क दौर के दौरान 0.5 प्रतिशत की दर से KNO_3 के पर्ण छिड़काव एवं वर्षा के तुरंत बाद 2 प्रतिशत की दर से यूरिआ के छिड़काव से मूंग (328 किलोग्राम प्रति हेक्टेयर) का 19 प्रतिशत एवं अरहर (1000 किलोग्राम प्रति हेक्टेयर) का 27 प्रतिशत अधिक उत्पादन हुआ।

चमुआ गांव (लखिमपुर जिला, असम) में, वर्षा आधारित फसल (909 किलोग्राम प्रति हेक्टेयर) की तुलना में तोरिया में एक अतिरिक्त सिंचाई देने से 10 प्रतिशत अधिक बीज उत्पादन (1000 किलोग्राम प्रति हेक्टेयर) सहित 13373 रुपए प्रति हेक्टेयर का निवल लाभ, 1.82 का बी:सी अनुपात एवं 4.08 किलोग्राम प्रति हेक्टेर–मिमी का वर्षाजल उपयोग क्षमता दिया।

हरदोई गांव (फैजाबाद जिला, उत्तर प्रदेश) में, बिना पलवार (1140 किलोग्रा प्रति हेक्टेयर) के किसानों की प्रक्रिया की तुलना में मक्का में 10 टन प्रति हेक्टेयर की दर से सुबबूल के हरे पत्त्तों से पलवार करने से 987 रुपए प्रति हेक्टेयर का निवल लाभ एवं 1.05 का बी:सी अनुपात सहित 28 प्रतिशत अधिक अनाज उत्पादन (1450 किलोग्रा प्रति हेक्टेयर) दर्ज हुआ।

तहकपल, तंडपल एवं गुमियापल गांव (बस्तर जिला, छत्तीसगढ़) में, बिना सिंचाई (1023 किलोग्राम प्रति हेक्टेयर) की तुलना में चावल में पुष्पण आंरभ की दशा में 2 सेंटीमीटर की गहराई तक अतिरिक्त सिंचाई देने से 42408 रुपए प्रति हेक्टेयर का निवल लाभ, 3.22 का बी:सी अनुपात एवं 2.24 किलोग्राम प्रति हेक्टेयर–मिमी का वर्षाजल उपयोग क्षमता सहित 1530 किलोग्राम प्रति हेक्टेयर का अतिरिक्त अनाज उत्पादन हुआ।

बुधाधनी गांव (कंधमाल जिला ओडिशा) में, वर्षा आधारित चावल (2200 किलोग्राम प्रति हेक्टेयर) की तुलना में समीप के नहर से चावल में अतिरिक्त सिंचाई देने से निवल लाभ (100000 रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.22) एवं वर्षाजल उपयोग क्षमता (4.36 किलोग्राम प्रति हेक्टेयर–मिमी) सहित अधिक उत्पादन (2600 किलोग्राम प्रति हेक्टेयर) दिया।

तरहा सरया गांव (मिर्जापुर जिला, उत्तर प्रदेश) में, नियंत्रण (2150 किलोग्राम प्रति हेक्टेयर) की तुलना में चावल में 0.5 प्रतिशत सूक्ष्म पोषक (Zn+Bo) सहित 2 प्रतिशत थोरिआ के पर्ण छिड़काव ने अधिक उत्पादन (2400 किलोग्रम प्रति हेक्टेयर), निवल लाभ (18600 रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.16) एवं वर्षाजल उपयोग क्षमता (4.70 किलोग्राम प्रति हेक्टेयर–मिमी) सहित 11.6 प्रतिशत का उत्पादन वृद्धि दर्ज किया। इसी प्रकार, बिना पर्ण छिड़काव (1650 किलोग्राम प्रति हेक्टेयर) की तुलना में मक्का में पर्ण छिड़काव ने अधिक अनाज उत्पादन (2400 किलोग्रम प्रति हेक्टेयर) दिया एवं उत्पादन में वृद्धि 45 प्रतिशत थी।

कोचारिया गांव (भिलवाड़ा जिला, राजस्थान) में, किसानों की प्रक्रिया (704 किलोग्राम प्रति हेक्टेयर) की तुलना में मक्का में 2 प्रतिशत KNO_3 के पर्ण छिड़काव ने अधिक निवल लाभ (14600 रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.21) सहित 25 प्रतिशत अधिक बीज उत्पादन (878 किलोग्राम प्रति हेक्टेयर) दिया। इसी प्रकार, लपसिया गांव (राजसमंद

जिला, राजस्थान) में, बिना पर्ण छिड़काव (405 किलोग्राम प्रति हेक्टेयर) के किसानों की तुलना में 2 प्रतिशत KNO_3 के पर्ण छिड़काव से अधिक मक्का अनाज उत्पादन (518 किलोग्राम प्रति हेक्टेयर), वर्षाजल उपयोग क्षमता (1.98 किलोग्राम प्रति हेक्टेयर–मिमी) एवं बी:सी अनुपात (0.90) दर्ज हुआ।

निगनोती गांव (इंदौर जिला, मध्य प्रदेश) में, बिना पर्ण छिड़काव की तुलना में 375 मि.ली. प्रति हेक्टेयर की दर से बीसवतउमुनमज बीसवतपकम (VAM&C) 50 SL एवं 400 लीटर पानी प्रति हेक्टेयर का उपयोग कर 250 ग्राम प्रति हेक्टेयर की दर से थियोरिआ का पर्ण छिड़काव से सोयाबीन के बीज उत्पादन में क्रमश : 6–8 प्रतिशत एवं 3–50 प्रतिशत की वृद्धि हुई। सोयाबीन की किस्मों में जेएस 95–60 ने 375 मि.ली. प्रति हेक्टेयर की दर से VAM&C 50 SL के छिड़काव से अधिकतम उत्पादन (950 किलोग्राम प्रति हेक्टेयर), निवल लाभ (14100 रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (0.86) दिया।

रउरा एवं पटुला गांव (रीवा जिला, मध्य प्रदेश) में, बिना सिंचाई (365 किलोग्राम प्रति हेक्टेयर) की तुलना में सोयाबीन किस्म जेएस 93–05 में अतिरिक्त सिंचाई से अधिकतम बीज उत्पादन (1065 किलोग्राम प्रति हेक्टेयर), निवल लाभ (32925 रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (3.19) दर्ज हुआ। इसी प्रकार, बिना सिंचाई (1620 किलोग्राम प्रति हेक्टेयर) की तुलना में अतिरिक्त सिंचाई से धान की शहभागी किस्म ने अधिकतम अनाज उत्पादन (2215 किलोग्राम प्रति हेक्टेयर) दर्ज हुआ।

पाटा मेघापुर गांव (जामनगर जिला, गुजरात) में, वर्षा आधारित फसल (1330 किलोग्राम प्रति हेक्टेयर) की तुलना में कपास में 30 मि.मी. की प्राण रक्षा सिंचाई के प्रयोग से बीज कपास के उत्पादन (2280 किलोग्राम प्रति हेक्टेयर), निवल लाभ (43300 रुपए प्रति हेक्टेयर), बी:सी अनुपात (1. 36) एवं वर्षाजल उपयोग क्षमता (2.21 किलोग्राम प्रति हेक्टेयर–मि.मी.) में वृद्धि हुई।

वारखेड़ (बीके) गांव (अकोला जिला, महाराष्ट्र) में, वर्षा आधारित फसल (968 किलोग्राम प्रति हेक्टेयर) की तुलना में सोयाबीन में कृषि तालाब में संचित वर्षाजल से एक संरक्षित सिंचाई देने से 15110 रुपए प्रति हेक्टेयर का अधिक निवल लाभ, 1.59 का बीरूसी अनुपात एवं 1.68 किलोग्राम प्रति हेक्टेयर दृमि.मी. का वर्षाजल उपयोग क्षमता सहित 12.5 प्रतिशत (1093 किलोग्राम प्रति हेक्टेयर) तक बीज उत्पादन में वृद्धि हुई।

अंतिम सूखा

बुधाधनी गांव (कंधमाल जिला ओडिशा) में, वर्षा आधारित मक्का (2500 किलोग्राम प्रति हेक्टेयर) की तुलना में अतिरिक्त सिंचाई ने मक्का (एनएमएच–51) ने 3000 किलोग्राम प्रति हेक्टेयर का अधिकतम अनाज उत्पादन, 11000 रुपए प्रति हेक्टेयर का निवल लाभ,1.58 का बी:सी अनुपात एवं 5 किलोग्राम प्रति हेक्टेयर–मिमी का वर्षाजल उपयोग क्षमता दी।

हिसार में, बिना अतिरिक्ष्त सिंचाई (883 किलोग्राम प्रति हेक्टेयर) की तुलना में संचित वर्षा जल से बाजरा (एचएचबी–67) की सिंचाई से अधिक वर्षाजल उपयोग क्षमता (4.5 किलोग्राम प्रति हेक्टेयर), निवल लाभ (878 रुपए प्रति हेक्टेयर) एवं बीरूसी अनुपात (1.1) सहित 1166 किलोग्राम प्रति हेक्टेयर का अधिक अनाज उत्पादन दर्ज हुआ।

कालिमतिधालिया गांव (बंसाकांथा जिला, गुजरात) में, बिना सिंचाई की तुलना में अरंड में पुष्पण एवं कैपसुल निर्माण पर दो अतिरिक्त सिंचाइयों से क्रमश: 1170 एवं 2315 किलोग्राम प्रति हेक्टेयर का अधिक बीज एवं डंठल का उत्पादन दर्ज किया गया। अतिरिक्त सिंचाई (485 किलोग्राम प्रति हेक्टेयर) से अधिकतम निवल लाभ (26488–रुपए प्रति हेक्टेयर), बीरूसी अनुपात (1.83) एवं वर्षाजल उपयोग क्षमता (1.20 किलोग्राम प्रति हेक्टेयर–मिमी) भी दर्ज हुआ।

बबुलगांव (परभनी जिला, महाराष्ट्र) में, बिना सिंचाई (290 किलोग्राम प्रति हेक्टेयर) की तुलना में स्प्रिंकलर द्वारा संचित वर्षा जल से अतिरिक्त सिंचाई (5 सेंटीमीटर) देने से 17016 रुपए प्रति हेक्टेयर का निवल लाभ, 1.97 का बी:सी अनुपात एवं 1.73 किलोग्राम प्रति हेक्टेयर–मिमी का वर्षाजल उपयोग क्षमता सहित 78 प्रतिशत (494 किलोग्राम प्रति हेक्टेयर) का अरहर बीज उत्पादन हुआ। इसी प्रकार, बिना सिंचाई की तुलना में अतिरिक्त सिंचाई से अधिक बीज कपास उत्पादन (1124 किलोग्राम प्रति हेक्ष्टेयर), निवल लाभ (25318 रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.00) एवं 3.94 किलोग्राम प्रति हेक्टेयर–मिमी) वर्षाजल उपयोग क्षमता दर्ज हुआ।

II. तैयारियां

आरंभ में एवं फसल मौसम के दौरान, मौसम प्रतिकूलताओं से जूझने की तैयारियों के रूप में जोखिम समुत्थान प्रौद्योगिकियोंध्प्रक्रियाओं का प्रदर्शन किया गया एवं इसकी प्रमुख विशेषताएं नीचे दी गई हैं।

वर्षाजल प्रबंधन

नग्ला दुलहे खान गांव (आग्रा जिला, उत्तर प्रदेश) में, बिना रिडजर सीडर (1008 किलोग्राम प्रति हेक्टेयर) के बोवाई की तुलना में रिडजर सीडर (1320 किलोग्राम प्रति हेक्टेयर) द्वारा बोवाई से बाजरा का अधिकतम अनाज उत्पादन दर्ज हुआ। किसानों की प्रक्रिया की तुलना में रिडजर सीडर द्वारा बोवाई से अधिक निवल लाभ (7343 रुपए प्रति हेक्टेयर), 1.45 का बीरूसी अनुपात एवं 4.83 किलोग्राम प्रति हेक्टेयर–मिमी का वर्षाजल उपयोग क्षमता भी दर्ज हुआ।

कालिमति/धालिया गांव (बंसाकांथा जिला, गुजरात) में, बिना खंड मेंढ (870 किलोग्राम प्रति हेक्टेयर) की तुलना में बाजरा में खंड मेंढ द्वारा स्वदृस्थाने नमी संरक्षण से 18222 रुपए प्रति हेक्टेयर का अधिक निवल लाभ, बी:सी अनुपात (1.87) एवं वर्षाजल उपयोग क्षमता (1.39 किलोग्राम प्रति हेक्टेयर–मिमी) सहित महत्वपूर्ण रूप से अधिकतम अनाज (1348 किलोग्राम प्रति हेक्टेयर) एवं चारा (3640 किलोग्राम प्रति हेक्टेयर) उत्पादन दर्ज हुआ।

निगनोती गांव (इंदौर जिला, मध्य प्रदेश) में, बोवाई की सपाट पद्धत्ति (870 किलोग्राम प्रति हेक्टेयर) की तुलना में चौड़ी क्यारी कूंड रोपण प्रणाली से सोयाबीन की बोवाई ने क्रमश: 3200 रुपए प्रति हेक्टेयर एवं 0.20 का निवल लाभ एवं बी:सी अनुपात सहित अधिकतम उत्पादन (600 किलोग्राम प्रति हेक्टेयर) दिया।

मुथुकृष्णापुरम गांव (थुथीकुडी जिला, तमिलनाडु) में, सपाट क्यारियों पर बोवाई की तुलना में स्व–स्थाने नमी संरक्षण के लिए चौड़ी क्यारी कूंड को अपनाने से क्रमश: मक्का (4360 किलोग्राम प्रति हेक्टेयर), मूंग (710 किलोग्राम प्रति हेक्टेयर) एवं ज्वार (2640 किलोग्राम प्रति हेक्टेयर) में 12,13 एवं 17 प्रतिशत अधिक उत्पादन हुआ।

बबुलगांव (परभनी जिला, महाराष्ट्र) में, सपाट क्यारी पद्धत्ति (487 किलोग्राम प्रति हेक्टेयर) की तुलना में सोयाबीन (एमएयूएस–71) में चौड़ी क्यारी कूंड से स्व–स्थाने वर्षाजल प्रबंधन ने अधिक बीज उत्पादन (632 किलोग्राम प्रति हेक्टेयर), निवल लाभ (9024/–रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.61) एवं वर्षाजल उपयोग क्षमता (2.21 किलोग्राम प्रति हेक्टेयर–मिमी) दिया।

फसल प्रणालियां

चमुआ गांव (लखिमपुर जिला, असम) में, चावल की खेती (1200 किलोग्राम प्रति हेक्टेयर) की तुलना में तिल़मूंग (2:2) के अंतर फसल प्रणाली से 67610/- रुपए का निवल लाभ एवं 6.9 का बी:सी अनुपात सहित 7902 किलोग्राम प्रति हेक्टेयर का अधिक चावल समतुल्य उत्पादन हुआ।

कोचारिया गांव (भिलवाड़ा जिला, राजस्थान) में, मक्का एवं उड़द के मिश्रित कृषि की तुलना में मक्का़उड़द (2:2) का अंतर फसल प्रणाली ने अधिकतम मक्का समतुल्य उत्पादन (1145 किलोग्राम प्रति हेक्टेयर), निवल लाभ (5780 रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.35) दिया।

चिक्कामारनहल्ली गांव (बेंगलूरू ग्रामीण जिला, कर्नाटक) में, अरहर की एकल फसल (795 किलोग्राम प्रति हेक्टेयर) की किसानों की प्रक्रिया की तुलना में अरहर (बीआरजी–1) ग्वार बीन (पिमसक इमंद) (एचए–4) ने अधिक अरहर बीज समतुल्य उत्पादन (1030 किलोग्राम प्रति हेक्टेयर), वर्षाजल उपयोग क्षमता (1.48), निवल लाभ (72773 रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (3.40) दर्ज हुआ।

नग्घ्ला दुलहे खान गांव (आग्रा जिला, उत्तर प्रदेश) में, एकल फसल प्रणाली के रूप में बाजरा से 464 रुपए प्रति हेक्टेयर का निवल लाभ, 1.03 का बी:सी अनुपात की तुलना में पट्टीदार फसल प्रणाली में उगाए गए बाजरा़ग्वार बीन (4:4) ने 1163 किलोग्राम प्रति हेक्टेयर का अधिकतम बाजरा समतुल्य उत्पादन, 3511 रुपए प्रति हेक्टेयर का निवल प्रतिफल एवं 1.23 का बी:सी अनुपात दर्ज हुआ।

कालिमति/धालिया गांव (बंसाकांथा जिला, गुजरात) में, 911 किलोग्राम प्रति हेक्टेयर का उत्पादन सहित एकल अरंड़ की तुलना में अरंड़मूंग फसल प्रणाली (1:1) ने अधिक वर्षाजल उपयोग क्षमता (1.43 किलोग्राम प्रति हेक्टेयर–मिमी), निवल लाभ (31872 रुपए प्रति हेक्टेयर एवं बी:सी अनुपात (2.05) सहित अधिक अरंड समतुल्य उत्पादन (1394 किलोग्राम प्रति हेक्टेयर) दर्ज हुआ।

पाटा मेघापुर गांव (जामनगर जिला,गुजरात) में, एकल मूंगफली (1869 किलोग्राम प्रति हेक्टेयर) की तुलना में मूंगफली अरंड की अंतर फसल प्रणाली (3:1) ने अधिक निवल लाभ (62990 रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.33) एवं वर्षाजल उपयोग क्षमता (2.91) सहित अधिक मूंगफली का समतुल्य उत्पादन (2022 किलोग्राम प्रति हेक्टेयर) दर्ज हुआ।

मुथुकृष्णापुरम गांव (थुथीकुडी जिला, तमिलनाडु) में, कपास़ग्वार बीन अंतर फसल प्रणाली (2:2) ने अधिक निवल लाभ (22730/- रुपए प्रति हेक्टेयर) एवं 1.53 का बी:सी अनुपात सहित अधिक बीज कपास समतुल्य उत्पादन (1563

किलोग्राम प्रति हेक्टेयर) दर्ज किया, उसके बाद 1.49 का बी:सी अनुपात सहित कपास़मूंग प्रणाली (2:2) का स्थान था।

पोषक प्रबंधन

चमुआ गांव (लखिमपुर जिला, असम) में, बिना उर्वरक प्रयोग के किसानों की तुलना में आधार के रूप में 20:20:10 किलोग्राम प्रति हेक्टेयर की दर से नाइट्रोजन:फासफोरस: पोटाश के प्रयोग के बाद अधिकतम कल्ला एवं बाली निकलने की अवस्था पर दो समान भागों में 20 किलोग्राम नाइट्रोजन का छिड़काव एवं अधिकतम कल्ला अवस्था पर 10 किलोग्राम पोटाश का छिड़काव से 38–43 प्रतिशत चावल का अधिक अनाज उत्पादन हुआ।

तेरहा सराया गांव (मिर्जापुर जिला, उत्तर प्रदेश) में, सिफारिश किए गए उवर्रकों (1530 किलोग्राम प्रति हेक्टेयर) के प्रयोग की किसानों की प्रक्रिया की तुलना में चावल में 50 प्रतिशत सिफारिश की गई उर्वरक मात्रा़ 50 प्रतिशत गोबर की खाद़ 2 प्रतिशत यूरिआ का पर्ण छिड़काव युक्त समेकित पोषक प्रबंधन से 15700/- रुपए प्रति हेक्टेयर का निवल लाभ, 2.4 का बी:सी अनुपात एवं 5.8 किलोग्राम प्रति हेक्टेयर–मिमी का वर्षाजल उपयोग क्षमता सहित अधिक उत्प्पादन (2350 किलोग्राम प्रति हेक्टेयर) दर्ज हुआ।

कोचारिया गांव (भिलवाड़ा जिला, राजस्थान) में, किसानों की प्रक्रिया की तुलना में 25 किलोग्राम प्रति हेक्टेयर की दर से जिंक सल्फेट के प्रयोग ने अधिक निवल लाभ (3827/- रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.26) सहित अधिक मक्का अनाज उत्पादन (888 किलोग्राम प्रति हेक्टेयर) दिया।

अचलपुर एवं नैनवान गांव (होशियारपुर जिला, पंजाब) में, केवल उर्वरक प्रयोग की किसानों की प्रक्रिया की तुलना में, अचलपुर एवं नैनवान में, 75 प्रतिशत अजैविक़ 25 प्रतिशत जैविक माध्यमों के संयोग द्वारा नाइट्रोजन के प्रयोग ने क्रमश: अधिकतम उत्पादन (3580 एवं 3410 किलोग्राम प्रति हेक्टेयर), वर्षाजल उपयोग क्षमता (52 एवं 49.5 किलोग्राम प्रति हेक्टेयर–मिमी) एवं निवल लाभ (34291 एवं 31315/- रुपए प्रति हेक्टेयर) दिया।

बबुलगांव गांव (परभनी जिला, महाराष्ट्र) में, बिना पर्ण छिड़काव (436 किलोग्राम प्रति हेक्टेयर) वाले किसानों की प्रक्रिया की तुलना में अरहर में 19:19:19 (0.5 प्रतिशत) के पर्ण छिड़काव से अधिक बीज उत्पादन (484 किलोग्राम प्रति हेक्टेयर), निवल लाभ (16422/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.94) तथा वर्षाजल उपयोग क्षमता (1.70 किलोग्राम प्रति हेक्?टेयर–मिमी) दर्ज हुआ।

सफल ऊर्जा प्रबंधन

हरदोइया गांव (फैजाबाद जिला, उत्तर प्रदेश) में, भूमि तैयारी की अन्य पद्धतियों की तुलना में एमबी हल़ एक बार हैरा से 25 सेंटीमीटर गहरी जुताई से अधिक मक्का उत्पादन (1410 किलोग्राम प्रति हेक्टेयर), निवल लाभ (5067/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.27) तथा वर्षाजल उपयोग क्षमता (4.91 किलोग्राम प्रति हेक्टेयर–मिमी) दर्ज हुआ।

चिक्कामारनहल्ली गांव (बेंगलूरू ग्रामीण जिला, कर्नाटक) में, किसानों की प्रक्रिया (2356 किलोग्राम प्रति हेक्टेयर) की तुलना में संशोधित बैल द्वारा चालित बीज ड्रिल द्वारा रागी की बोवाई से अधिक अनाज उत्पादन (2500 किलोग्राम प्रति हेक्टेयर), निवल लाभ (33072/- रुपए प्रति हेक्टेयर), बीरूसी अनुपात (2.31) तथा वर्षाजल उपयोग क्षमता (4.91 किलोग्राम प्रति हेक्टेयर–मिमी) दर्ज हुआ।

कालिमति/धालिया गांव (बंसाकांथा जिला, गुजरात) में, रोटो टिल ड्रिल द्वारा मूंग की बोवाई से अधिक निवल लाभ (43402/- रुपए प्रति हेक्टेयर), बीरूसी अनुपात (5.53) तथा वर्षाजल उपयोग क्षमता (0.68 किलोग्राम प्रति हेक्टेयर–मिमी) सहित महत्वपूर्ण रूप से अधिक बीज (665 किलोग्राम प्रति हेक्टेयर) एवं कड़बी उत्पादन (1560 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। इसके बाद पट्टीदार टिल ड्रिल (590 किलोग्राम प्रति हेक्टेयर) का स्थान था।

वैकल्पिक भूमि उपयोग

तहकपल, तंडपल एवं गुमियापल गांव (बस्तर जिला, छत्तीसगढ़) में, अन्य प्रणालियों की तुलना में कृषि–बागवानी प्रणालियों पर आधारित आम के पेड़ों में (8 वर्ष की उर्म), आम़कोलोकासिया (बवसवबेंप) प्रणाली से अधिक निवल लाभ (38506 रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.94) तथा वर्षाजल उपयोग क्षमता (2.68 किलोग्राम प्रति हेक्टेयर–मिमी) दर्ज हुआ।

खनेर गांव (सांबा जिला, जम्मु एवं कश्मीर) में, ओनला़ मिश्रित चारा प्रणाली के अंतर्गत किसानों के खेतों पर मिश्रित चारा का उत्पादन 24825 किलोग्राम प्रति हेक्टेयर का औसत उत्पादन सहित उत्पादन 21800 से 29000 किलोग्राम प्रति हेक्टेयर था एवं 1.91 से 255 का बी:सी अनुपात सहित

निवल लाभ 10409 रुपए प्रति हेक्टेयर से 17609 रुपए प्रति हेक्टेयर तक था।

निक्रा–अनुकूल अनुसंधान

- वारखेड़ जलग्रहण पर चयनित मृदा बेंच मार्क निर्देशित क्षेत्रों पर फसल प्रणालियों द्वारा अनुकूलन रणनीतियों पर किए गए अध्ययन में, 25 से 29, 33 से 34 एवं 38 से 44 वें मानक मौसमवैज्ञानिक सप्ताहों के दौरान 3 शुष्क दौरों द्वारा बरशीतकली तेहसील, अकोला जिला, महाराष्ट्र में फसल प्रभावित हुए। बिना संरक्षण कूंड़ों के किसानों की प्रक्रिया की तुलना में सोयाबीन (जेएस–335) में बोवाई के 30–35 दिनों के बाद संरक्षणों कूंडों की खुदाई से स्व–स्थाने नमी संरक्षण के परिणामस्वरूप 9 प्रतिशत अधिक बीज उत्प्पादन हुआ। अन्य मृदा प्रकारों की तुलना में अति उत्तम स्मेकटिटिक (smectitic), कलकेरियस वेरटिक असटोचरेप्टस (calcareous vertic Ustochrepts) मृदा में कूंडों की खुदाई से सोयाबीन का अधिक बीज उत्पादन (980 किलोग्राम प्रति हेक्टेयर) दर्ज हुआ। इसी प्रकार, वेरटिक असटोचरेप्टस (vertic Ustochrepts) मृदा (1953 किलोग्राम प्रति हेक्टेयर) के अंतर्गत सोयाबीऩ अरहर अंतर फसल प्रणाली (4:2) में, अधिक सोयाबीन समतुल्य उत्पादन दर्ज किया गया, जबकि क्रमश: टाइपिक हपलॉस्टर (Typic Haplusterts) एवं टाइपिक असटोचरेप्टस (Typic Ustochrepts) के अंतर्गत 1635 एवं 1594 किलोग्राम प्रति हेक्टेयर था।
- क्रमश: अजैविक एवं जैविक प्रबंधन की तुलना में समेकित पोषक प्रबंधन (625 किलोग्राम प्रति हेक्टेयर) के अंतर्गत खेतों में 15 एवं 18 प्रतिशत अधिक सूरजमुखी के बीजों का उत्पादन हुआ। जबकि, दोनों समेकित पोषक प्रबंधन एवं जैविक प्रबंधन ने मूंग के समान बीज उत्पादन (547–566 किलोग्राम प्रति हेक्टेयर) दर्ज हुआ, जबकि अजैविक प्रबंधन के अंतर्गत उत्पादन (515 किलोग्राम प्रति हेक्टेयर) न्यूनतम था। जैविक प्रबंधन (417 किलोग्राम प्रति हेक्टेयर) के अंतर्गत वाले खेतों में अरहर का उत्पादन अधिकतम था जोकि समेकित एवं अजैविक उपचारों की तुलना में क्रमश: 8 एवं 19 प्रतिशत अधिक था। औसतन, समेकित एवं अजैविक उपचारों की तुलना में फसल मौसम के दौरान जैविक प्रबंधन के अंतर्गत वाले खेतों 0.35–0.5 प्रतिशत अधिक मृदा नमी की मात्रा थी। इसी प्रकार, अन्य उपचारों की तुलना में जैविक प्रबंधन के अंतर्गत मृदा तापमान 0.70 सेंटीग्रेड कम थी।

गांव की जलवायु जोखिम प्रबंधन समिति

- गांव की जलवायु जोखिम प्रबंधन समिति निक्रा के गांवों में फसल, भूमि एवं मृदा आधारित हस्तक्षेप, कस्टम हायरिंग केंद्र आदि का सफल संचालन जैसे आवश्यकता आधारित जलवायु समुत्थ्थान हस्तक्षेपों के कार्यान्वयन में प्रमुख भूमिका निभाता है।

कस्टम हायरिंग केंद्र

- कस्टम हायरिंग केंद्र कम कीमत पर गरीब किसानों द्वारा आवश्यकता आधारित उपकरणोंमशीनों को किराए पर दिलाने में सहायता करता है एवं कम समय में भूमि की तैयारी एवं समय पर बडे भू–भाग में सही बोवाई तथा अधिक ऊर्जा दक्षता सहित अन्य कृषि प्रचालन का कार्य करता है। हरेक निक्रा गांव में कस्टम हायरिंग प्रबंधन समिति ने किराए से प्राप्त आय से कस्टम हायरिंग केंद्रों की गतिविधियों एवं उपकरणों के रख–रखाव की। कस्टम हायरिंग केंद्र अधिक मांग के दौरान श्रमिकों की कमी को दूर करने में महत्वपूर्ण भूमिका निभाता है।

गांव का बीज बैंक

- निक्रा के गांवों में विभिन्न फसलों के लघु अवधि एवं सूखा सहीष्णु किस्मों का बीज उत्पादन शुरू कर दिया है। वर्ष के दौरान, विभिन्न निक्रा गांवों में किसानों के पास विभिन्न वर्षा आधारित फसलों का करीब 42000 किलोग्राम बीज उपलब्ध है।

चारा बैंक

- मौसमी विचलनों के दौरान चारा की कमी को दूर करने के लिए, निक्रा के गांवों में चारा उत्पादन के अंतर्गत सामुदायिक भूमियों एवं कुछ किसानों के खेतों को इसमें लिया गया है। ऐसे प्रयासों में, चिक्कामारनहल्ली गांव, बेंगलूरू ग्रामीण जिले में वार्षिक चारा के साधन के रूप में एवं मेंढ़ को स्थिर बनाने के लिए खेत के मेंढों पर एस. हमाटा उगाया गया। निक्रा गांव में लाइव चारा बैंक, झांसी में 2000 क्विंटल से अधिक चारा है। निक्रा गांव बल्ल्लोवाल सांकुरी में, हरा चारा की उपलब्धता को बढ़ाने के लिए संकर नेपियर (Hybrid napier) का रोपण किया गया है। निक्रा के जगदलपुर गांव में, किसानों के खेतों में स्टाइलोसेंथिस (stylosanthes) नेपियर, बेरसीम

एवं ज्वार आधारित चारा प्रणाली की गई। चमुआ गांव, लखिमपुर जिले के चारा बैंक में संकर नेपियर (CO_2 एवं CO_4), कोंगनोसिगनल (congnosignal) एवं सेटारिआ जैसे वार्षिक चारा किस्मों की तीन प्रजातियों का रोपण किया गया है।

कृषि–सलाह

- ब्लेक बोर्ड पर मौसम सूचना एवं कृषि–सलाहों का प्रदर्शन, मोबाइल द्वारा एसएमएस सेवा तथा ऑल इंडिया रेडियों द्वारा सभी गांवों में कार्यान्वयन के लिए सही समय की आकस्मिक उपायों की सलाह दी गई है। वर्ष 2015–16 के दौरान, अनंतपुरम, फैजाबाद, बेंगलुरू, कोविलपट्टी, राजकोट, बिस्वनाथ चरिअलि एवं इंदौर में किसानों को सही समय की कृषि–सलाह सेवाएं जारी की गई।

मृदा स्वस्थ्य कार्ड

- निक्रा गांवों में जारी की गई मृदा स्वास्थ्य कार्ड का उपयोग स्थान–विशेष की पोषक प्रबंधन, पोषक छिड़काव एवं मृदा स्वास्थ्य के रख–रखाव के लिए किया जाएगा। वर्ष 2015–16 के दौरान विभिन्न केंद्रों द्वारा जारी किए मृदा स्वास्थ्य कार्डों में अनंतपुरम (49 किसान), अरजिआ (40 किसान), एसके नगर (93 किसान), फैजाबाद (15 किसान), कोविपट्टी (23 किसान), झांसी (60 किसान), विजयपुर (46 किसान), फुलबानी (49 किसान), जगदलपुर (86 किसान), आग्रा (40 किसान), वारणासी (30 किसान), रीवा (65 किसान) बिस्वनाथ चरिअलि (14 किसान) शामिल हैं।

प्रशिक्षण/क्षेत्रीय दौरे/क्षेत्रीय दिवस

- एक्रीपड़ा केंद्र द्वारा नियमित रूप से किसानों – वैज्ञानिकों – पणधारियों की बैठकों का आयोजनाय जलवायु परिवर्तनशीलता के बारे में किसानों को जागरूक बनाना एवं कृषि तथा संबद्ध क्षेत्रों पर इसके प्रभावों तथा कृषि सलाहय उन्ध्न्ध्त वर्षा आधारित प्रौद्योगिकियों/श्रेष्ठ प्रक्रियाओं पर मौसम पूर्व एवं मौसम में प्रशिक्षणय मौसम विचलनों के दौरान विषयपरक हस्तक्षेपोंके निष्पादन पर किसानों एवं अन्य पणधारियों को प्रदर्शित करने के लिए क्षेत्रीय दौरों क्षेत्रीय दिवसों का आयोजन किया गया। वर्ष के दौरान, केंद्रों द्वारा 67 प्रशिक्षणों एवं क्षेत्रीय दिवस दौरों का आयोजन किया गया जिससे किसानों सहित 3789 पणधारियों को लाभ हुआ।

जिला कृषि आकस्मिक योजनाओं के संचालन हेतु संपर्क

- वर्ष 2015–16 के दौरान, जिला स्तरीय फसल आकस्मिक योजना को अद्यतन बनाने के लिए केंद्रों के वैज्ञानिकों ने वैज्ञानिकों, कृषि विज्ञान केंद्र के अधिकारियों तथा संबंधित राज्यों के संबंधित विभागों के अधिकारियों को शामिल किया गया। इसके अलावा, केंद्रों के वैज्ञानिकों ने जिला कृषि आकस्मिक योजनाओं के संचालन के लिए 11 राज्यों (कर्नाटक, आंध्र प्रदेश, तेलंगाना, मध्य प्रदेश, महाराष्ट्र, राजस्थान, गुजरात, उत्तर प्रदेश, हरियाणा, झारखंड एवं छत्तीसगढ़) में आयोजित राज्य स्तर की बैठकों में भी भाग लिया एवं कार्य योजनाओं के विकास में योगदान दिया।

Executive Summary

The technology demonstration component (TDC) of NICRA, both on-station and on-farm, is being implemented at 23 Centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA), since 2011. During 2015-16, the emphasis was on real time contingency crop plan implementation and preparedness to cope with weather aberrations with interventions such as rainwater harvesting (*in-situ* and *ex-situ*) and efficient use, drought tolerant crops/ varieties, resilient crop management practices, efficient energy management. The interventions to cope with delayed onset of monsoon and seasonal drought (early, mid season and terminal) were demonstrated in 1050 farmers' fields covering about 400 ha in 33 villages in 24 districts across 15 states during *kharif* 2015. The onset of monsoon was delayed by more than two weeks in NICRA villages of Rajasmand and Solapur districts. Further, there were 4-6 dry spells at different stages of crops in NICRA villages of Lakhimpur, Garhwa, Kandhamal, Vijayapur and Solapur districts.

The salient achievements are summarized below.

I. Real-time contingency planning

Delayed onset of monsoon

At Kumbhi and Bankheta villages (Garhwa district, Jharkhand), under delayed onset of monsoon by 13 days, drought tolerant and short duration varieties gave higher yield and net returns as compared to local checks viz. rice cv. Arize Tej (3067 kg/ha, Rs 35071/ha); maize cv. Kanchan (3194 kg/ha, Rs 19954/ha); fingermillet cv. A-404 (1621 kg/ha, Rs 11687/ha); sesame cv. Shekhar (487 kg/ha, Rs 11867/ha) and blackgram cv. Birsa Urd-1 (1235 kg/ha, Rs 44578/ha).

At SK Nagar, under delayed onset of monsoon by 31 days, pearlmillet hybrid GHB 558 recorded higher grain (445 kg/ha) and fodder (1215 kg/ha) yield with higher net returns (Rs.2070/ha) and B:C ratio (0.25) than GHB 538 (395 kg/ha). Similarly, greengram var. GM-4 recorded though low but higher seed and stover yield of 405 and 1030 kg/ha, respectively compared to GM-3 (325 kg/ha).

At Rewa, under delayed onset of monsoon by 10 days, early maturing variety of soybean JS 20-29 recorded higher seed yield (1016 kg/ha) with net returns of Rs. 29720/ha, RWUE 1.18 kg/ha-mm and B:C ratio of 2.85. Similarly, improved varieties of blackgram (PU 30), greengram (HUM 1), sesame (TKG 21) and pigeonpea (Asha) also gave higher yield (632, 478, 350 and 1780 kg/ha, respectively) compared to local varieties.

Early season drought

At Kavalagi village (Vijayapur district, Karnataka), intercultivation and weeding in pigeonpea gave higher yield (1325 kg/ha), net returns (Rs.77922/ha) and RWUE (3.99 kg/ha-mm) compared to farmers' practice (933 kg/ha).

At Tahkapal, Tandpal and Gumiyapal villages (Bastar district, Chhattisgarh), furrow opening in rice with country plough gave higher grain yield of 2230 kg/ha with net returns of Rs.10763/ha, B:C ratio of 1.67 and RWUE of 3.26 kg/ha-mm compared to without furrow opening (1202 kg/ha).

At Budhadani village (Kandhamal district, Odisha), *in-situ* moisture conservation with raising of bund height in rice gave higher yield (2400 kg/ha), net returns (Rs. 11000/ha), and B:C ratio (1.84) compared to farmers' practice of no bunding (2100 kg/ha).

At Nignoti village (Indore district, Madhya Pradesh), seed yield of soybean cv. JS 93-05 increased by 8% (1060 kg/ha) with net returns of Rs 17920/ha and B:C ratio of 2.12 due to weeding/intercultural operation over without weeding (980 kg/ha).

At Vannedoddipally village (Anantapuramu district, Andhtra Pradesh), *in-situ* moisture conservation with opening of conservation furrows improved yield in groundnut (5%), castor (11%), pigeonpea (9%) and cotton (6%) compared to without conservation furrows (1510, 460, 676 and 470 kg/ha, respectively). Formation of conservation furrows gave additional net returns of Rs.820, Rs. 4650 and Rs.1350/ha in castor, pigeonpea and cotton respectively compared to farmers' practice.

At Rajkot, the seed cotton yield (1850 kg/ha) was increased by 17% due to furrow opening (45 cm wide) for *in-situ* moisture conservation at vegetative stage in cotton as compared to without furrow. It also recorded higher net returns (Rs.58575/ha), B:C ratio (2.00) and RWUE (3.15 kg/ha-mm) compared to without furrow.

At Babulgaon village (Parbhani district, Maharashtra), foliar spray of KNO_3 @ 2% in soybean

recorded 11% higher seed yield (484 kg/ha), net returns (Rs.5544/ha), B:C ratio (1.44) and RWUE (1.69 kg/ha) over control (435 kg/ha).

Midseason drought

At Kavalagi village (Vijayapur district, Karnataka), foliar spray of KNO_3 @ 0.5% during dry spell and urea @ 2% immediately after receipt of rains gave 19 and 27% higher yield of greengram (328 kg/ha) and pigeonpea (1000 kg/ha), respectively compared to without foliar spray with greengram and pigeonpea yield of 275 and 788 kg/ha, respectively.

At Chamua village (Lakhimpur district, Assam), one supplemental irrigation in rapeseed gave 10% higher seed yield (1000 kg/ha) with net returns of Rs 13373/ha, B:C ratio of 1.82 and RWUE of 4.08 kg/ha-mm compared to rainfed crop (909 kg/ha).

At Hardoiya village (Faizabad district, Uttar Pradesh), mulching with green leaves of subabool @ 10 t/ha in maize recorded 28% higher grain yield (1450 kg/ha) with net returns of Rs. 987/ha and B:C ratio of 1.05 compared to farmers' practice of no mulching (1140 kg/ha).

At Tahkapal, Tandpal and Gumiyapal villages (Bastar district, Chhattisgarh), supplemental irrigation at flower initiation in rice with 2 cm depth of water gave higher grain yield of 1530 kg/ha, with net returns of Rs.42208/ha, B:C ratio of 3.22 and RWUE of 2.24 kg/ha-mm compared to without irrigation (1023 kg/ha).

At Budhadani village (Kandhamal district, Odisha), supplemental irrigation in rice from nearby water stream gave higher yield (2600 kg/ha), net returns (Rs.10000/ha), B:C ratio (1.63) and RWUE (4.36 kg/ha-mm) compared to rainfed rice (2200 kg/ha).

At Terha Saraya Village (Mirzapur District, Uttar Pradesh), foliar spray of 2% thiourea with micro nutrients 0.5% (Zn + Bo) in rice recorded higher yield (2400 kg/ha), net returns (Rs.18600/ha), B:C ratio (1.16) and RWUE (4.70 kg/ha) with yield increase of 11.6% over control (2150 kg/ha). Similarly, maize gave higher grain yield (2400 kg/ha) and the increase in yield was 45% over without foliar spray (1650 kg/ha).

At Kochariya village (Bhilwara district, Rajasthan), foliar application of 2% KNO_3 in maize gave 25% higher seed yield (878 kg/ha) over farmers' practice (704 kg/ha) with higher net returns (Rs.14600/ha) and B:C ratio (1.21). Similarly, at Lapsiya village (Rajsamand district, Rajasthan), higher maize grain yield (518 kg/ha), RWUE (1.98 kg/ha-mm) and B:C ratio (0.90) were recorded with foliar spray of 2% KNO_3 over farmers' practice of no foliar spray (405 kg/ha).

At Nignoti village (Indore district, Madhya Pradesh), foliar spray of chlormequet chloride (VAM-C) 50 SL @ 375 ml/ha and thiourea @ 250 g/ha using 400 lit water/ha increased seed yield of soybean by 6-8% and 3-50% respectively over without foliar spray. Among the soybean varieties, JS 95-60 gave highest yield (950 kg/ha), net returns (RS.14100/ha) and B:C ratio (0.86) with the spray of VAM-C 50 SL @375 ml/ha.

At Raura and Patuna villages (Rewa district, Madhya Pradesh), supplemental irrigation in soybean var. JS 93-05 recorded maximum seed yield (1065 kg/ha), net returns (Rs. 32925/ha) and B:C ratio (3.19) over without irrigation (365 kg/ha). Similarly, Shahbhagi variety of paddy recorded highest grain yield (2215 kg/ha) with supplemental irrigation as compared to no irrigation (1620 kg/ha).

At Pata Meghpar village (Jamnagar district, Gujarat), life saving irrigation of 30 mm applied in cotton increased seed cotton yield (2280 kg/ha), net returns (Rs.43300/ha), B:C ratio (1.36) and RWUE (2.21 kg/ha-mm) compared to rainfed crop (1330 kg/ha).

At Varkhed (Bk) village (Akola district, Maharashtra), one protective irrigation from harvested rainwater in farm pond in soybean increased seed yield by 12.5% (1093 kg/ha), with higher net returns of Rs.15110/ha, B:C ratio of 1.59 and RWUE of 1.68 kg/ha-mm compared to rainfed crop (968 kg/ha).

Terminal drought

At Budhadani village (Kandhamal district, Odisha), maize (NMH -51) with supplemental irrigation gave the highest yield of 3000 kg/ha, net returns of Rs. 11000 /ha, B:C ratio of 1.58 and RWUE of 5 kg/ha-mm compared to rainfed maize (2500 kg/ha).

At Hisar, supplemental irrigation in pearlmillet (HHB-67) from harvested rainwater recorded higher grain yield of 1166 kg/ha with higher RWUE (4.5 kg/ha-mm), net returns (Rs.878/ha) and B:C ratio (1.1) compared to without supplemental irrigation (883 kg/ha).

At Kalimati/Dholiya village (Banaskantha district, Gujarat), two supplemental irrigations given at flowering and capsule formation in castor recorded higher seed and stalk yields of 1170 and 2315 kg/ha, respectively over no irrigation. The highest net returns

(Rs. 26488/ha), B:C ratio (1.83) and RWUE (1.20 kg/ha-mm) were also recorded with supplemental irrigation (485 kg/ha).

At Babulgaon village (Parbhani district, Maharashtra), supplemental irrigation (5 cm) from harvested rainwater with sprinklers increased pigeonpea seed yield by 78% (494 kg/ha) with net returns of Rs. 17016/ha, B:C ratio of 1.97 and RWUE of 1.73 kg/ha-mm over no irrigation (290 kg/ha). Similarly, higher seed cotton yield (1124 kg/ha), net returns (Rs.25318/ha), B:C ratio (2.00) and RWUE (3.94 kg/ha-mm) was recorded with supplemental irrigation compared to without irrigation (632 kg/ha).

II. Preparedness

In the beginning and during crop season, risk resilient technologies/practices were demonstrated as preparedness to cope with weather aberrations and the highlights are presented below.

Rainwater management

At Nagla Dulhe Khan village (Agra District, Uttar Pradesh), maximum grain yield of pearlmillet was recorded by sowing with ridger seeder (1320 kg/ha) as compared to sowing without ridger seeder (1008 kg/ha). Higher net returns (Rs.7343/ha), B:C ratio of 1.45 and RWUE of 4.83 kg/ha-mm were also recorded with sowing by ridger seeder over farmers' practice.

At Kalimati/Dholiya village (Banaskantha district, Gujarat), *in-situ* moisture conservation with compartmental bunding in pearlmillet recorded significantly highest grain (1348 kg/ha) and fodder (3640 kg/ha) yields with higher net returns of Rs.18222/ha, B:C ratio (1.87) and RWUE (1.39 kg/ha-mm) compared to no compartmental bunding (870 kg/ha).

At Nignoti village (Indore district, Madhya Pradesh), sowing of soybean with broad bed furrow (BBF) planting system gave maximum yield (600 kg/ha) with a net returns and B:C ratio of Rs. 3200/ha and 0.20 respectively compared to flat method of sowing (560 kg/ha).

At Muthukrishnapuram village (Thoothukudi district, Tamil Nadu), adoption of BBF method for *in-situ* moisture conservation resulted in 12, 13 and 17% higher yield in maize (4360 kg/ha), greengram (710 kg/ha) and sorghum (2640 kg/ha), respectively compared to sowing on flat beds.

At Babulgaon village (Parbhani district, Maharashtra), *in-situ* rainwater management with BBF in soybean (MAUS-71) gave higher seed yield (632 kg/ha), net returns (Rs.9024/ha), B:C ratio (1.61) and RWUE (2.21 kg/ha-mm) compared to flat bed method (487 kg/ha).

Cropping systems

At Chamua village (Lakhimpur district, Assam), intercropping system of sesame + greengram (2:2) produced higher rice equivalent yield of 7902 kg/ha with net returns of Rs 67610/ha and B:C ratio of 6.9 compared to rice cultivation (1200 kg/ha).

At Kochariya village (Bhilwara district, Rajasthan), maize + blackgram (2:2) intercropping system gave maximum MEY (1145 kg/ha), net returns (Rs.5780/ha) and B:C ratio (1.35) as compared to mixed cropping of maize and blackgram (725 kg/ha).

At Chikkamaranahalli village (Bengaluru rural district, Karnataka), pigeonpea (BRG-1) + field bean (HA-4) recorded higher pigeonpea seed equivalent yield (1030 kg/ha), RWUE (1.48 kg/ha-mm), net returns (Rs. 72773/ha) and B:C ratio (3.40) compared to farmers' practice of pigeonpea sole crop (795 kg/ha).

At Nagla Dulhe Khan village (Agra District, Uttar Pradesh), pearlmillet + clusterbean (4:4) grown in strip cropping system recorded highest pearlmillet equivalent yield of 1163 kg/ha, net returns of Rs.3511/ha and B:C ratio of 1.23 compared to net returns of Rs. 464/ha and B:C ratio of 1.03 recorded with pearlmillet as sole system.

At Kalimati/Dholiya village (Banaskantha district, Gujarat), castor + greengram intercropping system (1:1) recorded significantly higher castor equivalent yield (1394 kg/ha) with higher RWUE (1.43 kg/ha), net returns (Rs.31872/ha) and B:C ratio (2.05) over sole castor with yield of 911 kg/ha.

At Pata Meghpar village (Jamnagar district, Gujarat), groundnut + castor intercropping system (3:1) recorded higher groundnut pod equivalent yield (2022 kg/ha) with higher net returns (Rs. 62990/ha), B:C ratio (2.33) and RWUE (2.91) compared to sole groundnut (1869 kg/ha).

At Muthukrishnapuram village (Thoothukudi district, Tamil Nadu), cotton + clusterbean intercropping system (2:2) recorded higher seed cotton equivalent yield (1563 kg/ha) with higher net returns (Rs.22730/ha) and B:C ratio of 1.53 followed by cotton + greengram system (2:2) with B:C ratio of 1.49.

Nutrient management

At Chamua village (Lakhimpur district, Assam), application of N:P:K @ 20:20:10 kg/ha as basal

followed by top dressing of 20 kg N in two equal spilt at maximum tillering and panicle initiation stages and top dressing of 10 kg K at maximum tillering stage produced 38-43% higher grain yield of rice compared to farmers' practice of no fertilizer application, with higher net returns (Rs 35295/ha) and B:C ratio (2.7).

At Terha Saraya Village (Mirzapur District, Uttar Pradesh), integrated nutrient management involving 50% RDF + 50% FYM + foliar spray of 2% urea in rice recorded higher yield (2350 kg/ha) with net returns of Rs.15700/ha, B:C ratio of 2.4 and RWUE of 5.8 kg/ha-mm compared to farmers' practice of RDF (1530 kg/ha).

At Kochariya village (Bhilwara district, Rajasthan), application of zinc sulphate @ 25 kg/ha gave 18% higher maize grain yield (888 kg/ha) over farmers' practice (760 kg/ha) with higher net returns (Rs.3827/ha) and B:C ratio (1.26).

At Achalpur and Nainwan villages (Hoshiarpur district, Punjab), application of N through combination of 75% inorganic + 25% organic source gave maximum yield (3580 and 3410 kg/ha), RWUE (52 and 49.5 kg/ha-mm) and net returns (Rs.34291 and Rs.31315/ha), respectively at Achalpur and Nainwan over farmers' practice of fertilizer application alone (2925 and 2825 kg/ha).

At Babulgaon village (Parbhani district, Maharashtra), foliar spray of 19:19:19 (0.5%) in pigeonpea recorded higher seed yield (484 kg/ha), net returns (Rs.16422/ha), B:C ratio (1.94) and RWUE (1.70 kg/ha-mm) compared to farmers' practice of no foliar spray (436 kg/ha).

Efficient energy management

At Hardoiya village (Faizabad district, Uttar Pradesh), deep ploughing 25 cm with MB plough + 1 harrowing recorded higher maize yield (1410 kg/ha), net returns (Rs.5067/ha), B:C ratio (1.27) and RWUE (4.91 kg/ha-mm) compared to other methods of land preparation.

At Chikkamaranahalli village (Bengaluru rural district, Karnataka), sowing fingermillet with modified bullock drawn seed drill recorded higher grain yield (2500 kg/ha), net returns (Rs. 33072/ha) and B:C ratio (2.31) compared to farmer's practice (2356 kg/ha).

At Kalimati/Dholiya village (Banaskantha district, Gujarat), greengram sowing with Roto till drill recorded significantly higher seed (665 kg/ha) and stover yield (1560 kg/ha) with higher net returns (Rs.43402/ha), B:C ratio (5.53) and RWUE (0.68 kg/ha-mm) followed by strip till drill (590 kg/ha).

Alternate land use

At Tahkapal, Tandpal and Gumiyapal villages (Bastar district, Chhattisgarh), Among mango (8-year old) based agri-horti systems, mango + colocasia system recorded higher net returns (Rs.38506/ha), B:C ratio (2.94) and RWUE (2.68 kg/ha), compared to other systems.

At Khaner village (Samba District, Jammu and Kashmir), the yield of mixed fodder on farmers' fields under aonla + mixed fodder system ranged from 21800 to 29000 kg/ha with mean yield of 24825 kg/ha and the net returns ranged from Rs.10409/ha to Rs 17609/ha with B:C ratio of 1.91 to 2.55.

NICRA-Strategic Research

- In a study on adaptation strategies through cropping systems at selected soil benchmark sites at Varkhed watershed, Barishtakali Tehsil, Akola district, Maharashtra, the crops were affected by 3 dry spells during 25th to 29th, 33rd to 34th and 38th to 44th SMW. *In-situ* moisture conservation through opening of conservation furrow at 30-35 DAS in soybean (JS-335) resulted in 9% higher seed yield compared to farmers' practice of no conservation furrow. Higher seed yield (980 kg/ha) of soybean was recorded with opening of conservation furrow in very fine smectitic, calcareous Vertic Ustochrepts soil compared to other soil types. Similarly, in soybean + pigeonpea intercropping system (4:2), higher soybean equivalent yield (SEY) was recorded under Vertic Haplusterts soil (1953 kg/ha), while it was 1635 and 1594 kg/ha under Typic Haplusterts and Typic Ustoctirepts, respectively.
- In a field experiment on organic crop production, the seed yield of sunflower was 15 and 18% higher in the plots under INM (625 kg/ha) than that under inorganic organic management, respectively. However, both INM and organic management recorded similar seed yield of greengram (547-566 kg/ha) while the yield was lowest (515 kg/ha) under inorganic management. Pigeonpea yield was highest in the plots under organic management (417 kg/ha) which was higher by 8 and 19% compared to integrated and inorganic treatments, respectively. On average,

the soil moisture content was 0.35-0.5% higher in the plots under organic management during the crop season compared to integrated and inorganic treatments. Similarly, the soil temperature was lower under organic management by 0.7^0C compared to other treatments.

Village Climate Risk Management Committee (VCRMC)

The VCRMCs in NICRA villages played a major role in implementation of need based climate resilient interventions viz. crop, land and soil based interventions, efficient functioning of custom hiring centre etc.

Custom Hiring Centre (CHC)

CHCs helped in hiring the need based 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) in each NICRA village 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 Bank

Seed production of short duration and drought tolerant varieties of different field crops was taken up in NICRA villages. During the year, about 42000 kg seed of different rainfed crops is available with the farmers in different NICRA villages.

Fodder Bank

In order to meet the fodder scarcity during weather aberrations, community lands and some of the famers' fields were brought under fodder production in NICRA villages. In such efforts, *S. hamata* was established on the field bunds as a source of perennial fodder and to stabilize the the bunds in Chikkamaranahalli village, Bengaluru Rural district. Live fodder bank in NICRA village, Jhansi has more than 2000 q fodder. In NICRA village of Ballowal Saunkhri, hybrid napier has been planted to increase the availability of green fodder. In NICRA villages of Jagdalpur, *Stylosanthes*, napier, berseem and sorghum based fodder systems were established in farmers' fields. Three species of perennial fodder varieties viz., hybrid napier (CO-2 and CO-4), congnosignal and setaria were planted in fodder bank at Chamua village, Lakhimpur district.

Agro-advisories

Real time contingency measures were advised for implementation in all the villages through display of weather information and agro-advisories on black boards, SMS service through mobiles and All India Radio. During 2015-16, Ananthapuramu, Agra, Faizabad, Bengaluru, Kovilpatti, Rajkot, Biswanath Chariali 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 issued by different centres during 2015-16 include Anantapuramu (49 farmers), Arjia (40 farmers), SK Nagar (93 farmers), Faizabad (15 farmers), Kovilpatti (23 farmers), Jhansi (60 farmers), Vijayapura (46 farmers), Phulbani (40 farmers), Jagdalpur (86 farmers), Agra (40 farmers), Varanasi (30 farmers), Rewa (65 farmers) and Biswanath Chariali (14 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, 67 trainings and field days/visits were organized by the centres which benefitted 3789 stakeholders including farmers.

Linkages for Operationalizing District Agriculture Contingency Plans

During 2015-16, the scientists of the centres were actively involved updating the district level crop contingency plans, involving scientists and officials from KVKs and line departments in respective states. Further, the scientists from centres also participated in state level meetings organized in 11 states (Karnataka, Andhra Pradesh, Telangana, Madhya Pradesh, Maharashtra, Rajasthan, Gujarat, Uttar Pradesh, Haryana, Jharkhand and Chattisgarh) for operationalization of district agriculture contingency plans and contributed in developing action plans.

Introduction

Agriculture is the source of livelihood for nearly two-thirds of the population in India. The sector currently accounts for 11.6 of the GDP. A major part of the agriculture in India is rainfed (~77 million ha out of 142 million ha net sown area) and will remain so for at least for a foreseeable future. The sharp fluctuations in agricultural growth are mainly attributed to the vagaries of monsoon. Some part of the country or the other experiences monsoon failure almost every year but most states encounter drought once in 2 to 4 years. The south-west monsoon accounts for nearly 75% of the natural precipitation received in the country and therefore exert a strong influence on *kharif* food grain production and the economy in terms of agricultural output, farmers' income and price stability. Monsoon failures result in drought which has serious implications for small and marginal farmers and livelihoods of the rural poor.

Climate change impacts on agriculture are being witnessed in various parts of India which are more vulnerable in view of the high population depending on agriculture and excessive pressure on natural resources. Rainfall is the key variable influencing crop productivity in rainfed agriculture. Intermittent and prolonged droughts are a major cause of yield reduction in most crops. The rainfall drives water availability and determines sowing time (rainfed crops); temperature drives crop growth, duration; dry spells cause significant impact on standing crops, physiology, loss of economic products (eg. fruit drop) and extreme events (eg. high rainfall/floods/heat wave/cold wave/cyclone /hail/frost) cause enormous losses of standing crops. Rainfed crops are likely to be worst hit by climate change because of the limited options for coping with variability of rainfall and temperature. The projected impacts are likely to further aggravate yield fluctuations of many crops with impact on food security and prices. Climate change impacts are likely to vary in different parts of the country and are likely to be more vulnerable in terms of extreme events.

Several national initiatives were launched in India for climate change research and significant among them are Network Project on Climate Change (NPCC) (2004) by the Indian Council of Agricultural Research (ICAR), National Action Plan on Climate Change (NAPCC) (2010) consisting of 8 National Missions to represent multi-pronged, long term and integrated strategies for achieving key goals in the context of climate change. The National Mission for Sustainable Agriculture (NMSA), one of the eight missions, aims at devising strategies to make Indian agriculture more resilient to climate change. In the XI Five Year Plan, ICAR launched the National Initiative on Climate Resilient Agriculture (NICRA) in 2011 to undertake strategic research in network mode and also to demonstrate location-specific climate risk resilient technologies in farmers' fields in a participatory mode in 130 vulnerable districts spread across the country. In XII Plan, NICRA is being implemented as National Innovations on Climate Resilient Agriculture.

AICRPDA-NICRA Programme

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) was launched in 1970 by ICAR 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 AICRPDA Umbrella continued in applied and adaptive research mode. Presently, AICRPDA network has 22 centres and 8 Operational Research Projects (Fig-1) located in 15 states representing diverse rainfed agro-ecologies (Table-1). The location specific research at network centres based on natural resource management and socioeconomic status was the hallmark of the programme. Introduction of collaborative on-farm participatory research efforts in the Operational Research Project concept goes to the credit of the project. The project is supported by 516 staff members (128 scientists and 388 technical, administrative and

auxiliary). Over a period of 4 decades, AICRPDA network centres generated location-specific technologies for upscaling in the respective resource domains. 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 use efficiency.

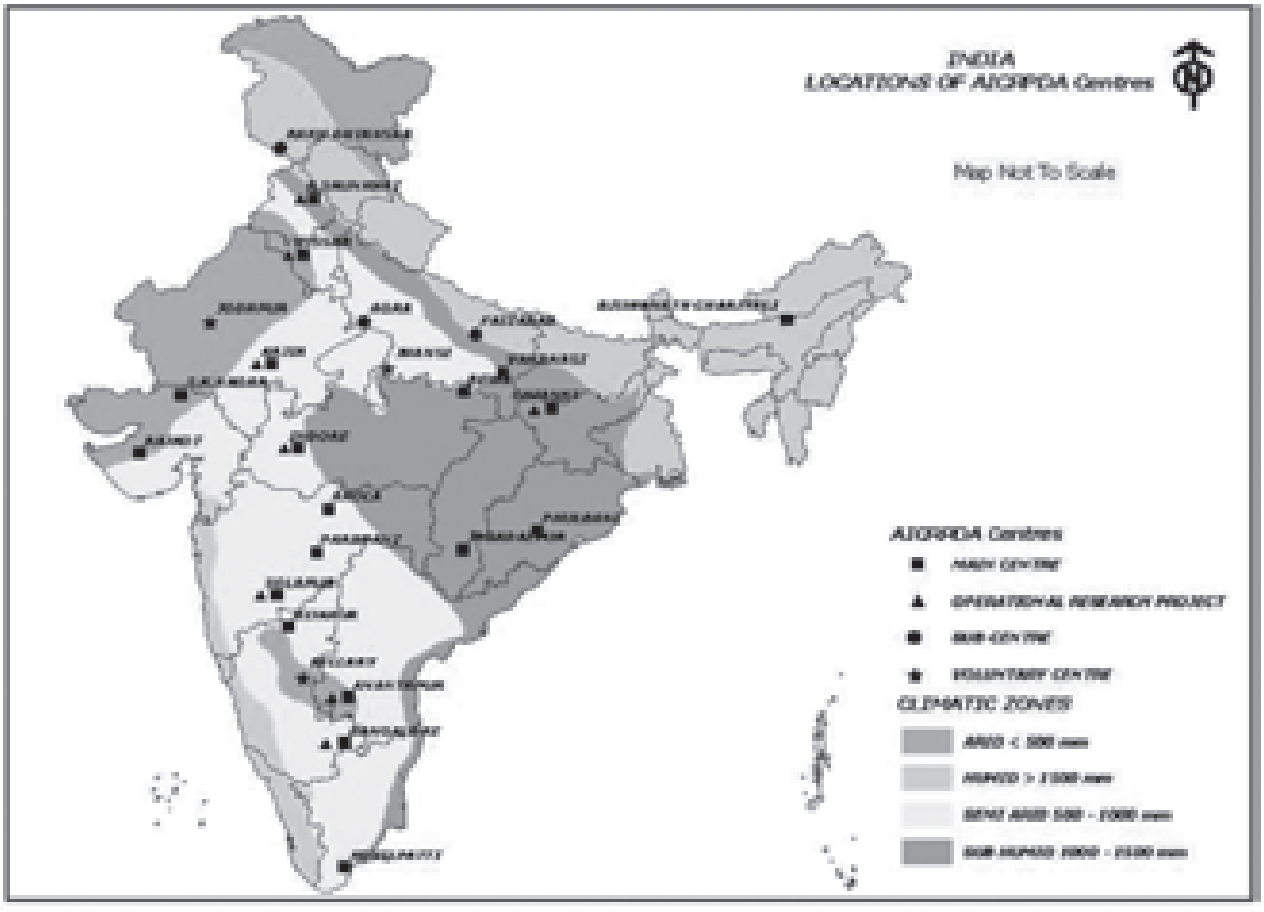


Fig 1: Location Map of AICRPDA Network Centres

Table 1: Agro-ecological setting of AICRPDA network centres

Name of the Centre	SAU/CAR institute/ their Hqrs)	Agro-Climatic Zone(NARP)/ Agro– Eco sub-region (AESR)	Climate	Mean Annual Rainfall(mm)	Dominant Soil Type	Major Rainfed Production system
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
Ballowal Saunkhri (MC&ORP)	PAU, Ludhiana	Kandi region in Punjab (9.1)	Sub humid (Hot dry)	1011	Inceptisols	Maize
Bengaluru (MC&ORP)	UAS_B, Bengaluru	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermillet
Bellary (VC)	CSWCRTI, Dehradun	Northern dry zone in Karnataka (3.0)	Arid (Hot)	502	Vertisols	*Rabi* Sorghum
Biswanath Chariali (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
Jagdalpur (MC)	IGAU, Raipur	Basthar Plateau zone in Chattisgarh (12.1)	Sub-humid (Hot moist)	1297	Inceptisols	Rice
Jhansi (VC)	IGFRI, Jhansi	Bundhelkhand zone in Uttar Pradesh (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, Bhubaneswar	Eastern Ghat Zone in Odisha (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 Uttar Pradesh (4.3/9.2)	Semi-arid (Hot moist) Sub-humid (Hot dry)	1049	Inceptisols	Rice
Vijayapur (MC)	UAS_D, Dharwad	Northern dry zone in Karnataka (6.1)	Semi-arid (Hot dry)	595	Vertisols	*Rabi* Sorghum

The AICRPDA Network centres were included in the National Initiative on Climate Resilient Agriculture (NICRA) Project of ICAR for taking up demonstration and research activities at various dryland centres in a network mode. The demonstration component of NICRA has been finalized in these centres in a participatory mode. Further, the network programme envisages identifying climatic vulnerabilities of agriculture in the selected villages by each centre 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. The location of the AICRPDA - NICRA adopted villages is shown in Fig-2, and the details are given in Table-2.

Fig 2: Location map of AICRPDA-NICRA adopted villages

Since 2011, the AICRPDA network centres initiated both on-station and on-farm research/ demonstrations on real-time contingency measures. For on-farm research/demonstration, the first step was to select a representative village in a most vulnerable district to weather aberrations such as drought, extreme events such as floods etc. In the selected villages, the bottom-up process included baseline survey and PRA to document the initial details about the impacts of weather aberrations on agriculture etc and to understand the farmers' awareness about climate change/variability. To implement RTCPs, innovative Village Level Institutions (VLIs) were constituted in a participatory mode such as Village Climate Risk Management Committee (VCRMC) for deciding on interventions effective implementation and overall smooth functioning, Custom Hiring Centre (CHC) for maintaining and hiring need based arm implements/ machinery for timely agricultural operations with precision, cost effectiveness and energy efficiency and Custom Hiring Centre Management Committee to maintain and hire farm implements. The other specific VLIs include fodder banks for fodder production and supply, seed banks for maintaining and supply of quality seed, nutrient banks (vermicomposting units etc) for production and supply of organic fertilizers etc. The approach was to saturate whole village with the climate resilient technologies. 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, inter-cropping and new varieties were demonstrated in a contiguous area 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. The action plans were prepared for each village with details of activities along with roles and responsibilities of stakeholders, period and budget for each intervention.

Table 2: AICRPDA-NICRA program- Details of villages

AICRPDA centre	Name of the Villages	District	State
Agra	Nagla Duleh khan	Agra	Uttar Pradesh
Akola	Warkhed	Akola	Maharashtra
Anantapur	Vannedoddipally	Anantapur	Andhra Pradesh
Arjia	Kochariya Lapsiya	Bhilwara Rajsamand	Rajasthan
Ballowal Saunkhri	Naiwan, Achalpur	Hoshiarpur	Punjab
Bengaluru	Chikkamaranahalli	Bengaluru Rural	Karnataka
Biswanath Chariali	Chamua	Lakhimpur	Assam
Bijapur	Kavalagi	Bijapur	Karnataka
Chianki	Kumbhi & Bankheta	Garhwa	Jharkhand
Faizabad	Hardoiya	Faizabad	Uttar Pradesh
Hisar	Budhshelly Balawas	Bhiwani Hisar	Haryana
Indore	Ningnoti	Indore	Madhya Pradesh
Jagdalpur	Tahakapal, Tandapal and Gumiyapal	Bastar	Chattishgarh
Jhansi	Kadesara Kala	Lalitpur	Uttar Pradesh
Kovilpatti	Muthukrishnapuram, Vadakkupatti	Thoothukkudi	Tamil Nadu
Parbhani	Babhulgaon	Parbhani	Maharashtra
Phulbani	Budhadani	Kandhamal	Odisha
Rajkot	Pata meghapar	Jamnagar	Gujarat
Rakh Dhiansar	Khaner	Samba	Jammu & Kashmir
Rewa	Patauna, Raura	Rewa	Madhya Pradesh
SK Nagar	Kalimati/ Dholia, Chandanki	Banaskantha Mehasana	Gujarat
Solapur	Narotewadi	Solapur	Maharashtra
Varanasi	Tedha	Mizapur	Uttar Pradesh

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 tools / implements 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.

Real Time Contingency Plan Implementation (RTCP) - Concept

During 1972-73, large scale scarcity of rainfall was experienced all over the country, particularly in the scarcity region of Maharashtra, Karnataka and Andhra Pradesh. Roving seminars were organized by the ICAR at different locations, at the end of which *new phrases* were coined *viz. contingent crop planning and mid-season correction*. As a follow up, dryland centres collected data on these two aspects and after analysis of weather data for the past 100 years, listed the weather aberrations: *i) delayed onset of monsoon; ii) early withdrawal of monsoon; iii) intermittent dry spells of various durations; iv)prolonged dry spells causing changes in the strategy ; and v) prolonged monsoon*. *Contingency plans,* for each region, was a conceptual approach unique from AICRPDA project in developing location specific contingent crop strategies which were first published in 1977 in *Indian Farming,* and with further refinements and updation in crops and varieties, the first document was brought out by AICRPDA in 1983 on *"Contingent crop production strategy in rainfed areas under different weather condition"*. The AICRPDA network centres developed crop contingency plans for each centre's domain. Further, during 2009-10, AICRPDA centres prepared contingency measures considering the weather aberrations, seasons, and predominant *kharif* and *rabi* crops with appropriate crop management strategies. CRIDA with information available at AICRPDA centres and SAUs, prepared district level agriculture contingency plans for more than 580 districts in collaboration with Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, GoI, ICAR institutes, State Agricultural/ Horticultural/Animal Science/Veterinary/Fisheries Universities, Krishi Vigyan Kendras (KVKs), State line departments. These plans essentially suggest coping strategies/measures in agriculture, horticulture and allied sectors in the event of delayed onset of monsoon, seasonal drought, unseasonal rainfall events, floods, cyclones, hail storm, heat/cold wave.

In view of frequent weather aberrations around the year in one or other part of the year impacting agricultural production, to minimize the losses in agriculture and allied sectors and to improve the efficiency of the production systems to enhance the production and income, the need was felt to implement contingency measures on real-time basis. Thus, Real Time Contingency Planning is considered as "Any contingency measure, either technology related (land, soil, water, crop) or institutional and policy based, which is implemented based on real time weather pattern (including extreme events) in any crop growing season".

The aim of real-time contingency measures is to i) to establish a crop with optimum plant population during delayed onset of monsoon; ii) to ensure better performance of crops during seasonal drought (early/ mid and terminal drought) and extreme events, enhance performance, improve productivity and income; iii) to ensure minimum damage to horticultural crops and their produce and also to enhance performance; iv) to minimize physical damage to livestock, poultry and fisheries sector and ensure better performance v) to ensure food security at village level and to enhance adaptive capacity and livelihoods of the farmers.

Some of the methods/measures to be adopted as real-time contingency plan implementation during various weather aberrations are presented below:

RTCP Measures in Rainfed Agriculture

a. Delayed onset of monsoon

In rainfed areas, as a general rule early sowing of crops with the onset of monsoon is the best-bet practice that gives higher realizable yield. Major crops affected due to monsoon delays are those crops that have a narrow sowing window and therefore cannot be taken up if the delay is beyond this cut-off date. Crops with wider sowing windows can still be taken up till the cut-off date without major yield loss and only the change warranted could be the choice of short duration cultivars (Srinivasarao *et al*., 2010). Beyond the sowing window, choice of alternate crops or cultivars depends on the farming situation, soil, rainfall and cropping pattern in the location and extent of delay in the onset of monsoon.

b. Early season drought

Early season drought may at times result in seedling mortality needing re-sowing or may result in poor crop stand and seedling growth. Further, the duration of water availability for crop growth gets reduced due to the delayed start, and the crops suffer from an acute shortage of water during reproductive stage due to early withdrawal of monsoon. The effect of early season drought is less on the crop, because during this period sowing is carried out. Various operations carried out are primary tillage, sowing, fertilizer application and intercultural operations (Srinivasarao *et al*., 2012). Other agronomic measures include resowing within a week to 10 days with subsequent rains for better plant stand when germination is less than 30%, thinning in small-seeded crops, interculture to break soil crust and remove weeds and create soil mulch for conserving soil moisture, avoiding top dressing of fertilizers till favourable soil moisture, opening conservation furrows at 10 to 15 m intervals, ridge and furrow across the slope for effective moisture conservation as well in as rainwater in wide spaced crops (>30 cm), pot watering may be taken up along with gap filling when the crop stand is less than 75% in crops like cotton, foliar spray of 2% urea during prolonged dry spells and providing supplemental irrigation wherever ground / surface water is available.

c. Mid-season drought

Stunted growth takes place if mid-season drought occurs at vegetative phase. If it occurs at flowering or early reproductive stage, it will have an adverse effect on the ultimate crop yield. *In-situ* soil-moisture conservation is a vital component of dryland crop management practices. During mid season drought plant protection, top-dressing of fertilizer, intercultural and supplemental irrigation are the usual practices. In case of long dry spells, crop based production system (location) related specific contingency plans are needed. Other agronomic measures include repeated interculture to remove weeds and create soil mulch to conserve soil moisture, thinning, avoiding top-dressing of fertilizers until receipt of rains, opening conservation furrows for moisture conservation, foliar spray of 2% KNO_3 or 2% urea solution or 1% water soluble fertilizers like 19-19-19, 20-20-20, 21-21-21 to supplement nutrition during dry spells, open alternate furrows, surface mulching with crop residues, and providing supplemental irrigation (10 cm depth), if available.

d. Terminal drought

If there is a terminal drought, crop-management strategies like plant protection, soil and water conservation, interculture, supplemental irrigation and harvesting are to be adopted. Terminal droughts are more critical as the grain yield is strongly related to water availability during the reproductive stage. Further, these conditions are often associated with an increase in ambient temperatures leading to forced maturity. The agronomic measure include providing life- saving or supplemental irrigation, if available,

from harvested pond water or other sources, harvesting crop at physiological maturity with some realizable yield or harvest for fodder and prepare for winter (*rabi*) sowing in double- cropped areas. Ratoon maize or pearl millet or adopt relay crops as chickpea, safflower, *rabi* sorghum and sunflower with minimum tillage after soybean in medium to deep black soils in Maharashtra or take up contingency crops (horsegram/cowpea) or dual-purpose forage crops on receipt of showers under receding soil moisture conditions.

e. Unseasonal heavy rainfall events

Suggested contingency measures include re-sowing, providing surface drainage, application of hormones/nutrient sprays to prevent flower drop or promote quick flowering/fruiting and plant-protection measures against pest/disease outbreaks with need based prophylactic/curative interventions. At crop maturity stage suggested measures include prevention of seed germination and harvesting of produce. If untimely rains occur at vegetative stage, the contingency measures include: draining out the excess water as early as possible, application of 20 kg N + 10 kg K/acre (0.4 ha) after draining excess water, application of 50 kg urea + 50 kg mutriate of potash (MOP)/acre (0.4 ha) after draining excess water, gap filling either with available nursery or by splitting the tillers from the surviving hills in rice, weed control, suitable plant protection measures in anticipation of pest and disease out breaks, foliar spray with 1% KNO_3 or water-soluble fertilizers like 19-19-19, 20-20-20, 21-21-21 at 1% to support nutrition, need-based fungicidal spray with Copper oxychloride 0.3% or Carbendazim 0.1% or Mancozeb 0.25% 2 to 3 times by rotating the chemicals, interculture at optimum soil-moisture condition to loosen and aerate the soil and to control weeds, earthing up the crop for anchorage etc.

f. Floods

Crop/field management depends on nature of material (sand or silt) deposited during floods. In sand-deposited crop fields/fallows, ameliorative measures include early removal or ploughing in of sand (depending on the extent of deposit) for facilitating *rabi* crop or next *kharif*. In silt-deposited Indo-Gangetic Plains, early *rabi* crop plan is suggested in current cropped areas and current fallow lands. Other measures include draining out of stagnant water and strengthening of field bunds etc. In *diara* (flood prone) land areas, measures include alternate crop plans for receding situations. Usually rice cropped areas are flood prone causing loss of nurseries, delayed transplanting or damage to the already transplanted fields etc. Suggested measures include promotion of flood tolerant varieties, community nursery raising, re-transplanting in damaged fields and transplanting new areas or direct seeding depending on seed availability so that the season is not lost. Other steps include prevention of pre-mature germination of submerged crop at maturity or of harvested produce by spray of salt solution.

Experienced weather at AICRPDA- NICRA villages during 2015-16

During 2015-16, the onset of monsoon was delayed by more than two weeks in NICRA villages located in Rajasmand and Solapur districts (Table). Further, there were 4-6 dry spells at different stages of crops in NICRA villages Lakhimpur, Garhwa, Kandhamal, Vijayapur and Solapur districts.

Table 3: Details of onset of monsoon in AICRPDA-NICRA villages (2015)

Villages & District	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Nagla Dulhe Khan (Agra)	South–western semiarid zone in Uttar Pradesh	2 July	1 July	-
Warkhed (Akola)	Western Vidarbha Zone in Maharashtra	10 June	11 June	1
Vannedoddipally (Ananthapuramu)	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh	7 June	1 June	-

Villages & District	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Kochariya (Bhilwara)	Southern zone in Rajasthan	1 July	24 June	-
Lapsiya (Rajsamand)	Southern zone in Rajasthan	2 July	24 July	22
Achalpur & Nainwan. (Hoshiarpur)	Kandi region in Punjab	1 July	29 June	-
Chikkamaranahalli (Bangalorerural)	Central, eastern and southern dry zone in Karnataka	2 June	1 June	-
Kavalagi (Vijayapur)	Northern dry zone in Karnataka	7 June	7 June	-
Chamua (Lakhimpur)	North Bank plain zone in Assam	5 June	6 June	1
Kumbhi & Bankheta (Garhwa)	Western plateau zone of Jharkhand	10 June	23 June	13
Hardoiya (Faizabad)	Eastern plain zone in Uttar Pradesh	21 June	25 June	4
Balawas & Budhshelly (Bhiwani)	South-western dry zone in Haryana	1 July	24 June	-
Nignoti (Indore)	Malwa plateau in Madhya Pradesh	12 June	11 June	-
Tahkapal (Bastar)	Basthar Plateau zone in Chattisgarh	15 June	4 June	-
Kadesara Kala (Lalitpur)	Bundhelkhand zone in Uttar Pradesh	25 June	23 June	-
Muthukrishnapuram and Thoppureddipatti (Toothukkudi)	Southern zone of Tamil Nadu	1 June	5 June	4
Babhulgaon (Parbhani)	Central Maharashtra Plateau Zone in Maharashtra	20 June	9 June	-
Budhani (Kandhamal)	Eastern Ghat Zone in Orissa	10 June	12 June	2
Patameghpar (Jamnagar)	North Saurashtra zones in Gujarat	16 June	18 June	2
Khaner (Samba)	Low altitude subtropical zone in Jammu and Kashmir	27 June	1 July	3
Patuana & Raura (Rewa)	Keymore plateau and Satpura Hill zone in Madhya Pradesh	23 June	30 June	7
Kalimati (Banaskantha)	Northern Gujarat in Gujarat	15 June	25 June	11
Narotewadi (Solapur)	Scarcity zone in Maharashtra	20 June	9 July	19
Tedha (Mirzapur)	Eastern Plain and Vindhyan Zone in Uttar Pradesh	1 July	25 June	-

In general, the total rainfall during *kharif* season (June-September), 2015 was below normal in all NICRA villages except in Balawas & Budhshelly (Bhiwani), Kalimati (Banaskantha), Nignoti (Indore), Pata Meghpar (Jamnagar), Chikkamaranahalli (Bengaluru Rural) and Tahkapal (Bastar) (Fig 3). Similarly, during *rabi* season (October-December) 2015, the rainfall was less than normal seasonal rainfall in all NICRA villages except Vannedoddipally (Ananthapuramu), Muthukrishnapuram & Thoppureddipatti (Toothukkudi) and Chikkamaranahalli (Bengaluru Rural). During the

period, no rainfall was received in 10 NICRA villages viz. Budhshelly (Bhiwani), Kochariya (Bhilwara), Lapsiya (Rajasmand), Nagla Dulhe Khan (Agra), Kalimati (Banaskantha), Narotewadi (Solapur), Nignoti (Indore), Pata Meghpar (Jamnagar), Kadesara Kalan (Lalitpur) and Hardoiya (Faizabad) (Fig 4). The rainfall was deficit by 50-100% during June 2015 in NICRA-villages of Agra, Garhwa, Indore, Lalitpur, Toothukkudi, Samba, Rewa and Solapur districts. In July, the deficit in rainfall was more than 60% in villages of Agra, Akola, Vijayapur, Lalitpur, Toothukkudi, Parbhani and Solapur districts. Similarly, in August, villages in Bhilwara, Rajasmand, Faizabad, Bhiwani, Indore, Toothukkudi, Parbhani, Jamnagar, Banaskantha, Solapur and Mirzapur districts recorded more than 50% deficit rainfall. In September, NICRA villages in Bhilwara, Rajasmand, Lalitpur, Jamnagar and Solapur districts did not receive any rainfall while the villages in Faizabad, Rewa and Mirzapur received scanty (more than 90% deficit) rainfall. Similarly, in October, 11 villages in Agra, Akola, Bhilwara, Rajasmand, Faizabad, Bhiwani, Kandhamal, Jamnagar and Banaskantha districts did not receive any rainfall (Table 4).

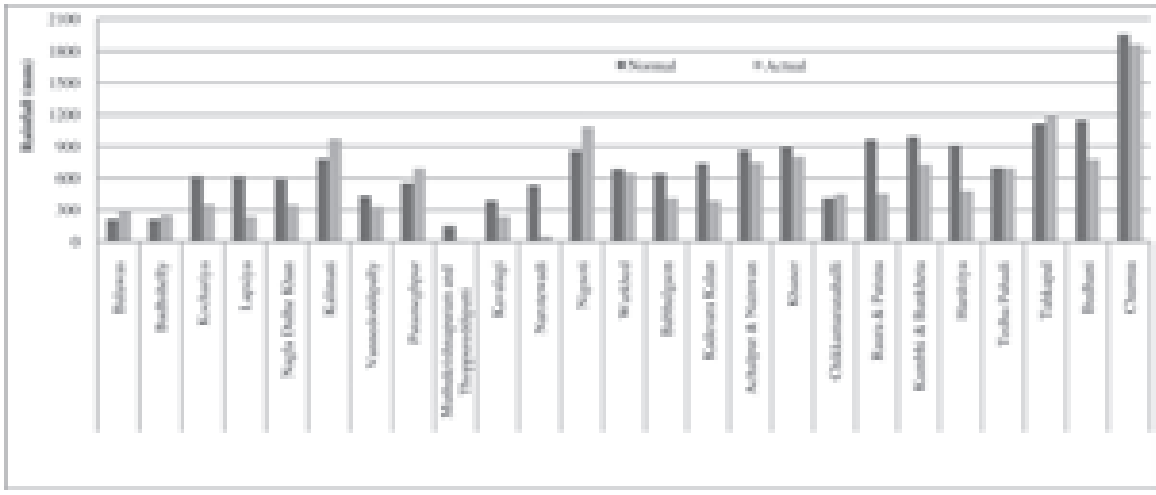


Fig 3: Normal and actual (2015) rainfall in AICRPDA-NICRA villages (June – September)

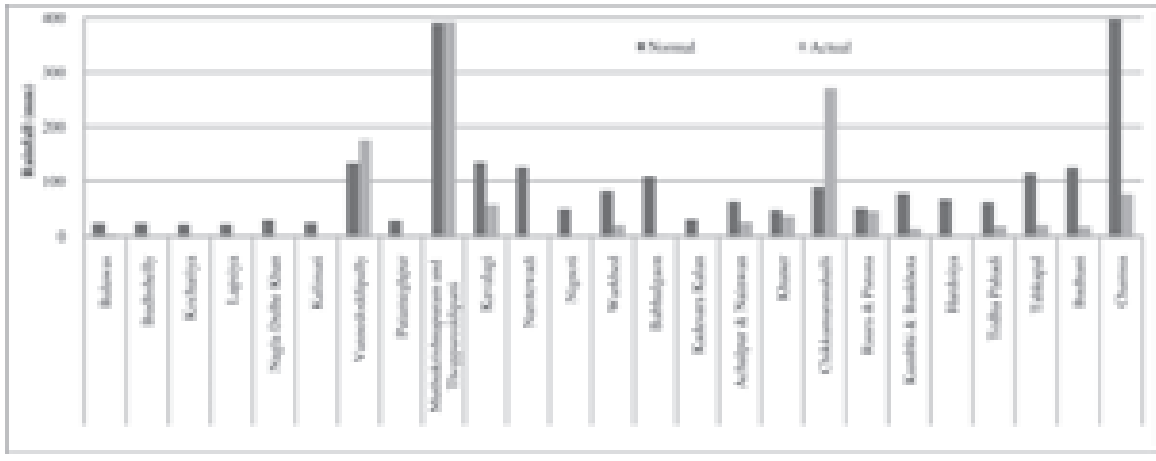


Fig 4: Normal and actual (2015) rainfall in AICRPDA-NICRA villages (October – December)

During 2015-16, the emphasis was on real-time contingency crop plan implementation and preparedness to cope with weather aberrations with interventions such as rainwater harvesting (*in-situ* and *ex-situ*) and efficient use, drought tolerant crops/ varieties, resilient crop management practices, and efficient energy management. The production-system wise and centre–wise salient achievements and other activities are presented in the following chapters.

Table 4: Month-wise rainfall in AICRPDA-NICRA villages during June-December, 2015

Villages & District	June			July			August			September			October			November			December		
	N	A	% Dev	N	A	% Dev	N	A	% Dev	N	A	% Dev	N	A	% Dev	N	A	% Dev	N	A	% Dev
Nagla Dulhe Khan (Agra)	52	15	-71	239	83	-65	207	162	-22	90	54	-40	25	0	-100	2	0	-100	2	0	-100
Warkhed (Akola)	137	135	-1	225	71	-68	159	283	78	147	124	-16	35	0	-100	18	0	-100	13		-100
Aminabad & Girigetla (Anantapuram)	94	91	-3	97	41	-58	97	51	-47	142	150	6	21	123	486	107	59	-45	5	0	-100
Kochariya (Bhilwara)	74	57	-23	196	223	14	249	75	-70	97	0	-100	10	0	-100	7	0	-100	4	0	-100
Lapsiya (Rajsamand)	74	62	-16	196	127	-35	249	48	-81	97	0	-100	10	0	-100	7	0	-100	4	0	-100
Achalpur & Nainwan (Hoshiarpur)	108	66	-39	288	421	46	304	157	-48	161	104	-35	28	11	-61	7	0	-100	27	14	-48
Chikkamaranahalli (Bengaluru rural)	59	78	32	80	73	-9	131	73	-44	139	225	62	154	74	-52	61	198	225	30	0	-100
Kavalagi (Vijayapur)	85	44	-48	73	3	-96	78	60	-23	152	157	3	97	56	-42	30	0	-100	7	0	-100
Chamua (Lakhimpur)	360	441	23	364	614	69	316	452	43	241	352	46	130	26	-80	20	50	150	11	0	-100
Kumbhi & Bankheta (Garhwa)	162	63	-61	320	445	39	359	174	-52	152	51	-66	62	12	-81	10	0	-100	6	0	-100
Hardoiya (Faizabad)	133	197	48	288	198	-31	301	73	-76	193	15	-92	51	0	-100	4	0	-100	11	0	-100
Balawas (Bhiwani)	20	75	275	80	135	69	60	21	-65	50	23	-54	8	0	-100	10	0	-100	3	0	-100
Budhshelly (Bhiwani)	20	82	310	80	140	75	60	23	-62	50	54	8	8	0	-100	10	3	-70	3	0	-100
Nignoti (Indore)	147	11	-93	244	375	54	326	156	-52	141	176	25	35	31	-11	11	0	-100	3	5.8	93
Tahkapal (Bastar)	236	430	82	343	144	-58	351	320	-9	193	311	61	88	10	-89	20	0	-100	6	9	50
Kadesara Kala (Lalitpur)	166	81	-51	269	83	-69	180	223	24	128	0	-100	21	0	-100	3	0	-100	5	0	-100
Muthukrishnapuram and Thoppureddipatti (Toothukkudi)	11	0	-100	20	0	-100	35	0	-100	84	12	-86	199	38	-81	139	266	91	139	88.6	-36
Babhulgaon (Parbhani)	172	126	-27	225	14	-94	236	83	-65	167	184	10	80	2	-98	21	0	-100	9	0	-100
Budhani (Kandhamal)	189	183	-3	350	217	-38	383	214	-44	228	166	-27	96	0	-100	24	0	-100	5	16	220
Patameghpar (Jamnagar)	103	354	244	252	168	-33	103	26	-75	97	0	-100	22	0	-100	5	0	-100	0	0	0
Khaner (Samba)	95	40	-58	323	398	23	337	248	-26	142	116	-18	19	11	-42	6	2	-67	22	23.1	5
Patuana (Rewa)	120	34	-72	309	187	-40	337	185	-45	199	18	-91	32	45	41	9.7	0	-100	8.5	0	-100
Kalimati (Banaskantha)	87	137	57	278	776	179	275	35	-87	142	24	-83	20	0	-100	3	0	-100	1	0	-100
Narotewadi (Solapur)	107	47	-56	116	0	-100	140	0	-100	173	0	-100	98	155	58	22	0	-100	6	0	-100
TedhaPahadi (Mirzapur)	87	181	108	293	331	13	337	148	-56	228	10	-96	49	17	-65	7	0	-100	5	0	-100

N – Normal A – Actual during 2015 % Dev - % Deviation

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 1865 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

Experienced weather condition during 2015-16

During the year 2015, the onset of monsoon was normal (1st June). A rainfall of 2467.6 mm was received which was deficit by 602.8 mm compared to normal (1864.8 mm). During south-west monsoon (*kharif*), a rainfall of 1680.4 mm was received against a normal rainfall of 1182.2 mm. The rainfall during *rabi* was excess by 81.5 mm compared to normal rainfall of 120 mm (Fig. 1.1.1).

Normal onset of monsoon	:	1st week of June
Onset of monsoon during 2015-16	:	1st week of June
Normal annual rainfall	:	1864.8 mm
Annual rainfall during 2015-16	:	2467.6 mm
Mean crop seasonal rainfall	:	1182 and 120 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2015-16	:	1680 and 201.5 mm during *kharif* and *rabi*, respectively

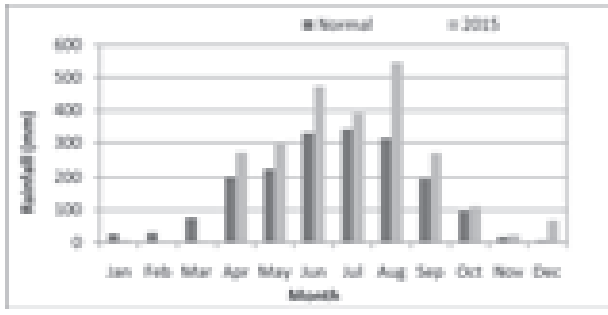


Fig . 1.1.1: Normal and actual (2015) monthly rainfall at Biswanath Chariali

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
11	25 September - 6 October	*Sali* rice	Reproductive stage
28	5 November – 2 December	Rapeseed, potato	Vegetative growth
27	13 December- 8 January, 2016	Rapeseed, potato	Seed filling (Rapeseed), tuber development (Potato)

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Potato	Vegetative	Supplemental irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

Potato was exposed to a prolonged dry spell of 28 days during 25 September to 6 October. Two supplemental irrigations were given at 30 and 60 days after planting. Higher tuber yield of 11538 and 9965 kg/ha in Kufri Pokhraj and Kufri Jyoti, respectively was realized when crop was provided with two supplemental irrigations. There was 30 to 33% increase in the yield of both the cultivars of potato with supplemental irrigation as compared to rainfed crop (Table 1.1.1).

Table 1.1.1: Performance of potato with supplemental irrigation from the harvested rainwater

Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With irrigation	Without irrigation				
Kufri Jyoti (90 days)	9965	7663	30.0	85.4	26475.0	1.36
Kufri Pokhraj (110 days)	11538	8668	33.1	95.7	42200.0	1.57

Preparedness

Rainwater management

Two popular potato varieties namely Kufri Jyoti and Kufri Pokhraj were grown in four different sowing dates with organic/crop residue mulching. The tuber yield of potato was increased by 33.7-51.3% when crop was grown with mulching as compared to that grown without mulching (Table 1.1.2). The net returns (Rs 58025/ha) and B: C ratio (1.79) was more with Kufri Pokhraj due to higher tuber yield (13120 kg/ha).

Table 1.1.2. Performance of potato under mulching

Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With mulching	Without mulching				
Kufri Jyoti (90 days)	10240	7660	33.7	87.7	29225	1.39
Kufri Pokhraj (110 days)	13120	8670	51.3	108.7	58025	1.79

Cropping systems

Intercropping of ginger with different varieties of pigeonpea revealed that yield of ginger with long and short duration pigeonpea varieties increased substantially as compared to the sole ginger (2621 kg/ha). Ginger intercropped with pigeonpea variety ICPL-11305 gave ginger yield of 14926 kg/ha compared to other treatments (Table 1.1.3). Moreover, severity of rhizome rot disease was the maximum in sole crop of ginger followed by intercrop with long duration pigeonpea.

Table 1.1.3: Performance of ginger (Cultivar- *Jati Adda*) intercropped with different varieties of pigeonpea

Treatment	Ginger yield (kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio
Control (Sole ginger)	2621	1.17	139483	1.8
Ginger + ICPL-11305	14926	6.67	1666133	14.3
Ginger + ICPL-88039	7389	3.30	761700	7.1
Ginger + TS-3R	5291	2.36	508877	5.0
Ginger + Local-2	5143	2.30	491143	4.9

c. On-farm demonstrations

Village profile

The NICRA project is being implemented in two villages of Lakhimpur district which is situated in the North Bank Plain zone of Assam. Apparent drought is the major weather aberration in one of the villages namely - *Chamua* (cluster of four villages); on the other hand, *Ganakdoloni* village is affected by 3-5 flash floods of 7 to 15 days duration in almost every year.

Brief profile of the villages

Chamua village

The NICRA programme is being implemented in Chamua village which is situated in the Narayanpur block of Lakhimpur district, Assam since 2010-11. The latitude and longitude of the village are 27°02'18''N and 93°52'46''E respectively. The altitude of the village varies from 83 to 90 meters. The total cultivated area of the village is 133 ha which is entirely rainfed. The mean annual rainfall of the village is 1987 mm with seasonal rainfall of 1375.3 mm during *kharif* (June-September). The major soil types are Inceptisols (sandy loam to silty clay loamy with pH ranging from 4.65 to 6.38). The soil organic matter content of the village varies from 0.34 to 3.03%. Status of available nitrogen (275 – 540 kg/ha) and Potassium (138 to 330 kg/ha) is medium; however available phosphorus (21.4 – 54.0 kg/ha) content of the soil is low to medium. High soil acidity, high phosphate fixation, micronutrients deficiency, iron toxicity, periodic soil moisture stress during winter seasons etc are some of the soil related problems of this village. Earlier mono-cropping was practiced by the farmers of the village and 90% of total cultivable land (118 ha) was occupied by only *Sali* rice. Presently farmers are encouraged to take up various crops like rapeseed, potato, tomato, black gram, green gram, turmeric, ginger, maize etc. Only 14.5% of the farmers are medium farmers and rest are either small or marginal farmers. Though depth of ground water table of the Chamua village is only 6 m, ground water is contaminated with both Arsenic (10 ppb) and iron (14.2 ppm) and not suitable for use. The village has different weather related problems like dry spells during growing season of *Sali* rice, scanty and less rainfall during *rabi* season and occurrence of occasional flash floods in a portion of the village. There is ample scope for rainwater harvesting due to presence of many natural farm ponds, and also for crop diversification due to availability of different land situations in the village.

Ganakdoloni village

The NICRA programme is being implemented in Gankdoloni village situated in the Dhalpur block of Lakhimpur district, Assam since 2012-13. The latitude and longitude of the village are 26°55'33''N and 93°52'17''E, respectively. Rainfall pattern of the village is same as Chamua village. The total farm families of village are 75 with cultivated area of 66 ha. Only eight farmers of the village are medium and rest are either small or marginal farmers. Ground water table is very shallow with no contamination of Arsenic in the village. The village is affected by 3-5 flash floods of 7 to 15 days duration during *kharif* season. On the other hand during *rabi* season, soil moisture deficit is a problem. Due to presence of only low lying lands there is limited scope for crop diversification. *Sali* rice grown in the village sufferes from flood every year.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is humid. The south-west monsoon contributes 64.5%, north-east 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, September and October) and *rabi* seasons. The area is also experiencing other extreme events like flood, hail storm and thunder storm.

Experienced weather condition during 2015-16

During 2015, in Chamua Narayanpur village, the onset of monsoon was normal (1st week of June). A rainfall of 2463.8 mm was received which was deficit by 436 mm compared to normal (2904 mm). During south-west monsoon (*kharif*), a rainfall of 1858.9 mm was received against a normal rainfall of 1958 mm. The rainfall during *rabi* was deficit by 18.2 mm compared to normal rainfall of 120 mm (Fig. 1.1.2).

Normal onset of monsoon : 1st week of June

Onset of monsoon during 2015-16 : 1st week of June

Normal annual rainfall : 2904 mm

Annual rainfall during 2015-16 : 2468 mm

Normal crop seasonal rainfall : 1958 and 397 mm during *kharif* and *rabi*, respectively

Crop seasonal rainfall during 2015-16 : 1858.9 and 76.5 mm during *kharif* and *rabi*, respectively

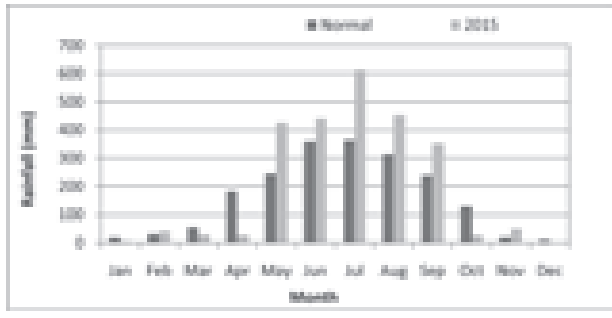


Fig. 1.1.2: Normal and actual (2015) monthly rainfall at Chamua village

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
111	26 July - 3 August	*Sali* rice	Transplanting and early tillering stage in upland areas
12	26 September - 7 October	*Sali* rice (medium and long duration cultivars)	PI Stage (long duration), grain filling (Short duration) filling stage
45	15 October - 30 November	*Sali* rice (long duration cultivars)	Grain filling stage
23 (*rabi* season)	17 December - 9 January, 2016	winter vegetables Rapeseed, potato,	Seed filling/tuber formation

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	*Sali* rice, turmeric, ginger	Early tillering, vegetative	Mulching in turmeric and ginger
Mid season drought	Sali rice, turmeric, ginger, potato, rapeseed	Grain filling, vegetative	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

The village experienced mid season dry spell of 23 days (17 December - 9 January, 2016). Supplemental irrigation from harvested rainwater was given to potato and rapeseed. In potato, one supplemental irrigation gave the highest tuber yield of 21563 kg/ha with Kufri Pokhraj and 16970 kg/ha with Kufri Jyothi and recorded net returns of Rs 142350/ha and Rs 96425/ha, respectively (Table 1.1.4). Similarly, in case of rapeseed, one supplemental irrigation gave 10% higher seed yield (1000 kg/ha) with net returns of Rs 13373/ha, B:C ratio of 1.82 and RWUE of 4.08 kg/ha-mm compared to rainfed crop (909 kg/ha).

Table 1.1.4: Performance of potato with supplemental irrigation from the harvested rainwater

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With irrigation	Without irrigation				
Kufri Pokhraj	21563	9490	127.2	96.8	142350	2.94
Kufri Jyoti	16970	9019	88.2	76.2	96425	2.32

Situation: Intermittent flash flood

Unlike NICRA village Chamua, flash flood is the major weather aberration in the NICRA village Ganakdoloni. The village was affected by two flash floods during 6 to 13 August and 26 August to 5 September, 2015. In spite of an early submergence as well as multiple submergences, local *Bao* varieties performed well as compared to the normal varieties, which were completely damaged by the floods.

Table 1.1.5: Performance of local *Bao* cultivars under intermittent flash floods at Ganakdoloni village

Bao cultivar	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Kekowa	2078	6905	1.50
Dhusuri	2312	9245	1.67
Rangabao	2458	10705	1.77
Maguri	2854	14665	2.06
Bahadur	1901	5135	1.37

Preparedness

Cropping systems

Short and medium duration cultivars of *Sali* rice were demonstrated in upland and midland situations, respectively. In general, long duration varieties performed better (3613-4087 kg/ha) compared to short duration varieties (2290-2785 kg/ha). Disang among short duration varieties and TTB-404 among long duration varieties produced higher grain yield with higher net returns compared to other varieties (Table 1.1.6).

Table 1.1.6: Performance of short and medium duration rice cultivars

Variety duration (days)	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
	With improved variety	With local variety			
Disang (100-120)	2785	2210	26.0	4785	2.84
Luit (100-120)	2290	1950	17.4	330	2.3
TTB-404 (135 to 140)	4087	3565	14.6	16275	3.15
Mulagabharuq (135 to 140)	3613	3060	18.1	12007	2.94

Intercropping system of sesame + greengram (2:2) produced higher rice equivalent yield of 7902 kg/ha with net returns of Rs 67610/ha and B:C ratio of 6.9 compared to rice cultivation (1200 kg/ha). Among different double cropping systems, *Sali* rice – potato system produced higher rice equivalent yield (22610 kg/ha) with net returns of Rs 319655/ha and B:C ratio of 2.42 compared to other systems (Table 1.1.7).

Table 1.1.7: Performance of rice based double cropping systems

Treatment	Yield (kg/ha)		REY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Crop 1	Crop 2				
Sali rice (Dishang) -potato (K. jyoti)	2610	20000	22610	319655	2.42	11.6
Sali rice (Dishang) - rapeseed (JT-90-1)	2860	1215	7112	34355	1.93	3.64
Sali rice (Mahshuri) - potato (K. pokhraj)	4380	8750	13130	37745	1.40	6.7
Sali rice (Mahshuri) - potato (K. Jyoti)	4380	7500	11880	25245	1.27	6.1
Sali rice (Mahsuri) - rapeseed (TS-38)	4380	977	7799	41225	2.12	4.0

Nutrient management

Application of N:P:K @ 20:20:10 kg/ha as basal followed by top dressing of 20 kg N in two equal spilt at maximum tillering and panicle initiation stages and top dressing of 10 kg K at maximum tillering stage produced 38-43% higher grain yield of rice compared to farmers' practice of no fertilizer application, with higher net returns (Rs 35295/ha) and B:C ratio (2.7) (Table 1.1.8).

Table 1.1.8: Performance of *Sali* rice cultivars with recommended nutrient management

Variety	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
	With intervention	Without intervention			
Ranjit	6200	3540	42.9	35295	2.7
TTB-303-2-23	5780	3574	38.0	31515	2.5

1.1.2. CHIANKI

a. Agro-ecological setting

Chianki centre is located in Chhattisgarh 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

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was delayed by 3 weeks (28th June). A rainfall of 917 mm was received which was deficit by 263 mm compared to normal (1180 mm) (Fig. 1.1.3). During *kharif* (June–September), 904.2 mm of rainfall was received which was deficit by 133.8 mm compared to normal of 1038 mm. During *rabi* season, it was 33.8 mm which was deficit by 32.1 mm compared to normal of 65.9 mm and in summer, rainfall was 9.6 mm which was deficit by 33.1 mm as against normal of 42.7 mm.

Normal onset of monsoon	:	4-10 June
Onset of monsoon during 2015-16	:	28 June
Annual mean rainfall	:	1180 mm
Annual rainfall during 2015-16	:	917 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	1038 and 65.9 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*)	:	904.2 & 33.8 mm, respectively

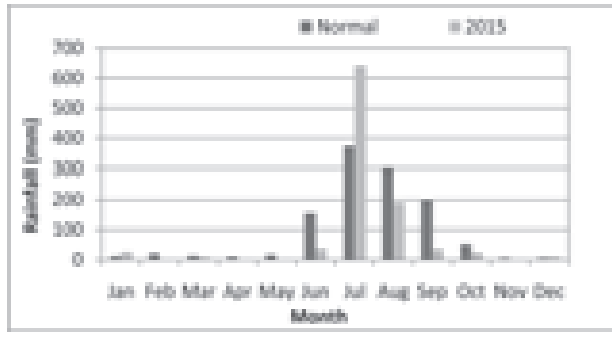


Fig. 1.1.3: Normal and actual (2015) monthly rainfall at Chianki

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
13	4 – 13 August	Rice, maize, sesame,	Flowering and grain filling sorghum
		Pigeonpea	Vegetative
19	28 August – 16 September	Rice, maize, sesame, sorghum	Grain filling and ripening
		Pigeonpea	Vegetative
31	23 September - 22 October	Rice, maize, sesame	Ripening
		Pigeonpea	Initiation of flowering
34	31 October - 2 December	Wheat, mustard, lentil, chickpea, linseed and pea	Sowing
		Pigeonpea	Flowering and pod formation
-	5 December onwards	Wheat, mustard, lentil, chickpea, linseed and pea etc.	Booting and flowering
		Pigeonpea	Pod formation to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Rice, maize, sesame, pigeonpea, sorghum, fingermillet	-	• Promotion of aerobic rice cultivation of drought tolerant varieties • Promotion of early duration maize variety • Promotion of intercropping of pigeonpea+ okra (1:1)
Terminal drought	Rice, maize, sesame, pigeonpea	Flowering stage of rice, tasselling in maize and flowering stage in sesame	• Promotion of contingent crops like horsegram, niger and toria

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2015, the onset of monsoon was delayed by 3 weeks (28th June). The improved varieties of rainfed upland rice viz., IR 92521-7-5, RP - 46-21-9-4-3-5, Vandana, IR 92546-1-4-1-4 and Bakar Dhan (local) were demonstrated to cope with delayed monsoon situation. IR 92521-7-5 recorded mean grain yield (2220 kg/ha) which was superior with RWUE of 2.45 kg/ha-mm followed by RP-46-21-9-4-3-5 (2110 kg/ha) with RWUE of 2.33 kg/ha-mm. The increase in grain yield with IR 92521-7-5 was 77.6% over local (Bakar Dhan), with higher net returns (Rs.21520/ha) and B:C ratio (2.55) compared to other varieties (Table 1.1.9).

Table 1.1.9: Performance of drought tolerant high yielding varieties of upland rice

Variety	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
IR 92521-7-5	2220	77.6	2.45	21520	2.55
RP - 46-21-9-4-3-5	2110	68.8	2.33	19760	1.71
Vandana	1822	45.8	2.01	15152	1.92
IR 92546-1-4-1-4	1585	26.8	1.75	11360	2.23
Bakar Dhan (local)	1250	-	1.38	8000	1.66

Similarly, four varieties of medium land transplanted rice were demonstrated out of which Arize-Tej was superior with higher grain yield (6599 kg/ha) and RWUE of 7.29 kg/ha-mm followed by BAU/IRRI-496 and Naveen (5969 and 5559 kg/ha). The increase in grain yield with drought tolerant varieties of medium land varieties Arize-Tej, BAU/IRRI-496 and Naveen were 154, 130 and 114%, respectively over local varieties (Table 1.1.10 and 1.1.11).

Table 1.1.10: Performance of drought tolerant high yielding varieties of rice for medium land situation

Variety	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Arize-Tej	6599	154	7.29	87084	5.71
BAU/IRRI-496	5969	130	6.60	77004	5.16
Naveen	5559	114	6.15	70444	4.81
Local	2600	-	2.87	26000	2.66

Among lowland transplanted rice varieties. Arize-6444 produced highest grain yield (7435 kg/ha) with higher RWUE of 8.22 kg/ha-mm followed by Cradhan-205 (7316 kg/ha). The increase in grain yield with drought tolerant varieties of rice i.e. Arize-6444, Cradhan-205, PHB-71 and Cradhan-303 were 132, 129, 129 and 112%, respectively over local variety (3200 kg/ha).

Table 1.1.11: Performance of drought tolerant high yielding varieties of rice under lowland situation

Variety	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Arize-6444	7435	132	8.22	100646	6.43
Cradhan-205	7316	129	8.09	98556	6.33
PHB-71	7314	129	8.09	98555	6.33
Cradhan-303	6781	112	7.50	98524	6.33
Local	3200	-	3.53	35600	3.28

Four varieties of sesame were evaluated for suitability under delayed onset of monsoon. Out of these varieties, Shekhar gave higher seed yield (644 kg/ha), RWUE (0.71 kg/ha-mm), net returns (Rs.19268/ha) and B:C ratio (2.75) compared to other varieties (Table 1.1.12). The increase in seed yield with improved varieties of sesame (Shekhar, Kanke white, JG-11 and JLT-408) were 139, 137, 125 and 121% higher over local (270 kg/ha), respectively.

Table 1.1.12: Performance of drought tolerant high yielding varieties of rice under lowland situation

Variety	Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Shekhar	644	139	0.71	19268	2.75
Kanke White	641	137	0.71	19127	2.74
JG-11	608	125	0.67	17576	2.60
JLT-408	596	121	0.66	17012	2.55
Local	270	-	0.29	-	1.26

c. On-farm demonstrations

Village profile

The program is being implemented by AICRPDA centre, Chianki in Kumbhi and Bankheta villages in Garhwa district, Jharkhand. The total cultivated area is 215 ha, out of which 150 ha is rainfed. The normal rainfall is 1152.4 mm. The major soil types are sandy loam, clay loam and loam. The major rainfed crops during *kharif* are rice, maize, pigeonpea, sesame, etc and *rabi* crops are chickpea, wheat, lentil, linseed and mustard. The number of small, marginal 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 2015-16

During the year 2015, the onset of monsoon was delayed by 10 days (20th June). A rainfall of 823.3 mm was received which was deficit by 329.1 mm compared to normal of 1152.4 mm (Fig....). During *kharif* (June - September), 731.8 mm rainfall was received which was deficit by 260.5 mm (26%) compared to normal (992.5) mm. During *rabi* season, 12.3 mm rainfall was received which was deficit by 34.5 mm (84%) compared to normal (77.6 mm) and in summer (March - May), 23.3 mm rainfall was received which was deficit by 24.7 mm compared to normal of 48 mm.

Normal onset of monsoon	:	4 - 10 June
Onset of monsoon during 2015-16	:	23 June
Annual mean rainfall	:	1152 mm
Annual rainfall during 2015-16	:	823.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	993 and 77.6 mm, respectively
Crop seasonal rainfall during: 2015-16 (*kharif* and *rabi*)		731.8 and 12.3 mm, respectively

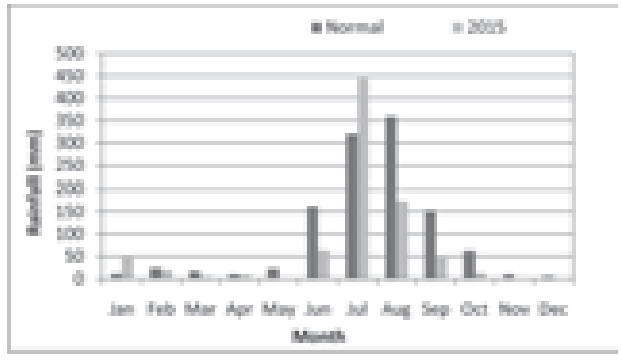


Fig. 1.1.4: Normal and actual (2015) monthly rainfall at Kumbhi & Bankheta

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	24 June - 5 July	Rice, maize, pigeonpea, sesame	Tillering in rice, vegetative stage of upland field crops
7	16 – 22 July	Rice, maize, pigeonpea, sesame	Tillering and panicle initiation in rice, vegetative stage in other crops
9	12 – 20 August	Rice, maize, pigeonpea, sesame	Panicle initiation and flowering in rice; flowering in sesame and maize
13	22 August – 3 September	Rice, maize, pigeonpea, sesame	Grain filling to maturity stage
15	18 September onwards	Wheat, mustard, lentil, chickpea, linseed and pea	Sowing, germination to flowering stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Delayed onset of monsoon	Rice, maize, pigeonpea	Short duration high yielding varieties

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During the year 2015, the onset of monsoon was delayed by 10 days (20th June). Drought tolerant varieties of medium land rice (Arize Tej, PAC-801 and Sahbhagi dhan) were demonstrated on farmers' fields to cope with delayed onset of monsoon. Higher grain yield of 3067 kg/ha was recorded with Arize Tej along with RWUE of 3.99 kg/ha-mm and B:C ratio of 3.51 as compared to local variety (1534 kg/ha). Similarly, the higher net returns (Rs.35071/ha) and B:C ratio (3.51) were also recorded with Arize-Tej compared to other varieties (Table 1.1.13).

Table 1.1.13: Performance of drought tolerant high yielding varieties of rice under lowland situation

Variety	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Arize Tej	3067	99.9	3.99	35071	3.51
PAC-801	3438	104.7	4.48	41014	3.93
Sahbhagi dhan	3420	119.0	4.45	40724	3.91
Local	1534	-	-	-	-

High yielding drought tolerant hybrid of maize (Kanchan) yielded mean grain yield of 3194 kg/ha with mean RWUE of 4.18 kg/ha-mm which was 166% increase in grain yield as compared to local variety (1312 kg/ha) (Table...). The A-404 variety of fingermillet gave higher yield (1621 kg/ha) with rainwater use efficiency of 4.18 kg/ha-mm, net returns of Rs.11684/ha and B:C ratio (2.00) over local cultivar. In sorghum, CSV-20 recorded higher grain yield (1866 kg/ha), RWUE (2.37 kg/ha-mm), net returns (Rs.8122/ha) and B:C ratio (1.66) compared to local cultivar. Sesame variety Shekhar also gave higher seed yield (487 kg/ha) over local cultivar (170 kg/ha). Similarly, higher seed yield of blackgram (1235 kg/ha) was given by Birsa Urd-1 over local cultivar (578 kg/ha) with higher RWUE (1.57 kg/ha-mm), net returns (Rs.44578/ha) and B:C ratio (5.05) (Table 1.1.14).

Table 1.1.14: Performance of drought tolerant varieties of maize

Variety/ hybrid	Grain/ Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Maize					
Kanchan	3194	166.3	4.18	19954	2.30
Local	1312	-	-	-	-
Fingermillet					
A-404	1621	193.7	2.00	11687	2.00
Local	552	-	-	-	-

Variety/ hybrid	Grain/ Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sorghum					
CSV-20	1866	164.7	2.37	8122	1.66
Local	705	-	-	-	-
Sesame					
Shekhar	487	186.0	0.67	11868	2.08
Local	170	-	-	-	-
Blackgram					
Birsa Urd-1	1235	146.0	1.57	44578	5.05
Local	578	-	-	-	-

Two drought tolerant varieties of pigeonpea (Bahar and Narendra Arhar-1), gave higher seed yield (1559 and 1335 kg/ha), respectively over local cultivar (1091 kg/ha) with higher net returns (Rs.73699 and 47575/ ha), B:C ratio (6.90 and 4.81) and RWUE (2.42 and 1.65 kg/ha-mm) over local cultivar (Table 1.1.15).

Table 1.1.15: Performance of drought tolerant varieties of pigeonpea

Variety	Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Bahar	1559	61	2.42	73699	6.90
Narendra Arhar - 1	1335	22	1.65	47575	4.81
Local	1091	-	-	-	-

To cope up with the delayed onset of monsoon followed by seasonal drought, pigeonpea (Bahar) + okra (SG-152) intercropping was demonstrated in 15 farmer's fields. Maximum pigeonpea equivalent yield of 2107 kg/ha was recorded in pigeonpea + okra intercropping system with RWUE of 2.71 kg/ha-mm and B:C ratio of 4.39.

1.1.3. FAIZABAD

a. Agro-ecological setting

Faizabad centre is located in Northern plain, Rohilkhand, Avadh and South Bihar plains (AESR 9.2) and Eastern plain agro-climatic zone in Uttar Pradesh. The climate is hot dry sub-humid. Annual normal potential evapo-transpiration is about 549 mm. Annual normal rainfall is 1040 mm. Length of growing period is 150-180 days. Drought occurs once in ten years.

b. On-station experiments

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was timely (25th June; normal onset of monsoon is 21st June). A rainfall of 635 mm was received which was deficit by 405.1 mm (38.9%) compared to normal rainfall (1040.1 mm). During South-west monsoon (*kharif*), 484.3 mm rainfall was received which was deficit by 430.8 mm (47.1%) compared to normal of 914.9 mm. During North-east monsoon (October - December), no rainfall was received which was deficit by 100% compared to normal (65.6 mm) and during summer, 111.7 mm of rainfall was received which was excess by 78.7 mm (238.5%) compared to normal rainfall of 33.2 mm (Fig....).

Normal onset of monsoon	:	21 June
Onset of monsoon during 2015-16	:	25 June
Annual mean rainfall	:	1040.1 mm
Annual rainfall during 2015-16	:	635 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	914.9 mm and 65.6 mm, respectively
Crop seasonal rainfall during (*kharif & rabi*) 2015-16	:	484.3 mm and no rainfall, respectively

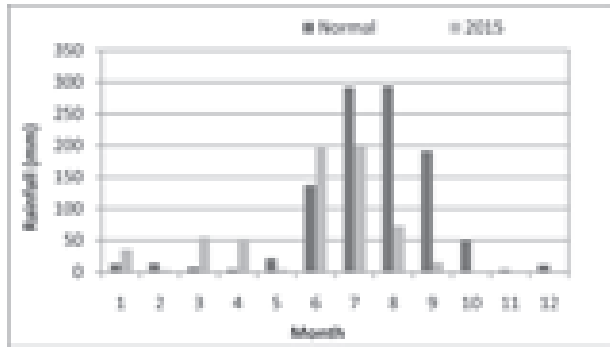


Fig. 1.1.5: Normal and actual (2015) monthly rainfall at Faizabad

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
13	19- 31 July	Paddy, maize, sorghum, sesame, blackgram, pigeonpea	Seedling and vegetative stage
5	5- 9 August		
5	13- 17 August		
-	Till crop harvest	-	Flowering & maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season and terminal drought	Paddy, maize, sorghum, pigeonpea	Vegetative and reproductive stage	Mulching, weeding, interculture, foliar spray, thinning

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

During 2015, the rainfall was deficit by 43.6% in June, 32.2% in July, 75% in August and 92% in September. There was a dry spell of 13 days from 19-31 July at the vegetative stage of paddy, maize, sorghum, sesame and pigeonpea. To mitigate the moisture stress condition, mulching with green leaves of subabool @ 10 t/ha was done in maize and sorghum on 27th July 2015. Maize (Naveen) recorded higher grain yield of 1375 kg/ha, net returns of Rs.3888/ha, B:C ratio of 1.21 and RWUE of 4.79 kg/ha-mm with mulching compared to without mulching (Table 1.1.16). Similarly, sorghum recorded 21.7% higher grain yield (1150 kg/ha) with mulching compared to without mulching (945 kg/ha).

Table 1.1.16: *In-situ* moisture conservation through mulching under early season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With mulching	Without mulching				
Maize	Naveen	1375	1032	33.2	4.79	3888	1.21
Sorghum	CSV-10	1150	945	21.7	4.01	1785	1.10

Two weedings followed by interculture were done at 25 and 45 days after sowing i.e. on 27th July and 17th August 2015 to keep the field weed free and to break the capillaries for checking the moisture loss. Maize (Naveen) recorded higher grain yield of 1500 kg/ha, net returns of Rs.6070/ha, B:C ratio of 1.33 and RWUE of 5.23 kg/ha-mm with weeding/ interculture compared to control (Table 1.1.17). Similarly, weeding and interculture increased yields of sorghum, sesame and blackgram by 72.4, 56.9 and 86.7%compared to without weeding/ interculture.

Table 1.1.17: *In-situ* moisture conservation through mulching under early season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Maize	Naveen	1500	825	81.8	5.23	6070	1.33
Sorghum	CSV-10	1345	780	72.4	4.69	5002	1.29
Sesame	T-12	510	325	56.9	1.78	30415	2.83
Blackgram	NDU-1	560	300	86.7	1.95	25592	1.69

Situation: Terminal drought

During 2015, The rainfall was deficit by 75% in August and 92 % in September. There was a dry spell of 10 days from 5-17 August the flowering to maturity of paddy, maize, sorghum, sesame and pigeonpea. To overcome the terminal drought foliar spray of 2% urea was done on standing crops on 30th August 2015 (50 DAS). Maize (Naveen) recorded higher grain yield of 1530 kg/ha, net returns of Rs.6645/ha, B:C ratio of 1.35 and RWUE of 5.33 kg/ha-mm with foliar spray compared to control (Table 1.1.18). Similarly, sorghum grain yield increased by 18% due to foliar spray compared to no foliar spray.

Table 1.1.18: Performance of different crops with foliar spray under terminal drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray				
Maize	Naveen	1530	1280	19.5	5.33	6645	1.35
Sorghum	CSV-10	1250	1060	17.9	4.36	3175	1.18

Preparedness

Cropping systems

Among different intercropping systems, the maize + sesame system (1:1) recorded higher maize equivalent yield (4654 kg/ha), net returns (Rs.45100/ ha), B:C ratio (3.36) and RWUE (6.06 kg/ha-mm) compared to maize + blackgram other intercropping system (Table 1.1.19).

Table 1.1.19: Performance of maize and pigeonpea based intercropping systems

Treatment	Yield (kg/ha)		MEY	LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop					
Maize + blackgram	1285	510	4345	1.87	39687	2.93	6.25
Maize + sesame	1270	470	4654	1.80	45100	3.36	6.06

LER: Land equivalent ration; MEY: Maize equivalent yield

Nutrient management

Among nutrient management practices, application of RDF (60:40:30 kg NPK/ha) in maize recorded higher grain yield (1270 kg/ha), net returns (Rs.7040/ha), B:C ratio (0.38) and RWUE (3.28 kg/ ha-mm) compared to other treatments (Table 1.1.20).

Table 1.1.20: Effect of treatments on crop yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stalk				
Control	850	3525	16000	1250	0.08	2.19
RDF (60:40:30 kg NPK/ha)	1270	5200	18600	7040	0.38	3.28
75% RDF + 6 t/ha FYM	1130	4400	21850	510	0.03	2.92
75% RDF + 2.5 t/ha vermicompost	1190	4765	25450	1640	0.06	3.05

Among nutrient management practices, application of RDF (60:40:30 kg NPK/ha) recorded lower soil chemical properties pH (0.75), organic carbon (0.34). However, soil organic C content (0.39%), available N (160.7 kg/ha), P (15.7 kg/ha) and (315.5 kg/ha) was highest is the plots under 75% RDF + 2.5 t/ha vermicompost (Table 1.1.21).

Table 1.1.21: Effect of treatments on soil chemical properties

Treatment	pH	Organic C (%)	Av. nutrients (kg/ha)		
			N	P	K
Control	0.77	0.28	136.0	10.2	298.5
Full RDF (60:40:30 kg NPK/ha)	0.75	0.34	156.5	13.1	312.5
75% RDF + 6t/ha FYM	0.73	0.36	154.0	14.0	309.7
75% RDF + 2.5 t/ha vermicompost	0.74	0.39	160.7	15.7	315.5
Initial values	0.78	0.33	146.2	12.3	308.7

Energy management

Among different methods of land preparation deep ploughing 25 cm with MB plough + 1 harrowing recorded higher maize yield (1479 kg/ha) with net returns (Rs.6220/ha), B:C ratio (1.30) and RWUE (5.15 kg/ha-mm) compared to other methods of land preparation (Table 1.1.14). Similarly, deep ploughing 25 cm with MB plough + 1 harrowing recorded higher field efficiency (6.5 hr/ha), higher energy input 10649 (MJ/ha), output energy 77649 (MJ/ha) and output input ratio was 7.29 compared to other methods of land preparation (Table 1.1.22).

Table 1.1.22: Effect of treatments on maize yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stalk				
Deep ploughing 25 cm with MB plough + 1 harrowing	1479	3106	18480	6220	1.30	5.15
Ploughing with rotavator single operation	1104	2208	16870	1346	1.07	3.84
Ploughing with cultivator 2 operations	1098	2142	17082	927	1.05	3.82

Table 1.1.23: Effect of treatments on energy use efficiency

Treatment	Field efficiency (hr/ha)	Energy (MJ/ha)		Output input ratio
		Input	Output	
Deep ploughing 25 cm with MB plough + 1harrowing	6.5	10649	77649	7.29
Ploughing with rotavator single operation	3.5	9258	55973	6.04
Ploughing with cultivator 2 operations	2.5	8367	54697	6.54

c. On-farm demonstrations

Village profile

The programme is being 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 landless, 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 major rainfed crops. The soil moisture status is deficit during growth and flowering stages of major rainfed crops. The maximum/minimum temperature during *kharif* season is 39.3 and 25.7°C, and 44.5 and 5.1°C during *rabi* season. 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 hailstorm, frost, heat wave and cold wave.

Experienced weather conditions during 2015-16

The rainfall data of Faizabad centre was taken. During 2015, the onset of monsoon was timely (25th June; normal onset of monsoon is 21st June). A rainfall of 635 mm was received which was deficit by 405.1 mm (38.9%) compared to normal (1040.1 mm). During south-west monsoon (*kharif*), 484.3 mm rainfall was received which was deficit by 430.8 mm (47.1%) compared to normal of 914.9 mm. During north-east monsoon (October - December), no rainfall was received which was deficit by 65.6 mm (100%) compared to normal (65.6 mm) and during summer, 111.7 mm of rainfall was received which was excess by 78.7 mm (238.5%) compared to normal rainfall of 33.2 mm.

Normal onset of monsoon	:	21 June
Onset of monsoon during 2015-16	:	25 June
Annual mean rainfall	:	1040.1 mm
Annual rainfall during 2015-16	:	635 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	914.9 mm and 65.6 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif and rabi*)	:	484.3 mm and no rainfall, respectively

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
13	19- 31 July	Paddy, maize, sorghum, sesame, blackgram, pigeonpea	Growth and vegetative stage
5	5- 9 August		
5	13- 17August		
-	25 August Withdrawal of monsoon	-do-	Flowring & maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented	No. of farmers	Area covered (ha)
Mid season and Terminal drought	Paddy, maize, sorghum, pigeonpea	Mulching, weeding, interculture, foliar spray, thinning	70	14.8

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

During 2015, the rainfall was deficit by 43.6% in June, 32.2% in July, 75% in August and 92% in September. There was a dry spell of 13 days from 19-31 July at the vegetative stage of paddy, maize, sorghum, sesame and pigeonpea, which not only affected the growth of pigeonpea, maize and sorghum but also total failure of paddy. To mitigate the moisture stress condition, mulching with green leaves of subabool @ 10 t/ha was done in paddy, pigeonpea, maize and sorghum crops on 27th July 2015. Among different crops, maize (Naveen) recorded higher grain yield of 1450 kg/ha, net returns of Rs. 987/ha, B:C ratio of 1.05 and RWUE of 5.05 kg/ha-mm compared to other crops. The increase is yields with mulching were 27.8% is sorghum and 27.9% in maize compared to no mulching (Table 1.1.24).

Table 1.1.24: *In-situ* moisture conservation through mulching under early season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation practice	With normal practice				
Maize	Naveen	1450	1140	27.9	5.05	987	1.05
Sorghum	CSV-10	1310	1025	27.8	4.56	300	1.02

Two weedings followed by interculture were done at 25 and 45 days after sowing were done to keep the field weed free and to break the capillaries for checking the moisture loss. Among different crops, of maize (Naveen) recorded higher grain yield of 1580 kg/ha and RWUE of 5.23 kg/ha-mm, where as sesame (T-12) recorded higher net returns of Rs.27600/ha and B:C ratio of 2.66 and compared to other crops (Table 1.1.25)

Table 1.1.25: Performance of crops under weed control/interculture during mid season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Maize	Naveen	1580	1305	21.1	5.51	7550	1.41
Sorghum	CSV-10	1400	1230	13.8	4.88	6040	1.35
Sesame	T-12	480	385	24.7	1.67	27600	2.66
Blackgram	NDU-1	530	410	29.3	1.85	23278	2.32

Situation: Terminal drought

During 2015, there was a dry spell of 10 days from 5-17 August during flowering to maturity of paddy, maize, sorghum, sesame and pigeonpea. Further, early withdrawal of monsoon (25 august) severely affected crops at maturity.

To overcome the effect of terminal drought, foliar spray of 2% urea was done on standing crops on 30th August 2015. Maize (Naveen) recorded higher grain yield of 1575 kg/ha, net returns of Rs.7158/ha, B:C ratio of 1.38 and RWUE of 5.49 kg/ha-mm compared to sorghum (Table 1.1.26).

Table 1.1.26: Effect of foliar spray on crops under terminal drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray				
Maize	Naveen	1575	1290	22.1	5.49	7158	1.38
Sorghum	CSV-10	1420	1210	17.3	4.95	1575	1.09

Preparedness

Cropping systems

Among maize based intercropping cropping systems, maize + sesame system (1:1) recorded higher maize equivalent yield (4351 kg/ha), net returns (Rs.41237/ha), B:C ratio (3.16) and RWUE (5.87 kg/ha-mm) compared to maize + blackgram intercropping systems (Table 1.1.27).

Table 1.1.27: Performance of maize and pigeonpea based intercropping systems

Treatment	Yield (kg/ha)		MEY	LER	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop						
Maize + blackgram	1300	475	4150	1.75	20600	36585	2.38	6.18
Maize + sesame	1255	430	4351	1.72	19100	41237	3.16	5.87

LER: Land equivalent ratio; MEY: Maize equivalent yield

Energy management

Among different methods of land preparation, deep ploughing 25 cm with MB plough + 1 harrowing recorded higher maize yield (1410 kg/ha), net returns (Rs.5067/ha), B:C ratio (1.27) and RWUE (4.91 kg/ha-mm) compared to other methods of land preparation. Similarly, deep ploughing 25 cm with MB plough + 1 harrowing recorded higher field efficiency (6.5 hr/ha), higher energy input 10649 (MJ/ha), output energy 76635 (MJ/ha) and output input ratio (7.19) compared to other methods of land preparation (Table 1.1.28).

Table 1.1.28: Effect of treatments on maize yield, economics and energy use efficiency

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Field efficiency (hr/ha)	Energy (MJ/ha)		Output input ratio
	Grain	Stover					Input	Output	
Deep ploughing 25 cm with MB plough + 1 harrowing	1410	2961	5067	1.27	6.5	4.91	10649	76635	7.19
Ploughing with rotavator single operation	1070	2048	601	1.03	3.5	3.72	9258	52593	5.68
Ploughing with cultivator 2 operations (farmers practice)	1050	1995	33	1.01	2.5	3.65	8367	51345	6.14

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 Chhattisgarh. 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

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was normal (4th June). A total rainfall of 1560.5 mm was received which was excess by 156.5 mm compared to normal of 1404.4 mm (Fig. 1.1.6). During South-west monsoon (*kharif*), there was 1306.6 mm rainfall which was excess of 185.1 mm (16.5%) as against normal rainfall of 1121.5 mm. During North-east monsoon (October - December), 17.6 mm of rainfall was received which was deficit 97.2 mm as that of normal (114.8 mm). During summer, 226.3 mm of rainfall was received which was excess by 80.02 mm (54.9%) compared to normal rainfall of 146.1 mm.

Normal onset of monsoon	:	5 June
Onset of monsoon during 2015-16	:	4 June
Annual mean rainfall	:	1404 mm
Annual rainfall during 2015-16	:	1560.5 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	1122 and 115 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	1306.6 and 17.6 mm; respectively

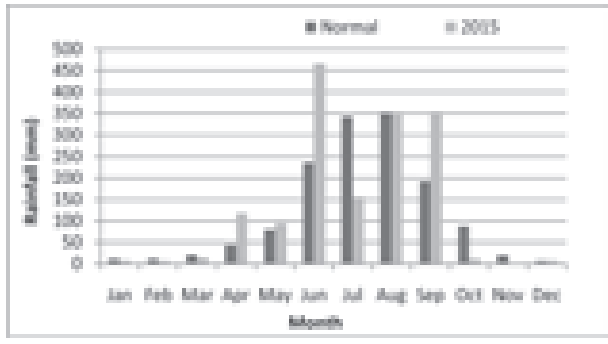


Fig. 1.1.6: Normal and actual (2015) monthly rainfall at Jagdalpur

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
7	1-7 July	Rice, maize & niger	Germination & seedling
7	22-28 September	Rice, maize & niger	Vegetative
21	1 October to 21 October	Rice, maize & niger	Flowering & grain filling
39	25 October to 2 December	Rice, maize & niger	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Rice	-	Multi-storey nursery raising
	Maize	-	Little millet as catch crop
Early season drought	Rice	Tillering stage	Each 7th row opening by country plough Life saving irrigation
	Maize	Vegetative stage	Scooping in alternate row

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Rice	Late jointing	Each 7th row opening by country plough 2% nitrogen foliar spray
	Niger	Vegetative stage	Spraying water twice on crop
Terminal drought	Horsegram, niger	Flowering & maturity	Water spray

Salient achievements of on-station experiments

Real time contingency crop planning

Situation: Early season drought

The rainfall was excess in June (97.9%) and deficit in July (54.4%). There was dry spell of 7 days (1-7 July) coinciding with germination and seedling stage of crops.

Furrows were opened after every 7th furrow by running country plough on 25th days after sowing with available soil moisture. The practice gave higher grain yield of 1893 kg/ha with net returns of Rs.411716/ ha, B:C ratio of 2.07 and RWUE of 2.77 kg/ha-mm compared to without furrow opening (Table 1.1.29).

Table 1.1.29: Effect of furrow opening on rice yield and economics

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Without furrow opening	1453	-	2.12	9436	2.18
with 7th furrow opening	1893	30.3	2.77	11716	2.07

Situation: Mid season drought

There was a dry spell of 21 days during 1-21 October at booting and panicle stage of rice. Among two rice varieties, MTU1001 with foliar spray (2% urea) gave higher grain yield of 3754 kg/ha, net returns of Rs.31051/ha, B:C ratio of 3.22 and RWUE of 4.41 kg/ha-mm compared to farmers' practice of growing MTU-1010 variety without foliar spray (Table 1.1.30).

Table 1.1.30: Effect of foliar spray on rice varieties

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
MTU 1010	3423	2721	20.51	4.02	27074	2.93
MTU 1001	3754	2896	22.85	4.41	31051	3.22

Supplemental irrigation at flower initiation stage in rice with 2 cm depth of water gave higher grain yield of 1895 kg/ha, with net returns of Rs.10736/ha, B:C ratio of 1.89 and RWUE of 2.91 kg/ha-mm compared to without irrigation (Table 1.1.31).

Table 1.1.31: Effect of supplemental irrigation at different growth stages of rice

Stage of life saving irrigation	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Tillering	1167	30.7	1.79	2009	1.17
Jointing	1664	86.3	2.63	7970	1.66
Flower initiation	1895	112.2	2.91	10736	1.89
No life saving irrigation	893	-	1.41	1720	1.19

Situation: Terminal drought

There was a dry spell of 39 days during 25th October to1st December at grain filling and maturity stage of rice. No RTCP interventions could be implemented to cope with such a prolonged dry spell.

Preparedness

Cropping systems

By using the harvested water, staggered rice nursery was raised for transplanting under conditions of delayed onset of monsoon. Rice variety (MTU 1010) transplanted with 20 days old seedlings gave higher grain yield of 7150 kg/ha with net returns of Rs.60800/ha, B:C ratio of 3.43 and RWUE of 10.29 kg/ha-mm compared to other nursery techniques (Table 1.1.32).

Table 1.1.32: Effect of days of seedling on production of rice with change in seedling establishment

Nursery stage	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	With normal practice				
10 days nursery	3950	2498	63.2	5.66	22400	1.89
15 days nursery	5300	2675	50.5	7.60	38600	2.54
20 days nursery	7150	3924	54.9	10.29	60800	3.43
25 days nursery	6400	3522	55.0	9.27	51800	3.07

Intercropping systems

Among different intercropping, systems the fingermillet + pigeonpea system (7:2) sown with tractor draw seed drill recorded significantly higher yield fingermillet yield of 1339 kg/ha and pigeonpea yield of 530 kg/ha with net returns (Rs.42624/ha), B:C ratio (3.04) and RWUE (2.17 kg/ha-mm) followed by fingermillet + pigeonpea (7:2) sown with bullock drawn implement compared to fingermillet + blackgram (7:2) (Table 1.1.33).

Table 1.1.33: Performance of maize and pigeonpea based intercropping systems

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop			
FM + pigeonpea (7:2)	1500	432	41280	2.43	2.24
FM + blackgram (7:2)	1489	387	37369	2.20	2.18
FM + pigeonpea (7:2) by tractor	1339	530	42624	3.04	2.17

LER: Land equivalent ratio; CEY: crop equivalent yield; MAI: Monetary advantage index FM: fingermillet

Nutrient management

Crop demand based nitrogen application using leaf colour chart (LCC) was evaluated in two varieties of rice. Among the varieties, samleshwari recorded significantly higher yield (6601 kg/ha) with higher net returns (Rs.64212/ha), B:C ratio (2.3) and RWUE (7.75 kg/ha-mm) compared to MTU 1010. Similarly among nutrient management, LCC d" 3 (N20 in 3 splits) recorded significantly higher yield (6211 kg/ha), net returns (Rs.59646/ha), B:C ratio (1.8) and RWUE (7.30 kg/ha-mm) compared to other treatments (Table 1.1.34).

Table 1.1.34: Effect of treatments on crop yield and economics

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Stover				
Variety						
MTU 1010	5902	12335	15000	55824	2.1	6.93
Samleshwari	6601	13796	15000	64212	2.3	7.75
CD at 5%	20.00	47.0	-	-	-	-
Nitrogen management						
Recommended practice	6033	12608	15000	54391	1.7	7.08
(N30 in 2 splits)	5753	12024	18000	51040	1.6	6.76
LCC = 2 (N30 in 2 splits)	5945	12425	18000	50342	1.7	6.98
LCC = 3 (N20 in 3 splits)	6221	7279	21000	59646	1.8	7.30
CD at 5%	27.34	66.5	-	-	-	

Energy management

Among different sowing implements, sowing of rice with seed drill recorded higher grain yield (2926 kg/ha), net returns (Rs.20112/ha), B:C ratio (2.34) and RWUE (3.44 kg/ha-mm) compared to other methods of sowing. Similarly, sowing with seed drill recorded lesser field efficiency (1.25 hr/ha), higher energy input (2926 MJ/ha), output energy (42632 MJ/ha) and energy use efficiency was (175.1) compared to other methods of sowing (Table 1.1.35).

Table 1.1.35: Effect of treatments on rice yield, economics and energy use efficiency

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Field efficiency (hr/ha)	Energy (MJ/ha)		Output input ratio
	Grain	Stover					Input	Output	
Desi plough	2167	5071	16009	2.60	2.55	4.00	2167	31579	21.8
Seed drill sown	2926	6846	20112	2.34	3.44	1.25	2926	42632	175.1
Broadcasting	2194	5135	17334	2.93	2.58	2.30	2195	31974	22.7

Alternate land use

Under alternate land use system, among the different treatments, trench at base of trees for restoring rainwater + colocasia intercrop recorded higher yield of both mango (2879 kg/ha) and colocasia (1887 kg/ha) with net returns (Rs.54494/ha), B:C ratio (3.59) and RWUE (3.62 kg/ha) compared to other intercropping systems (Table 1.1.36).

Table 1.1.36: Effect of treatments on yield and economics of mango plantation

Treatment	Yield (kg/ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ ha)	B:C ratio
	Main crop	Inter crop	Stover/stalk yield				
T_1	2590	823	1690	17000	15921	1.94	2.73
T_2	2348	1530	1800	19000	42208	3.22	2.94
T_3	2245	1102	2345	20000	24098	2.20	2.68
T_4	2013	1015	1790	19000	21605	2.14	2.42
T_5	2879	1887	1980	21000	54494	3.59	3.62
T_6	2678	1360	2476	22000	32390	2.47	3.38

T1: Spading out at base on trees for restoring rainwater + cowpea intercrop; T2: Spading out at base on trees for restoring rainwater + colocasia intercrop; T3: Spading out at base on trees for restoring rainwater + bhindi intercrop; T4: Trench at base on trees for restoring rainwater + cowpea intercrop; T5: Trench at base on trees for restoring rainwater + colocasia intercrop; T6: Trench at base on trees for restoring rainwater + bhindi intercrop

c. On-farm demonstrations

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 and minor millets, while during *rabi* are vegetables, chikpea, kulthi (horsegram) 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 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 24 SMW. The dry spells were 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 soil moisture status is deficit during reproductive stages of major rainfed crops. The extreme events like unusual and high intensity rainfall in short span are increasing during July-August (30, 32 and 34 SMWs) and October (41 and 44 SMWs). 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 (32%) has increased during last 10 years and sowing window of the dominant rainfed crops is delayed from 24th to 25th SMW.

Experienced weather conditions during 2015-16

During 2015, in Tahkapal village, onset of monsoon was delayed by 29 days (4th July). A rainfall of 1443.7 mm was received which was excess by 39.3 mm compared to normal rainfall of 1404.4 mm. During South-west monsoon (*kharif*), 1206.5 mm rainfall was received which was 85.0 mm excess compared to normal rainfall of 1121.5 mm; during North-east monsoon, 19.02 mm of rainfall was received which was deficit by 95.78 mm compared to normal (114.8 mm). During summer, 208.97 mm of rainfall was received which was excess by 62.87 mm compared to normal (146.1 mm) (Fig. 1.1.7).

Normal onset of monsoon	:	5 June
Onset of monsoon during 2015-16	:	4 June
Annual mean rainfall	:	1404 mm
Annual rainfall during 2015-16	:	1443.7 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	1121 and 115 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif & rabi)*	:	1207 and 19 mm, respectively

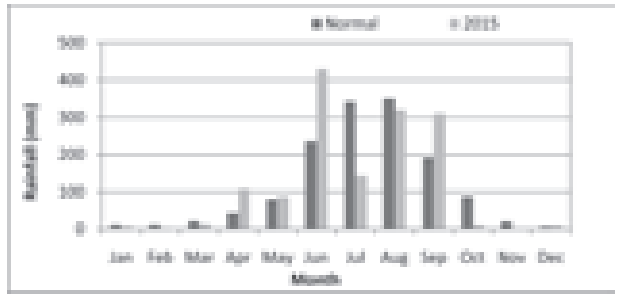


Fig. 1.1.7: Normal and actual (2015) monthly rainfall at Tahkapal village

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
7	1-7 July	Rice, maize & niger	Seedling
7	22-28 September	Rice, maize & niger	Flowering
24	30 September-23 October	Rice, maize & niger	Grain filling & Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Rice	Tillering stage	Furrow opening with country plough
Mid season drought	Rice	Flowering	One life saving irrigation
Terminal drought	Rice	Grain filling	Supplemental irrigation from harvested rainwater

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

The rainfall was excess in June (82.8%) and deficit in July (57.9%). A dry spell of 7 days occurred during 1-7 July. Direct seeding rice become dry after germination for which scooping made in between rows of paddy by spade out ditches and opening of furrow with country plough on 25th days after sowing with available soil moisture Furrow opening with country plough gave higher grain yield of 2230 kg/ha with net returns of Rs.10763/ha, B:C ratio of 1.67 and RWUE of 3.26 kg/ha-mm compared to without furrow opening (Table 1.1.37).

Table 1.1.37: Effect of furrow opening on rice crop under rainfed ecosystem

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Furrow opening with spade	2160	3.16	7916.89	1.44
Furrow opening with country plough	2230	3.26	10763.00	1.67
Control	1202	1.84	2427.00	1.20

Situation: Mid season drought

There was a spell of 7 days during 22-28 September at booting and panicle stage of rice. Supplemental irrigation was given at different stages, supplemental irrigation at flower initiation in rice with 2 cm depth of water gave higher grain yield of 1530 kg/ha, with net returns of Rs.42208/ha, B:C ratio of 3.22 and RWUE of 2.24 kg/ha-mm compared to without irrigation (Table 1.1.38).

Table 1.1.38: Effect of supplemental irrigation on rice

Stage of irrigation	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With irigation	Without irrigation				
No life saving irrigation (Check)	1023	617	75	1.50	15921	1.94
Life saving irrigation at flower initiation stage	1530	1071	70	2.24	42208	3.22
Life saving irrigation at tillering stage	1102	761	69	1.69	24098	2.20
Life saving irrigation at jointing stage	1015	721	71	1.60	21605	2.14

Life saving irrigation was given at flower initiation stage in rice with 2 cm depth of water gave higher grain yield of 1798 kg/ha, with net returns of Rs.9303/ ha, B:C ratio of 1.80 and RWUE of 2.14 kg/ha-mm compared to without irrigation (Table 1.1.39).

Table 1.1.39: Effect of supplemental irrigation on rice crop under rainfed condition

Stage of irrigation	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Tillering	1167	30.7	1.79	2009	1.17
Jointing	1664	86.3	2.63	7970	1.66
Flower initiation	1895	112.2	2.91	10736	1.89
No life saving irrigation	893	-	1.41	1720	1.19

Situation: Terminal drought

There was a dry spell of 24 days during October at booting, panicle, flower initiation to maturity stage of rice.

Supplemental irrigation of 2 cm depth at flowering stage in different farmer's fields recorded higher yield (ranges from 1025 to 1495 kg/ha), net returns (Rs.15921 to 42208/ha), B:C ratio (1.94 to 3.22) and RWUE (1.20 to 1.81 kg/ha-mm), respectively compared to without supplemental irrigation (617 to 1071 kg/ha) (Table).

Preparedness

Cropping systems

Among the drought tolerant varieties, Indira Barani dhan of rice recorded highest yield (1699 kg/ ha), net returns (Rs.5395/ha), B:C ratio (1.68) and RWUE (1.70 kg/ha-mm) compared to other varieties. In fingermillet, improved variety GPU 28 recorded higher yield (1523 kg/ha), with net returns of Rs.9578/ ha, B:C ratio of 1.79 and RWUE of 1.52 kg/ha-mm compared to farmers' practice (Table 1.1.40).

Table 1.1.40: Evaluation of drought tolerant rice varieties under rainfed ecosystem

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	Without normal practice				
Sahbhagi	1798	1234	68.6	1.79	6574	1.78
CR 40	1748	1023	58.5	1.74	5976	1.73
Indira Barani dhan	1699	1124	66.1	1.70	5395	1.68
Satka	1652	1193	72.2	1.65	4830	1.63
Vandana	1607	987	61.5	1.60	4281	1.59
GPU 28	1523	989	64.9	1.52	9578	1.79
IR -2	1245	876	70.4	1.24	6243	1.39

Intercropping systems

Among different intercropping systems, fingermillet + pigeonpea (7:2) drilling recorded higher pigeonpea equivalent yield (PEY) (1202 kg/ha), net returns (Rs.26622/ha), B:C ratio (3.22) and RWUE (1.70 kg/ha-mm) compared to mixing seed (7:2) broadcasting (Table 1.1.41).

Table 1.1.41:Performance of different intercropping systems

Treatment	Yield (kg/ha)		PEY	LER	MAI	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop						
FM+PP (7:2) drilling	1830	412	1202	1.56	801.44	26622	3.22	1.70
Mixing seed (7:2) broadcasting	934	233	680	0.83	-230.76	11530	2.28	0.89
Sole fingermillet (FM)	2230	-	-	2230	-	14760	2.23	1.70
Sole pigeonpea (PP)	560	-	-	560	-	4600	1.31	0.88

LER: Land equivalent ratio; PEY: Pigeonpea equivalent yield; MAI: Monetary advantage index

Nutrient management

Among nutrient management in rice, LCC d" 2 (N20 in 3 splits) recorded higher yield (3544 kg/ha), net returns (Rs.20028/ha), B:C ratio (1.89) and RWUE (4.22 kg/ha-mm) compared to other treatments (Table 1.1.42).

Table 1.1.42: Effect of nitrogen application through leaf colour chart (LCC) on rice yield and economics

Nutrient management through LCC	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Recommended (N30 in 2 split)	2627	3.13	11525	1.58
LCC = 2 (N20 in 3 split)	3544	4.22	20028	1.89
LCC = 3 (N30 in 2 split)	3274	3.90	19289	1.96
LCC = 4 (N15 in 4 split)	3032	3.61	12387	1.52

Fertilizer application in 3 splits of N is rice (tillering, late jointing, and booting) recorded significantly higher yield (3088 kg/ha), net returns (Rs.17448/ha), B:C ratio (1.65) and RWUE (3.67 kg/ha-mm) compared to other treatments (Table 1.1.43).

Table 1.1.43: Effect of split application of N on rice yield and economic

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover			
2 split of N	2289	1327	10040	1.37	2.72
3 split of N	3088	1731	17448	1.65	3.67
4 split of N	2852	1859	16804	1.71	3.39

Mechanization of rice cultivation (ploughing with cultivation, sowing with seed drill and harvesting with reaper) recorded higher yield (2735 kg/ha) with net returns (Rs.32823/ha), B:C ratio (1.82) and RWUE (2.03 kg/ha-mm) compared to farmer's practice. Similarly, mechanization recorded higher energy input 1076 MJ/ha, output energy 39853 MJ/ha and energy use efficiency was 37.02 compared to farmer's practice (Table 1.1.44).

Table 1.1.44: Effect of treatments on rice yield, economics and energy use efficiency

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Energy (MJ/ha)		Energy use efficiency
	Grain	Stover				Input	Output	
Mechanization	2735	6414	32823	1.82	2.03	1076	39853	37.02
Farmers' practice*	1126	2640	13511	1.04	2.09	3097	14074	4.54

*Farmers' practice: 3 pass of country plough and broadcasting of paddy seed planking followed by

Alternate land use

Among mango (8-year old) based agri-horti systems, mango + colocasia intercrop recorded higher net returns (Rs.38506/ha), B:C ratio (2.94) and RWUE (2.68 kg/ha), compared to other systems (Table 1.1.45).

Table 1.1.45: Effect of treatments on crop yield and economics of mango plantation (2.00 hectare)

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop			
Mango + cowpea	2363	751	14525	1.77	2.49
Mango + colocasia	2142	1396	38506	2.94	2.68
Mango + okra	2363	751	14525	1.77	2.49

1.1.5. PHULBANI

a. Agro-ecological setting

Phulbani centre 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 conditions during 2015-16

During the year 2015, the onset of monsoon was delayed by 2 days (12 June). A rainfall of 1060.6 mm was received during the year which was deficit by 346.6 mm than normal rainfall of 1407.3 mm. Out of total rainfall, 778.8 mm was received during *kharif* season (June- September) and was deficit by 371.7 mm (32.3%) than normal of 1246.2 mm. In *rabi* season, there was 69.6% deficit rainfall (108.73 mm) than normal of 52.7 mm and in summer, it was excess by 69.77 mm (64.3%) than normal of 108.4 mm (Fig. 1.1.8).

Normal onset of monsoon	:	10 June
Onset of monsoon during 2015-16	:	12 June
Annual mean rainfall	:	1407.3 mm
Annual rainfall during 2015-16	:	1060.6 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	1150 & 124.7 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	778.8 & 16 mm, respectively

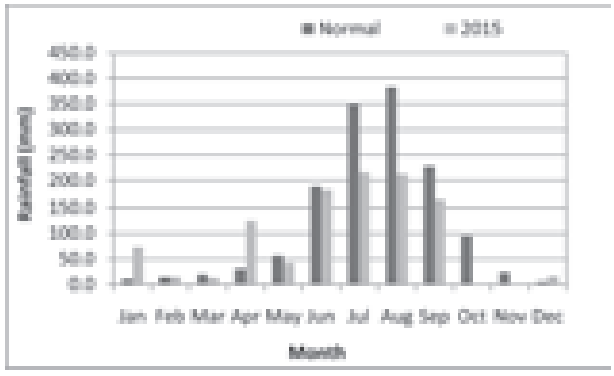


Fig. 1.1.8: Normal and actual (2015) monthly rainfall at Phulbani

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
10	12 -21 July	Rice, maize, cowpea, pigeonpea, radish	Germination / seedling
11	3 -13 August	Rice	Tillering / stem elongation
		Maize	Vegetative/tasselling
		Pigeonpea, cowpea, radish, greengram, blackgram	Vegetative
11	2 - 12 September	Rice	Panicle initiation/flowering
		Maize	Cob development
		Pigeonpea	Vegetative
		Cowpea, radish	Maturity
		Greengram, blackgram	Flowering/pod development
40	22 September – 30 October	Rice	Milking/ripening/maturity
		Maize	Cob development /maturity
		Greengram, blackgram	Pod development/ maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought 10 days (12 -21 July); 11 days (3 -13 August)	Rice	Germination/ seedling	Summer ploughing, increase bund height, *in-situ* moisture conservation
	Maize, pigeonpea	Germination/ seedling	*In-situ* moisture conservation, gap filling, re-seeding
	Cowpea	Germination/ seedling	*In-situ* moisture conservation, complete hoeing and weeding
	Greengram, blackgram, vegetable crops	Seedling	In-situ moisture conservation, gap filling, hoeing and weeding
Mid season drought 11 days (2-12 September)	Rice	Late tillering /PI/ flowering	Intercultivation, strengthen the field bund
	Maize	Cob development	Life saving irrigation, weeding, plant protection measures
	Cowpea, pigeonpea	Vegetative	Life saving irrigation, weeding
	Greengram, Vegetable crops	Flowering/pod development	Life saving irrigation, weeding
Terminal drought 40 days (22 Sept – 30 Oct.)	Rice	Flowering/milking/ maturity	Life saving irrigation, foliar spray (1% MOP)
	Maize	Cob development/ maturity	Life saving irrigation

Salient achievements of on-station experiments

Real time contingency crop planning

Situation: Early season drought

During 2015-16, monsoon arrived 2 days later (12th June) than the normal time (10th June) of onset. As there was no delay in monsoon, seeds are sown just after arrival of monsoon but acute drought stress occurred during early season. The rainfall was deficit by 3.2% in June, 38.2% in July, 44.2% in August and 27.3% in September compared to normal rainfall. There were dry spells of 10 days from 12th to 21st July and 11 days from 3rd to 13th August. Early season drought severely affected seedling and vegetative growth of rice, maize, cowpea, pigeonpea, greengram, blackgram and other crops. *In-situ* moisture conservation practices (hoeing & weeding) were taken at vegetative/tillering stages of crops.

Rice variety Sahabhagi gave maximum yield (2300 kg/ha), RWUE (3.56 kg/ha-mm), net returns (Rs.6000/ha) and B:C ratio (1.4) than other varieties. The yield increase with *in-situ* moisture conservation practice was 16.7% as compared to farmers' practice (1900 kg/ha). Maize (NMH -51), greengram (TARM-1), blackgram (T-9), tomato (Laxmi),) and okra (Sakti) with *in-situ* moisture conservation practice gave 20, 22, 20, 16.6 and 21% higher yield as compared to normal practices (no hoeing & weeding) in maize, greengram, blackgram, tomato and okra, respectively (Table 1.1.36).

Table 1.1.46: Performance of different crops under *in-situ* moisture conservation varieties

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation	With normal practice				
Rice	Sahabhagi, ZHU 11-26, ODR 1-2	2300 2000 2000	1900 1800 1700	16.7	3.52	6000	1.40
Maize	NMH -51	3000	2500	20.0	5.0	12000	1.67
Greengram	TARM-1	500	410	22.0	1.32	10000	2.0
Blackgram	T-9	480	400	20.0	1.26	9200	1.92
Tomato	Laxmi	17500	15000	16.6	38.1	100000	2.33
Okra	Sakti	5200	4300	21.0	11.33	70000	2.16

Situation: Mid season drought

During 2015-16, a dry spell of 11 days from 2nd to 12th September, affected growth and development of different crops. Light hoeing & weeding was taken up in rice, maize, greengram, blackgram, tomato, okra and radish. The yield increase in rice field with *in-situ* moisture conservation practice was 21.6% as compared to farmers' practice (1850 kg/ha). Maize (NMH -51), greengram (TARM-1), blackgram (T-9) and radish (Pusa Chetki) with *in-situ* moisture conservation practice gave 21.6, 14.8, 22.0, 20 and 15% higher yield as compared to normal practices in maize, tomato and okra, respectively (Table 1.1.47).

Table 1.1.47: Performance of different crops with weeding/interculture

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Rice	ZHU 11-26	2255	1850	21.6	1.82	7500	1.50
Maize	NMH -51	3100	2700	14.8	2.51	12000	1.63
Greengram	TARM-1	500	410	21.9	0.62	10000	2.00
Blackgram	T-9	480	400	20.0	0.62	9200	1.92
Radish	Pusa Chetki	23000	2000	15.0	52.5	75000	2.87

Situation: Terminal drought

During 2015-16, the rainfall was deficit by 44.2% in August and 27.3% in September compared to normal rainfall. Long dry spell of 40 days from 22nd September to 30th October coincided with maturity stage of rice and cob development and maturity stages of maize. Life saving irrigation in rice and maize, and foliar spray in rice were given to cope with terminal drought.

Rice (Sahabhagi) gave the highest grain yield (2100 kg/ha), net returns of Rs. 6000/ha, B:C ratio of 1.4 and RWUE of 1.70 kg/ha-mm with supplemental irrigation. Maize (NMH -51) with supplemental irrigation gave the highest yield of 3200 kg/ha, net returns of Rs. 13000 /ha, B:C ratio of 1.68 and RWUE of 2.58 kg/ha-mm (Table 1.1.48).

Table 1.1.48: Performance of different crops under supplemental irrigation

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Supplemental irrigation	With normal practice				
Rice	Sahabhagi	2100	1550	35.5	1.70	6000	1.4
Maize	NMH -51	3200	27 00	18.5	2.58	13000	1.68

Foliar spray with 1% potassium chloride in rice during dry spells at flowering-milking stage improved the performance of rice variety Sahabhagi, and recorded higher grain yield (2100 kg/ha), net returns (Rs.6000/ha), B:C ratio (1.4) and RWUE (3.52 kg/ha-mm) compared to without foliar spray.

Preparedness

Among maize based intercropping systems, maize + pigeonpea (2:2) gave higher maize equivalent yield (5800 kg/ha) with higher net returns (Rs.33500/ha), B:C ratio (2.52) and RWUE (9.73 kg/ha-mm) compared to maize + cowpea intercropping system (Table 1.1.49). However, pigeonpea + radish intercropping (2:2) gave higher net returns (Rs.42,000/ha) compared to maize based intercropping systems.

Table 1.1.49: Performance of different crops under *in-situ* moisture conservation varieties

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With intervention	Without intervention				
Maize + cowpea (2:2)	Maize (NMH-51 + cowpea (Gomti)	Maize (3200) cowpea (2200 green pods) MEY-5400	Sole maize 3500	54.0	9.06	30000	2.25
Maize + pigeonpea (2:2)	Maize (NMH-51 + pigeonpea (NTL-724)	Maize (3100) pigeonpea (900) MEY-5800	Sole maize 3500	65.7	9.73	33500	2.52
Pigeonpea+ radish (2:2)	Pigeonpea (NTL-724) + radish (pusa chetki)	Pigeonpea (850) + radish (850) + radish (14000) PEY-2250	Sole pigeonpea 1000	125.0	3.78	42000	2.40

c. On-farm demonstrations

Village profile

The program is being implemented 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 and 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 2015-16

The rainfall data of Phulbani centre (being the nearest agromet station) was used for on-farm rainfall analysis.

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
10	12 -21 July	Rice, maize, cowpea, pigeonpea, radish	Germination / seedling
11	3 -13 August	Rice Maize Pigeonpea, cowpea, radish	Tillering / stem elongation Vegetative/tasselling Vegetative
11	2 - 12 September	Rice Maize Pigeonpea Cowpea, radish	PI/flowering Cob development Vegetative Maturity
40	22 September - 30 October.	Rice Maize	Milking/ripening/maturity Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Early season drought	Rice, maize	Raising of bund height
	Cowpea	Hoeing & weeding
Mid season drought	Rice	2nd weeding before flowering
	Maize, pigeonpea	Light hoeing & weeding
Terminal drought	Rice, maize	Life saving irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During 2015, there were dry spells of 10 days from 12th to 21st July and 11 days from 3rd to 13th August. Early season drought affected germination and seedling growth of rice, maize, cowpea, pigeonpea, greengram, blackgram and other crops. *In-situ* moisture conservation with raising of bund height was demonstrated in rainfed uplands (in case of rice and maize + cowpea). Rice variety (Sahabhagi) gave maximum yield (2400 kg/ha), net returns (Rs. 11000/ha), and B:C ratio (1.84) and RWUE (4 kg/ha-mm). The yield increase with *in-situ* moisture conservation practice was 14.3% as compared to farmers' practice (2100 kg/ha). Similarly, maize (NMH -51) + cowpea (Gomti) (2:2) intercropping gave maximum yield (5200 kg/ha), net returns (Rs. 30000/ha) and B:C ratio (2.36). The yield increase with *in-situ* moisture conservation practice was 57.6% as compared to farmers' practice (3300 kg/ha) (Table 1.1.50).

Table 1.1.50: Performance of different crops under *in-situ* moisture conservation varieties

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation practice	With normal practice				
Rice	Sahabhagi (110 days), Lalat (125 days)	2400	2100	14.3	4.00	11000	1.84
Maize + cowpea (2:2)	Maize (NMH -51 cowpea (Gomti)	Maize 3100 Cowpea 2100 MEY-5200	Sole maize 3300	57.6	7.25	30000	2.36

Timely weeding assumes great significance for soil moisture retention as well as for avoiding competition of crop with weeds. Hoeing & weeding was done coinciding with the vegetative stage (maize)/ tillering (rice) during 3rd and 6-7th week after transplanting in rice; 3rd and 6-7th week after sowing in maize. Rice gave maximum yield (2700 kg/ha), RWUE (1.88 kg/ha-mm), net returns (Rs. 9500/ha) and B:C ratio (1.63). The yield increase with *in-situ* moisture conservation was 19.5% as compared to farmers' practice (2100 kg/ha). Maize, cowpea and pigeonpea with *in-situ* moisture conservation practice gave 18.5, 16.7 and 25% higher yield as compared to normal practices, respectively (Table 1.1.51).

Table 1.1.51: Performance of different crops under *in-situ* moisture conservation varieties

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Rice	Sahabhagi (110 days); Lalat (125 days)	2200 2700	2000 2100	19.5	1.88	9500	1.63
Maize	Maize (NMH -51)	3200	2700	18.5	2.58	13000	1.68
Cowpea	Gomti	7000	6000	16.7	15.5	22000	1.46
Pigeonpea	NTL - 724	1000	800	25.0	1.67	18000	1.82

Among different intercropping systems, maize + cowpea (2:2) system, gave higher maize equivalent yield (5800 kg/ha) with highest net returns (Rs.33000/ ha), B:C ratio (2.32) and RWUE (9.7 kg/ha-mm) compared to other intercropping systems (Table 1.1.52).

Table 1.1.52: Performance of different crops under *in-situ* moisture conservation varieties

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With intervention	Without intervention				
Maize + cowpea (2:2)	Maize (NMH-51) + cowpea (Gomti)	3400 2400 MEY-5800	3800	52.6	9.7	33000	2.32
Maize + pigeonpea (2:2)	Maize (NMH-51) + pigeonpea (NTL-724)	3000 800 MEY-5400	3200	62.5	9.0	29000	2.16
Pigeonpea + radish (2:2)	Pigeonpea (NTL-724) + radish (Pusa Chetki)	800 13000 PEY-2100	1000	110.0	3.52	33000	2.10

Situation: Mid season drought

During 2015, the rainfall was deficit by 44.2% in August and 27.3% in September compared to normal rainfall. Dry spell of 11 days from 2nd September to 12th September, affected growth and development of different crops. Supplemental irrigation from nearby water stream was given during dry spells (17th August, 16th September and 27th September) at critical growth stages (tillering to milking) of rice which significantly improved the rice yield. Among rice varieties, Lalat recorded higher yield (2600 kg/ha), net returns (Rs.10000/ha), B:C ratio (1.63) and RWUE (4.36 kg/ha-mm) followed by Sahabhagi with a grain yield of 2200 kg/ha compared to without irrigation (Table 1.1.53).

Table 1.1.53: Performance of rice under supplemental irrigation

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With irrigation	Without irrigation				
Rice	Sahabhagi (110 days)	2200	1600	37.5	3.69	6000	1.38
	Lalat (125 days)	2600	2200	18.2	4.36	10000	1.63

Light hoeing & weeding was taken up in rice, maize, cowpea and pigeonpea. Rice variety (Lalat) gave maximum yield (2200 kg/ha), RWUE (3.69 kg/ha-mm), net returns (Rs. 7000/ha) and B:C ratio (1.47). The yield increase with *in-situ* moisture conservation was 22.2% as compared to farmers' practice (1800 kg/ha). Maize, cowpea and pigeonpea with *in-situ* moisture conservation gave 23, 20 and 33.3% higher yield as compared to normal practices respectively (Table 1.1.44).

Table 1.1.54: Performance of different crops under *in-situ* moisture conservation intervention

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation practice	With normal practice				
Rice	Sahabhagi	2000	1700	17.6	3.35	5000	1.33
	Lalat	2200	1800	22.2	3.69	7000	1.47
Maize	NMH -51	3200	2600	23	5.36	14000	1.78
Cowpea	Gomti	7200	6000	20	16	24000	1.5
Pigeonpea	NTL - 724	800	600	33.3	1.34	10000	1.45

Situation: Terminal drought

During 2015, long dry spell of 40 days from 22nd September to 30th October coincided with maturity stage of rice and cob development and maturity stage of maize crop. Life saving irrigation was given to rice and maize from nearby water stream. Rice (Sahabhagi) gave the highest grain yield (2100 kg/ha), net returns (Rs. 6000/ha), B:C ratio (1.4) and RWUE of 1.70 kg/ha-mm. Maize (NMH -51) with supplemental irrigation gave the highest yield of 3000 kg/ha, net returns of Rs. 11000 /ha B:C ratio of 1.58 and RWUE of 5 kg/ha-mm (Table 1.1.55).

Table 1.1.55: Performance of different crops under supplemental irrigation

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With supplemental irrigation	Without supplemental irrigation				
Rice	Sahabhagi (110 days)	2100	1550	35.48	1.70	6000	1.4
Maize	NMH -51	3000	2500	20.0	5.0	11000	1.58

1.1.6. VARANASI

a. Agro-ecological setting

Varanasi centre 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: Nil

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was timely (16th June). A rainfall of 1008.6 mm was received which was deficit by 72.4 mm compared to normal (1081.7 mm) (Fig. 1.1.9). During South-west monsoon (*kharif*), 857.3 mm of rainfall was received which was deficit by 87.2 mm compared to normal (944 mm). During North-east monsoon (October - December), 23 mm of rainfall was received which was deficit by 37.9 mm compared to normal (60.9 mm). During summer, 81.1 mm of rainfall was received which was excess by 48.8 mm compared to normal (32.3 mm).

Normal onset of monsoon	:	25th SMW (18-24 June)
Onset of monsoon during 2015-16	:	16 June
Annual mean rainfall	:	1081.7 mm
Annual rainfall during 2015-16	:	1008.6 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	944.5 & 60.9 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	857.3 & 23 mm, respectively

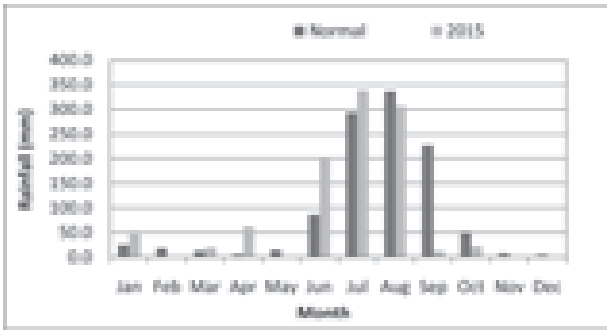


Fig. 1.1.9: Normal and actual (2015) monthly rainfall at Varanasi

c. On-farm demonstrations

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 945 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 experiences 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 26th 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 2015-16

During 2015, at Terha Saraya village, the onset of monsoon was timely (25th June). A rainfall of 803 mm was received which was deficit by 33.7 mm compared to normal (836.7 mm) (Fig. 1.1.10). During south-west monsoon (*kharif*), 669.5 mm of rainfall was received which was deficit by 30 mm compared to normal (699.5 mm). During north-east monsoon (October -December), 17 mm of rainfall was received which was excess by 43.9 mm compared to normal (60.9 mm). In summer (March-May), 78 mm rainfall was received which was 46 mm deficit as compared to the normal (32.3 mm).

Normal onset of monsoon : 25th SMW (18-24 June)

Onset of monsoon during 2015-16 : 25 June

Annual mean rainfall : 836.7 mm

Annual rainfall during 2015-16 : 803 mm

Mean crop seasonal rainfall during *kharif* and *rabi* : 699.5 & 60.9 mm, respectively

Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*) : 696 & 17 mm, respectively

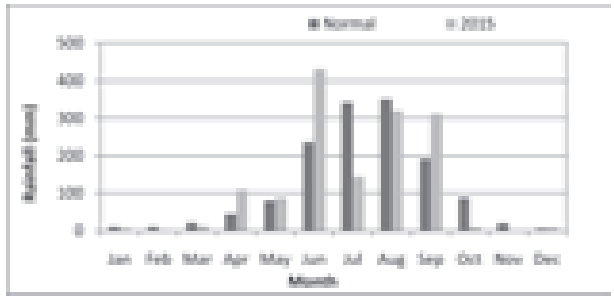


Fig 1.1.10. Normal and actual (2015) monthly rainfall at Pahari

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
31	19 August - 21 September	Rice Maize Sesame	Tillering (rice) Vegetative
34	23 September- 27 October	Rice, maize and sesame	Rice crop failed due to long dry spell, Maturity stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented	No. of farmers	Area covered (ha)
Mid season drought	Rice	Weeding by dryland weeder and foliar spray with 2% thiourea	14	3.5
	Maize	Foliar spray of 2% urea+ 0.5% $ZnSO_4.7H_2O$	12	3.0
	Pigeonpea	Plant population maintenance (thinning)	25	10
	Greengram	Picking of mature pods	10	2.5
	Pearlmillet	Weeding and soil mulching by dryland weeder	28	7.0
Terminal drought	Rice	Supplemental irrigation	12	3.0
	Maize	Green cobs harvested and stalk used for fodder	15	4.0
	Pigeonpea	Weeding & soil mulching by dryland weeder	25	10
	Pearlmillet	Supplemental irrigation	06	1.6

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

During 2015, at Pahari village, there was a dry spell of 31 days from 19 August to 21 September during vegetative stage of the maize, sesame and tillering stage of rice.

Supplemental irrigation was given in rice at panicle initiation stage with sprinklers from harvested rainwater. The increase in yield was 100%, with supplemental irrigation over no irrigation. The higher grain yield (2450 kg/ha), net returns (Rs. 18800/ha) with B:C ratio of 1.17 and RWUE (4.8 kg/ha-mm) was recorded due to supplemental irrigation. Similarly maize yield (2400 kg/ha), net returns (Rs.18600/ha), B:C ratio (1.16) and RWUE (4.9 kg/ha-mm) were higher with supplemental irrigation (Table 1.1.56).

Table 1.1.56: Performance of different crops under supplemental irrigation

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With irrigation	Without irrigation				
Rice	NDR-97 (95 days)	2450	Crop failure due to drought	100	4.8	18800	1.17
	HUR-3022 (105 days)	2100			4.1	14500	0.91
Maize	Sweta (80 days)	2400	1650	45	4.9	18600	1.16

Weeding with dryland weeder in maize, sesame and pearlmillet increased yields by 21, 24 and 30%, respectively as compared to broadcasting method without weeding. Among different crops, maize (Sweta) gave higher yield (2270 kg/ha), net returns (Rs.16780), B:C ratio (2.1) and RWUE (4.4 kg/ha-mm) (Table 1.1.57).

Table 1.1.57: Performance of different crops with weeding/interculture

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Maize	Sweta	2270	1880	21	4.4	16780	2.1
Sesame	Shekhar	385	310	24	77	14950	1.9
Pearlmillet	Pusa 322	1370	1050	30	2.7	4440	1.4

To overcome the stress due to midseason drought, foliar spray of 2% thiourea with micro nutrients 0.5% (Zn + Bo) were undertaken in rice at panicle initiation stage. The treatment recorded higher yield (2400 kg/ha), net returns (Rs.18600/ha), B:C ratio (1.16) and RWUE (4.70 kg/ha) with yield increase of 11.6% over control (2150 kg/ha). Similarly, maize gave higher grain yield (2400 kg/ha) and the increase in yield was 45% over without foliar spray (Table 1.1.58).

Table 1.1.58: Performance of rice and maize with foliar sprays

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray				
Rice	NDR-97	2400	2150	11.6	4.70	18600	1.16
Maize	Shweta	2400	1650	45	4.9	18600	1.16

Preparedness

Rainwater management

In-situ moisture conservation practices were demonstrated in maize, sesame and pearlmillet along with line sowing + weeding and soil mulching by dryland weeder. This gave higher seed yield of maize (Sweta) (2370 kg/ha), net returns (Rs.25800/ha), B:C ratio (2.5) and RWUE (4.4 kg/ha-mm) as compared to farmers' practice (1880 kg/ha). Similar trend was followed in sesame (375 kg/ha) and pearlmillet (1540 kg/ha), respectively compared to farmer's practice (310 and 1250 kg/ha, respectively) (Table).

Vegetables were cultivated with supplemental irrigation from harvested rainwater in farm pond. Among different crops, bottle gourd gave higher yield (18000 kg/ha), net returns (Rs.55000/ha), B:C ratio (2.5) and RWUE (27.0 kg/ha-mm) compared to other crops (Table 1.1.59).

Table 1.1.59: Performance of vegetables under supplemental irrigation from harvested water in the farm pond

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Bottle gourd	18000	350000	55000	2.5	27.0
Brinjal	10500	40000	65000	2.6	16.1
Chilli	4800	40000	56000	2.4	7.3

Cropping systems

Different short duration varieties of rainfed maize, sesame and pearlmillet were demonstrated during *kharif*. Maize variety Shweta with line sowing on ridges recorded higher grain yield (2300 kg/ha), net returns (Rs.17200/ha), B:C ratio (1.3) and RWUE of 4.5 kg/ha-mm. The grain yield increased by 35% as compared to farmer's practice. Similarly, sesame (JT-508) recorded higher seed yield (410 kg/ha), net returns (Rs.16700/ha), B:C ratio (2.3) and RWUE of 0.81 kg/ha-mm. Similarly, pearlmillet (pusa-322) recorded higher grain yield (1900 kg/ha), net returns (Rs.10800/ha), B:C ratio (0.9) and RWUE of 3.76 kg/ha-mm compared to farmer's practice (Table 1.1.60).

Table 1.1.60: Performance of different crops under *in-situ* moisture conservation

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With normal practice				
Maize	Shweta (80)	2300 (Improved variety + line sowing on ridges)	1700 (Local variety + farmer practice)	35	4.5	17200	1.3

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With normal practice				
Sesame	JT-508(115)	410 (Improved Var. + line sowing on ridges)	325 Local variety + farmer practice)	26	0.81	16700	2.3
Pearlmillet	Pusa-322 (80 days)	1900 (Line sowing)	1450 (Broad-casting)	31	3.76	10800	0.9

The intercropping system of maize (Sweta) + greengram (HUM-16) (4:2) gave maize equivalent yield of 3505 kg/ha, and land equivalent ratio (1.51) whereas okra (Anamika) + rice (NDR-97) recorded rice equivalent yield of 6726 kg/ha with net returns of Rs.73900/ha and B:C ratio of 3.91.

Nutrient management

Integrated nutrient management involving 50% RDF + 50% FYM + foliar spray of 2% were in rice recorded higher yield (2350 kg/ha) with net returns of Rs.15700/ha, B:C ratio of 2.4 and RWUE of 5.8 kg/ha compared to farmer practice (RDF) (1530 kg/ha) (Table 1.1.61).

Table 1.1.61: Integrated nutrient management in rice

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
100% RDF	1530	2860	14000	13905	1.9	2.7
50% RDF + 50% FYM	2070	3480	15200	22575	2.4	3.7
50% RDF + 50% FYM + foliar spray of 2% urea	2350	4050	15700	22475	2.4	5.8

Alternate land use

In aonla based agri-horti intercropping system, greengram was demonstrated as an intercrop. The system gave aonla equivalent yield of 6884 kg/ha with net returns of Rs.68840/ha, B:C ratio of 4.3 and other crops

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

Experienced weather conditions during 2015-16

During the year 2015, the onset of monsoon was delayed by 17 days (19th July). A rainfall of 679.2 mm was received which was excess by 21.5 mm compared to normal rainfall of 657.7 mm (Fig.). During South-West monsoon (June to September), 521.6 mm rainfall was received which was excess by 92.8 mm (15.7%); During October-December, there was no rain against normal of 20.2 mm. During summer (March- May), 83.8 mm of rainfall was received which was excess by 68.7 mm compared to normal (15.1 mm) (Fig…).

Normal onset of monsoon	:	2 July
Onset of monsoon during 2015-16	:	19 July
Annual mean rainfall	:	657.7 mm
Annual rainfall during 2015-16	:	679.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	614.5 and 20.2 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*)	:	521.7 and 0 mm, respectively

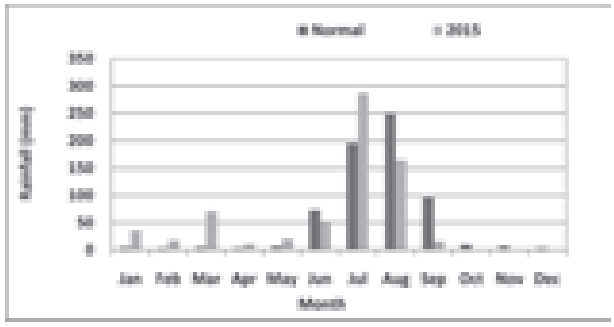


Fig. 1.2.1: Normal and actual (2015) monthly rainfall at Arjia

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
14	26 June to 8 July	Maize	Emergence/ seedling
31	19 August to 18 September	Maize	Vegetative/ tasseling
>30	20 September onwards	Maize and all other crops	Grain filling to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Maize, blackgram, greengram, clusterbean, sesame, horsegram, groundnut	Seedling and vegetative	Improved varieties and intercropping
Terminal drought	Maize	Silking to maturity	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2015, the onset of monsoon was delayed by 17 days (19th July). Different crops and their varieties were evaluated under late sown condition. There were three dry spells viz., (1st was at emergence/seedling stage (26 June to 8 July), 2nd at vegetative or tasseling stage (19th August to 18th September) and 3rd at maturity stage (20th September onwards). The yield levels of all crops and cropping systems were low. However, blackgram and greengram performed well due to short growing periods and more tolerance to drought in comparison to other crops and their varieties over sole crops. Blackgram gave highest MEY (1659 kg/ha) followed by greengram (1407 kg/ha) which was 348 & 280% higher, respectively over sole maize (370 kg/ha) (Table 1.2.1).

Table 1.2.1: Yield of different crops and cropping systems under delayed onset of monsoon

Treatment	Seed/grain yield (kg/ha)	Stover yield (kg/ha)	MEY (kg/ha)	% increase over maize
Maize	370	4797	370	0
Blackgram	231	834	1659	348
Greengram	303	1258	1407	280
Clusterbean	367	925	612	65
Sesame	50	643	472	28
Sorghum	0	1754	719	94
Horsegram	181	985	1022	176
Groundnut	750	1335	517	40
Maize + blackgram (2:2)	433	3740	709	92
Groundnut + sesame (6:2)	1103	1420	671	81

Situation: Terminal drought

During the year 2015, there were three dry spells (first one of 14 days duration coinciding with emergence or seedling stage, second dry spell during vegetative and tasseling stage and third during silking to maturity) during crop season. Foliar spray of soluble NPK @ 2% (during drought) produced significantly higher mean maize grain and straw yield (2170 and 4162 kg/ha) and was 3 and 24% higher over control (1678 kg/ha and 3365 kg/ha), respectively (Table 1.2.2).

Table 1.2.2: Effect of agronomical practices and chemical spray on productivity of maize

Treatment	Grain yield (kg/ha)			Stover yield (kg/ha)		
	2014	2015	Mean	2014	2015	Mean
Control (Normal practices)	1944	1411	1678	3426	3304	3365
Reduce 25% plant population	1827	1376	1602	3247	2735	2991
Remove lower leaves (4-5)	2109	1527	1818	3483	2999	3241
Soil stirring one time during drought	2256	1712	1984	3984	3860	3922
Thio-urea spray 0.05%	2299	1851	2075	3905	3915	3910
Soluble NPK @ 2%	2407	1932	2170	4074	4248	4162

Treatment	Grain yield (kg/ha)			Stover yield (kg/ha)		
	2014	2015	Mean	2014	2015	Mean
KNO_3 @ 2% during drought	2309	1793	2051	3950	4373	4161
Ridging after 1st interculture	-	1735	1735	-	4082	4082
CD at 5%	294	277	-	477	526	-

c. On-farm demonstrations

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 ha and 253 ha out of which 220 ha 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 in Kochariya and sandy loam in Lapsiya village. The major rainfed crops during *kharif* are maize, blackgram, groundnut in Kochariya while sorghum, maize, blackgram in Lapsiya and during *rabi* are wheat, barley and mustard in both the villages. The ground water table is 210 and 250 m at Kochariya and Lapsiya, respectively. The source of irrigation is dug well and tube well covering 23.9 and 22.1% of cultivated area in 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* season revealed an increase of 1.17^0C in maximum temperature and decrease of 0.79^0C as compared to their respective normal for the past 20 years. During *rabi*, there was a decrease of 0.96^0C 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 2015-16

During 2015, in Kochariya village, onset of monsoon was normal (1st July). A rainfall of 354.1 mm was received which deficit by 303.6 mm compared to normal 657.7 mm (Fig 1.2.2.). During South-West monsoon (*kharif*), 354.1 mm rainfall was received which was deficit by 260.4 mm (42.4%) than normal of 614.5 mm. During *rabi* and summer, there was no rain against normal of 20.2 and 15.1 mm, respectively.

During 2015, in Lapsiya village, onset of monsoon was normal (2nd July). A rainfall of 272 mm was received which was deficit by 385.7 mm compared to normal (657.7 mm) (Fig.). During South-West monsoon (June to September), 237 mm rainfall was received which was deficit by 377.5 mm than normal rainfall of 614.5 mm. During October- December, there was no rain as against normal of 20.2 mm and during summer (March - May), 14 mm rainfall was received against normal rainfall of 15.1 mm.

Normal onset of monsoon	:	2 July (Rajsamand), 1 July (Bhilwara)
Onset of monsoon during 2015-16	:	24 July (Lapsiya), 24 June (Kochariya)
Annual mean rainfall	:	657.7 mm
Annual rainfall during 2015-16	:	272 mm (Lapsiya), 354.1 mm (Kochariya)
Mean crop seasonal rainfall (*kharif* and *rabi*) respectively	:	614.5 mm and 20.2 mm during *kharif* and *rabi*,
Crop seasonal rainfall during 2015-16 *kharif*	:	237 mm (Lapsiya) & 354.1 mm (Kochariya) during and there was no rainfall during *rabi*

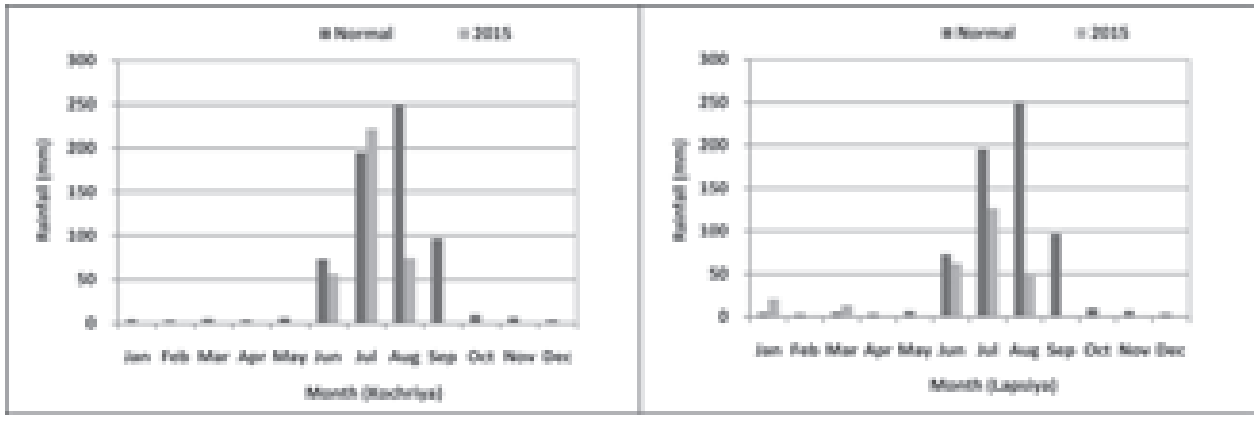


Fig. 1.2.2: Normal and actual (2015) monthly rainfall at Kocharia & Lapsiya

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

A dry spell of 11 days occurred during tasseling stage of maize and flowering stage of sorghum. Demonstrations on foliar application of 2% KNO_3 in maize were conducted at Kochariya village to cope with midseason drought during 30th July to 9th August. Foliar application of 2% KNO_3 gave 25% higher seed yield (878 kg/ha) over farmers' practice (704 kg/ha) with higher net returns (Rs.14600/ha) and B:C ratio (1.21) compared to farmers' practice (Table....). The increase in yield with foliar spray of KNO_3 was 25% over farmers' practice of no foliar spray. Similarly, at Lapsiya village higher maize grain yield (518 kg/ha), RWUE (1.98 kg/ha-mm) and B:C ratio (0.90) were recorded with foliar spray of 2% KNO_3 over farmers' practice of no foliar spray (Table 1.2.3).

Table 1.2.3: Response of maize to foliar spray at Kochariya and Lapsiya villages under midseason drought

Intervention	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Kochariya						
Foliar spray of 2% KNO_3	878	2150	25	2.89	3067	1.21
Farmers' practice	704	1750	-	2.32	131	1.01
Lapsiya						
Foliar spray of 2% KNO_3	518	1870	28	1.98	-1273	0.90
Farmers' practice	405	1550	-	1.55	-2955	0.76

Similarly, in sorghum, foliar spray of 2% urea was done during the drought period for two times at 10 days interval. Foliar spray of 2% urea gave 18% higher sorghum grain yield (1120 kg/ha) over farmers' practice of no foliar spray (948 kg/ha) with higher RWUE (3.69 kg/ha-mm), net returns (Rs.9215/ha) and B:C ratio (1.68) at Kochariya village. Similar trend was observed with foliar spray of 2% urea in sorghum in Lapsiya village (Table 1.2.4).

Table 1.2.4: Response of sorghum to foliar spray of 2% urea at Kochariya and Lapsiya villages

Intervention	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Kochariya						
Foliar spray of 2% urea	1120	3750	18.1	3.69	9215	1.68
No foliar spray	948	3200		3.12	6676	1.53
Lapsiya						
Foliar spray of 2% urea	988	3400	22.9	3.78	7306	1.56
No foliar spray	804	2850		3.07	4373	1.35

One supplemental irrigation was given in maize + blackgram (2:2) intercropping system during 11 days mid season drought (30 July to 9 August) and it gave 52% higher maize grain equivalent yield (1330 kg/ha) over farmers' practice (873 kg/ha) with higher RWUE (4.38 kg/ha-mm), net returns (Rs.9119/ha) and B:C ratio (1.52). Similarly, supplemental irrigation in groundnut + sesame (6:2) intercropping system at 55 DAS gave 77% higher groundnut pod equivalent yield (788 kg/ha) over farmers' practice (388 kg/ha) with higher RWUE (2.60 kg/ha-mm), net returns (Rs.12661/ha) and B:C ratio (1.64) (Table 1.2.5).

Table 1.2.5: Performance of different intercropping systems under supplemental irrigation at Kochariya village

Intervention	Yield (kg/ha)						RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Straw/stover		MEY				
	Maize	Blackgram	Maize	Blackgram	Grain	Straw			
Maize + blackgram (2:2) intercropping system									
With SI	1014	68	2950	207	1330	3281	4.38	9119	1.52
Without SI	706	36	2100	118	873	2289	2.87	1296	1.08
Groundnut + sesame (6:2) intercropping system									
With SI	665	48	1150	208	788	1192	2.60	12661	1.64
Without SI	388	22	870	105	445	891	1.46	924	1.05

SI : Supplimental irrigation

Preparedness

Rainwater management

In-situ moisture conservation practices in maize at Kochariya village gave 28% higher seed yield (988 kg/ha) over farmers' practice at ploughing twice (774 kg/ha) with higher net returns (Rs.4857/ha) and B:C ratio (1.31). Similarly, at Lapsiya, the *in-situ* moisture conservation practices gave 37% higher seed yield (514 kg/ha) over farmers' practice (375 kg/ha). Similarly, *in-situ* moisture conservation practices demonstrated in sorghum at Kochariya gave 25% higher sorghum grain yield (1180 kg/ha) compared to farmers' practice of no *in-situ* moisture

conservation (945 kg/ha) with higher net returns (Rs.9285/ha) and B:C ratio (1.63). At Lapsiya, *in-situ* moisture conservation practices gave 28% higher grain yield (980 kg/ha) with higher net returns (Rs.6755/ha) and B:C ratio (1.46) over farmers' practice (Table 1.2.6).

Table 1.2.6: Response of maize to *in-situ* moisture conservation practices in Kochariya and Lapsiya villages

Crop	Intervention	Yield (kg /ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ ha)	B:C ratio
		Grain	Mean (5 yrs)	Stover				
Maize	**Kochariya**							
	With *in-situ* practices	988	2256	2750	28	3.25	4857	1.31
	Without *in-situ* practices	774	1840	2270	-	2.55	2411	1.17
	Lapsiya							
	With *in-situ* practices	514	1559	1750	37	1.96	-2979	0.80
	Without *in-situ* practices	375	1299	1380	-	1.43	-3800	0.70
Sorghum	**Kochariya**							
	With *in-situ* practices	1180	-	3970	25	3.88	9285	1.63
	Without *in-situ* practices	945	-	3140	-	3.11	6540	1.52
	Lapsiya							
	With *in-situ* practices	980	-	3910	28	3.74	6755	1.46
	Without *in-situ* practices	765	-	3240	-	2.92	4680	1.37

Improved practice included soil & water conservation measures viz., peripheral bunding, deep ploughing, chieseling, tillage and sowing across the slope, soil mulching, and making ridges after sowing (30 DAS)

Cropping systems

In an on-farm demonstration of maize + blackgram (2:2) intercropping system at Kochariya, maximum MEY (1145 kg/ha), net returns (Rs.5780/ha) and B:C ratio (1.35) were recorded as compared to mixed cropping of maize and blackgram. Similarly, in Lapsiya village, maximum MEY (541 kg/ha) was recorded with intercropping system of maize + blackgram (2:2) but with negative net returns (Rs.-1643/ha) and B:C ratio of 0.88 (Table 1.2.7). The increase in MEY with intercropping of maize + blackgram (2:2) was 71% more over mixed cropping of both crops. The crop yields were low due to prolonged dry spell of more than 40 days during grain filling and maturity.

Table 1.2.7: Yield and economics of maize + blackgram (2:2) intercropping system

Village	Cropping system	Yield (kg /ha)		MEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ ha)	B:C ratio
		Maize	Black gram					
Kochariya	Maize + blackgram (2:2)	890	55	1145	58	3.77	5780	1.35
	Mixed cropping	725	0	725	-	2.39	-330	0.98
Lapsiya	Maize + blackgram (2:2)	425	25	541	71	2.07	-1643	0.88
	Mixed cropping	317	0	317	-	1.21	-5027	0.61

In an on-farm demonstration of groundnut + sesame (6:2) intercropping system at Kochariya, maximum pod yield of groundnut (368 kg/ha) and seed yield of sesame (26 kg/ha), net returns of Rs.1418/ha and B:C ratio of 1.08 were attained in groundnut + sesame (6:2) intercropping system compared to mixed cropping of both crops. Similarly, in Lapsiya, maximum equivalent yield (375 kg/ha), grain yield of maize (318 kg/ha) and seed yield of sesame (22 kg/ha) were recorded with maize + blackgram (2:2) intercropping system compared to mixed cropping of both crops. The higher RWUE (1.43 kg/ha-mm), net returns (Rs.908/ha) and B:C ratio (1.06) were also recorded with maize + blackgram (2:2) intercropping system over mixed cropping of both crops (Table 1.2.8).

Table 1.2.8: Yield and economics of intercropping systems

Village	Cropping system	Yield (kg /ha)		GEY MEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ ha)	B:C ratio
		Groundnut (Pod)	Sesame (Seed)					
Kochariya	Groundnut + sesame (6:2) intercropping	368	26	435	36	1.43	1418	1.08
	Groundnut and sesame mixed cropping	320	0	320	-	1.05	-1840	0.88
Lapsiya	Maize+blackgram (2:2) intercropping	318	22	375	67	1.43	908	1.06
	Maize and blackgram mixed cropping	224	0	224	-	0.86	-4600	0.68

Sowing of sesame seed during first interculture (hoeing and weeding) in sole cropping of maize due to less plant population gave 50% higher maize grain equivalent yield (1031 kg/ha) over farmers' practice (685 kg/ha) with higher net returns and B:C ratio over farmers' practice (Table 1.2.9). Similarly at Lapsiya, inclusion of sesame in sole crop of maize, gave 99% higher maize grain equivalent yield (526 kg/ha) over farmers' practice (264 kg/ha).

Table 1.2.9: Yield and economics of maize + sesame intercropping system

Village	Cropping system	Yield (kg /ha)		GEY MEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ ha)	B:C ratio
		Groundnut (Pod)	Sesame (Seed)					
Kochariya	Maize + sesame intercropping	825	32	1031	50	3.39	4310	1.29
	Maize and sesame mixed cropping	685	0	685	-	2.25	-840	0.94
Lapsiya	Maize + sesame intercropping	385	22	526	99	2.01	-3435	0.76
	Maize and sesame mixed cropping	264	0	264	-	1.01	-7069	0.48

In an on-farm demonstrations of sorghum + greengram (2:1) intercropping system at Kochariya, maximum sorghum equivalent yield (1210 kg/ha) was recorded with sorghum + greengram (2:1) intercropping system compared to farmers' practice with higher net returns of Rs. 7735/ha and B:C ratio of 1.51. Similarly, at Lapsiya village, maximum sorghum equivalent yield (998 kg/ha) was attained in sorghum + greengram (2:1) intercropping system over farmers' practice of mixed cropping (Table 1.2.10).

Table 1.2.10: Performance of sorghum + greengram (2:1) intercropping system at Kochariya and Lapsiya villages

Treatment	Yield (kg/ha)				SEY (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Straw/stover							
	Sorghum	Green gram	Sorghum	Green gram	Grain	Mean (5 yrs)				
Kochariya										
Improved practice	950	48	3150	110	1210	2657	31.31	3.98	7735	1.51
Farmers' practice	824	18	2450	80	922	2029	-	3.03	3003	1.21
Lapsiya										
Improved practice	770	42	2850	95	998	1628	37.44	3.81	4975	1.34
Farmers' practice	612	21	2200	65	726	1254	-	2.77	919	1.07

At Kochariya, improved variety of maize (PM-3) gave 112% higher grain yield (878 kg/ha) over the local cultivar (415 kg/ha) with highest net returns (Rs.4317/ha) and B:C ratio (1.31) followed by PM-5. At Lapsiya, PM-3 gave 80% higher grain yield (404 kg/ha) over the local cultivar (225 kg/ha) with higher B:C ratio (0.78) (Table 1.2.11). In general, the crop yields were poor due to dry spells during crop season

Table 1.2.11: Yield and economics of maize varieties at Kochariya and Lapsiya villages

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Kochariya						
PM-5	746	2650	80	-	2969	1.21
PM-3	878	2450	112	-	4317	1.31
Local	415	1900	-	-	-2940	0.78
Lapsiya						
PM-5	328	1500	46	1.25	-4158	0.67
PM-3	404	1650	80	1.54	-2719	0.78
Local	225	1150	-	0.86	-6075	0.50

Among different varieties of sorghum, CSV-15 gave 82% higher grain yield (990 kg/ha) over the local cultivar (545 kg/ha) in Kochariya village. Similarly, in Lapsiya (Rajsamand), CSV-15 gave 79% higher sorghum grain yield (875 kg/ha) over local cultivar (488 kg/ha). CSV-15 also gave higher net return (Rs. 6788/ha) and B:C ratio (1.55) than other varieties (Table 1,2,12).

Table 1.2.12: Yield and economics of sorghum varieties at Kochariya and Lapsiya villages

Village	Variety	Yield (kg/ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ ha)	B:C ratio
		Grain	Mean (5 yrs)	Straw				
Kochariya	CSV-15	990	1999	3650	82	3.26	8305	1.65
	CSV-17	770	1696	2560	41	2.53	2940	1.23
	Local	545	1525	1850	-	1.79	-935	0.92
Lapsiya	CSV-15	875	1671	3475	79	3.34	6788	1.55
	CSV-17	780	1399	2350	60	2.98	2835	1.23
	Local	488	1181	1725	-	1.86	-1782	0.85

Among groundnut varieties demonstrated in Kochariya, TG 37A gave 38% higher pod yield (522 kg/ha) compared to local (378 kg/ha) with higher RWUE (1.72 kg/ha-mm), net returns (Rs.5200/ha) and B:C ratio (1.30) (Table 1.2.13). Similarly, the same variety of groundnut (TG 37A) at Lapsiya gave 45% higher pod yield (326 kg/ha) over local (198 kg/ha).

Table 1.2.13: Yield and economics of groundnut varieties at Kochariya and Lapsiya villages

Village	Variety	Yield (kg/ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ ha)	B:C ratio
		Pod	Mean (5 yrs)	Stover				
Kochariya	TAG-24	470	1750	850	24	1.55	2700	1.16
	TG- 37A	522	1799	1020	38	1.72	5200	1.30
	Local	378	2025	780	-	1.24	-450	0.97
Lapsiya	TAG-24	288	1100	740	45	1.10	-2560	0.84
	TG- 37A	326	1230	820	65	1.25	-910	0.94
	Local	198	442	540	-	0.76	-5110	0.64

Nutrient management

Application of zinc sulphate @ 25 kg/ha gave 18% higher maize grain yield (888 kg/ha) over farmers' practice (760 kg/ha) with higher net returns (Rs.3827/ha) and B:C ratio (1.26) at Kochariya. Similar results were recorded with application of 25 kg $ZnSO_4$/ha in maize in Lapsiya village (Table 1.2.14).

Table 1.2.14: Response of maize to application of zinc sulphate at Kochariya and Lapsiya villages

Village	Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw				
Kochariya	25 kg $ZnSO_4$/ha	898	2450	18.2	2.96	3827	1.26
	Control	760	2160	-	2.50	1790	1.13
Lapsiya	25 kg $ZnSO_4$/ha	408	1550	16.9	1.56	-3963	0.71
	Control	349	1200	-	1.33	-4814	0.62

Alternate land use

The major components of the silvi-pastoral system consist of forages (*Cenchrus setgerus –CAZRI-76*) and perennial tree components in Lapsiya village. *In-situ* rainwater management (contour trenches at 8 m interval) were taken up as a critical input to stabilize the yields. Improved grasses with rainwater conservation practices performed better and gave higher mean dry grass yield (6525 kg/ha) as compared to local grass (2676 kg/ha) gave higher net returns (Rs.20800/ha) and B:C ratio (3.18) compared to farmers' practice (Local grass) (Table 1.2.15).

Table 1.2.15: Yield and economics of silvipastoral system in Lapsiya village

Treatment	Gross yield (kg/ha)		Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	2015	Mean (4 yrs)			
Improved practice (Cenchrus setigerus)	5200	6525	20800	14250	3.18
Farmer practice (local grass*)	2100	2676	4200	1200	1.40

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 evapotranspiration is 739 mm.

b. On-station experiments

Experienced weather condition during 2015-16

The annual rainfall recorded during the year 2015 was 917 mm, which was deficit by 177.3 mm than the normal annual rainfall of 1094.3 mm. Out of the total rainfall, 611 mm was received during the *kharif* season (June to September) as against normal of 862 mm. In *rabi*, 13 mm rainfall was received which was 177.5 mm deficit than normal of 190.5 mm. In summer season, 197 mm rainfall was received which was excess by 114.9 mm as against normal of 82.1 mm (Fig. 1.2.3).

Normal onset of monsoon : 1 July

Onset of monsoon during 2015-16 : 5 July

Annual mean rainfall : 1094.3 mm

Annual rainfall during 2015-16 : 917 mm

Mean crop seasonal during *kharif* and *rabi* : 862 and 190.5 mm, rainfall respectively

Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*) : 611.1 mm during *kharif* and 13 mm during *rabi*

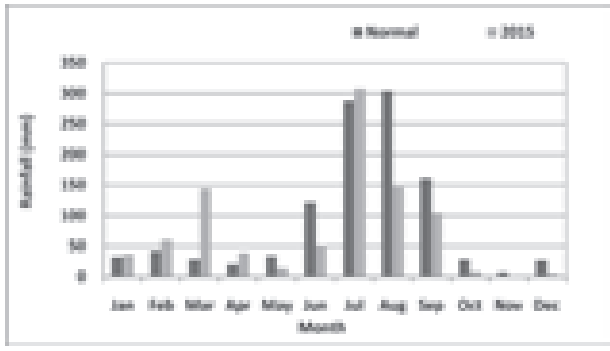


Fig. 1.2.3: Normal and actual (2015) monthly rainfall at Ballowal Saunkhri

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
28	22 August – 18 September	Maize	Silking
		Blackgram/greengram	Flowering/pod formation
		Sesame	Flowering/pod formation
21	24 September – 13 October	Maize	Dough
10	15 – 24 October	Rabi crops	Sowing and germination
15	26 October – 9 November	Rabi crops	Vegetative
32	11 November - 9 December		

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid-season drought	Maize Blackgram/ greengram	Silking/ dough Flowering/ pod formation	• Reduction in plant population, • Foliar spray • Soil mulching
	Sesame	Flowering/ pod formation	

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

In 2015, the rainfall was deficit by 51.8% in August and 34.7% in September. There was a dry spell of 28 days occurred at silking stage of maize and flowering stages of greengram, blackgram and sesame. Surface mulching of crop residues along with foliar spray of 1% KNO_3 showed maximum improvement in yield of maize as compared to no intervention. Maximum maize seed yield (2979 kg/ha), straw yield (7438 kg/ha), RWUE (5.32 kg/ha-mm) and net returns of Rs.18603/ha were recorded with crop residue mulching along with foliar spray of 1% KNO_3 as compared to other contingency measures (Table 1.2.16).

Table 1.2.16: Performance of maize under various real time contingency measures

Treatment	Grain yield (kg/ha)	% increase in yield	Straw yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
No intervention	2432	-	6781	4.34	13904	1.47
Crop residue mulching	2672	9.9	7432	4.77	15778	1.50
Foliar spray of 1% KNO_3	2865	17.8	7396	5.11	17524	1.53
Reduction in plant population	2641	8.6	6708	4.71	16256	1.54
Crop residue mulching + foliar spray of 1% KNO_3	2979	22.5	7438	5.32	18603	1.55
Crop residue mulching + reduction in plant population	2839	16.7	7109	5.06	17283	1.53
Foliar spray of 1% KNO_3 + reduction in plant population	2885	18.6	6906	5.15	18376	1.58

In blackgram (Cv. Mash-114), soil mulching along with foliar spray of 1% KNO_3 gave maximum seed yield (573 kg/ha), stover yield (2976 kg/ha), RWUE (1.39 kg/ha-mm) with higher net returns of Rs.5440/ha and 1.39 B:C ratio over all other contingency measures. The increase in yield with soil mulching along with foliar spray of KNO_3 was 21% over no intervention (Table 1.2.17).

Table 1.2.17: Performance of blackgram under various real time contingency measures

Treatment	Yield (kg/ha)	% increase in yield	Stover yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
No intervention	475	-	2277	1.15	2866	1.15
Soil mulching	509	7	2443	1.27	3391	1.23
Foliar spray of 1% KNO_3	535	13	2715	1.33	4177	1.29
Foliar spray of 0.1% thiourea	524	10	2457	1.30	4403	1.27
Soil mulching + foliar spray of 1% KNO_3	573	21	2976	1.39	5440	1.39
Soil mulching + foliar spray of 0.1% thiourea	545	15	2773	1.37	4856	1.32

In another trials, soil mulching and foliar spray of 1% KNO_3 recorded higher sesame yield (435 kg/ha), RWUE (1.05 kg/ha-mm), net returns (Rs.24241/ha) and B:C ratio (2.26) over all other contingency measures. The increase in sesame yield with soil mulching and foliar spray of 1% KNO_3 was 13.5% over no intervention (Table 1.2.18).

Table 1.2.18: Performance of sesame under various real time contingency measures

Treatment	Yield (kg/ha)	% increase in yield	Stover yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
No intervention	383	-	3553	0.92	21136	2.23
Soil mulching	406	6.1	3802	0.98	22341	2.22
Foliar spray of 1% KNO_3	391	2.2	3719	0.94	20389	2.09
Foliar spray of 0.1% thiourea	389	1.6	3504	0.94	20939	2.17
Soil mulching + foliar spray of 1% KNO_3	435	13.5	3859	1.05	24241	2.26
Soil mulching + foliar spray of 0.1% thiourea	412	7.5	3896	0.99	22691	2.23

Preparedness

Rainwater management

Sowing of maize, greengram and blackgram on ridges proved to be superior to flat sowing. The yield attributes, yield, WUE and economics were higher with ridge sowing. The increase in grain/seed yield of maize, greengram and blackgram was 44.3, 32.8 and 11.6% over flat sowing, respectively with corresponding net returns of Rs.10442/ha, Rs.16683/ha and Rs. 6076/ha and B:C ratio of 1.84, 2.42 and 1.72, respectively (Table 1.2.19).

Table 1.2.19: Effect of establishment methods on yield and economics of different crops

Crop	Grain yield (kg/ha)		Straw yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	RP	FP	RP	FP	RP	RP	FP	RP	FP	RP	FP
Maize	2324	1611	5976	4602	44.3	5.62	3.90	10442	49	1.34	1.0
Greengram	635	478	-	-	32.8	2.06	1.55	16683	8641	1.74	1.40
Blackgram	588	527	-	-	11.6	1.42	1.27	6076	4220	1.26	1.19

RP: Ridge planting; FP: Flat planting

Cropping systems

Maize hybrid PMH 2 gave maximum yield of 3080 kg/ha with net returns of Rs.18122/ha and B:C ratio 1.61 compared to Prakash (2950 kg/ha). Among the blackgram cultivars, Mash-114 gave highest seed yield (560 kg/ha), net returns (Rs.4248/ha) and B:C ratio (1.19) over Mash-338. Greengram cultivar PAU 911 recorded higher yield (620 kg/ha), net returns (Rs.10605/ha) and B:C ratio (1.51) over ML 818. Sesame cultivar Punjab Til No.2 recorded marginally higher yield (442 kg/ha), net returns (Rs.27036/ha) and B:C ratio (2.58) over RT 346 (Table 1.2.20).

Table 1.2.20: Performance of improved varieties of different *kharif* crops

Crop	Variety Duration	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Maize	PMH 2 (82 days)	3080	7.45	18122	1.61
	Prakash (82 days)	2950	7.13	11586	1.55
Greengram	PAU 911 (75 days)	620	1.50	10605	1.51
	ML 818 (80 days)	610	1.47	10155	1.49
Blackgram	Mash 114 (83 days)	560	1.35	4248	1.19
	Mash 338 (90 days)	520	1.26	2532	1.12
Sesame	RT 346 (87 days)	430	1.04	25836	2.51
	Punjab Til No. 2	442	1.07	27036	2.58

c. On-farm demonstrations

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 ha in Achalpur and 320 ha 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, and 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 vulnerability 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. 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^{0}C and 21.4 to 26.2^{0}C, whereas during *rabi* season it varied from 16.0 to 38.9^{0}C and 2.3 to 20.4^{0}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 2015-16

The annual rainfall recorded during the year 2015 was 1153.5 mm, which was 5.4% excess than the normal annual rainfall of 1094.3 mm. Out of total 1153.5 mm rainfall, 751.3 mm was received during the *kharif* season (June to September) as against normal of 862 mm. In *rabi*, 24.5 mm rainfall received which was 37.4 mm deficit than normal of 61.9 mm and in summer season, it was 261.2 mm which was excess by 179.1 mm as against normal of 82.1 mm.

Normal onset of monsoon : 1 July

Onset of monsoon during 2015-16 : 29 June

Annual mean rainfall : 1094.3 mm

Annual rainfall during 2015-16 : 1153.5 mm

Mean crop seasonal rainfall during *kharif* and *rabi* : 862 mm during *kharif* and 61.9 mm during *rabi*

Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*) : 751.3 mm during *kharif* and 24.5 mm during *rabi*

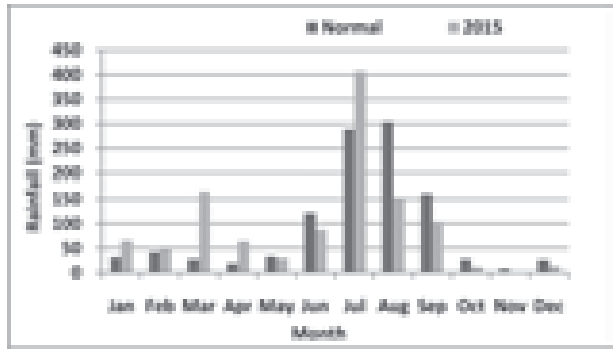


Fig. 1.2.4 Normal and actual (2015) monthly rainfall at Ballowal Saunkhri

Dry spells during crop growing season (2015-16)

Dry spell/Wet spell		Crop	Stage of the crop
Duration (days)	Dates & months		
23	24 August - 15 September	Maize	Silking/ dough
		Blackgram/greengram,	Flowering/ pod formation
		sesame	

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Maize (silking & dough)	About 15% plant population (weak plants) were removed and used as fodder.

Salient achievements of on-farm demonstrations

Preparedness

Rainwater management

At Achalpur, summer ploughing immediately after the wheat crop harvest conserved moisture and gave higher maize yield of 3350 kg/ha compared to sowing without summer ploughing. Similarly at Nainwan, summer ploughing gave higher maize yield of 3475 kg/ha with net returns of Rs.31565/ha and B:C ratio of 1.99. At Achalpur, sowing of maize across the slope gave the grain yield of 3250 kg/ha with net return of Rs.30054/ha with B:C ratio of 2.02, over sowing of maize along the slope. Similarly at Nainwan, sowing of maize across the slope gave higher grain yield of 3150 kg/ha with net returns of Rs.28303/ha with B:C ratio of 1.97. Earthing up in maize resulted in higher maize yield (3425 kg/ha) with net returns of Rs.32122/ha and B:C ratio of 2.11, compared to without earthing up at Achalpur (Table 1.2.21).

Table 1.2.21: Effect of different *in-situ* moisture conservation practices on maize

In-situ moisture conservation practice	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	With farmers practice				
Achalpur						
Summer ploughing	3350	3153	6.3	29.49	29377	1.92
Sowing across slope	3250	3050	6.6	30.4	30054	2.02
Earthing up	3425	3130	9.4	28.4	32122	2.11
Nainwan						
Summer ploughing	3475	3180	9.3	28.43	31565	1.99
Sowing across slope	3150	2925	7.7	31.4	28303	1.97
Earthing up	3525	3150	11.9	28.0	33544	2.16

Cropping systems

In an assessment of different maize cultivars (PMH2, PMH1 and Prakash) during *kharif* 2015, PMH 2 hybrid gave maximum yield of 3820 kg/ha, net returns of Rs.39411 and B:C ratio of 2.29 followed by PMH1 with yield of 3640 kg/ha and net returns of Rs. 36260/ha, over local cultivar. Similarly at Nainwan, PMH 2 gave highest grain yield of 3840 kg/ha, which was 31.5% higher over local cultivar with net returns of Rs.39762 and B:C ratio of 2.31 (Table 1.2.22)

Table 1.2.22: Performance of maize varieties/ hybrids under rainfed condition

Variety/ hybrid	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved variety/ hybrid	Farmers` variety				
Achalpur						
PMH 1	3640	2840	28.2	52.9	36260	2.20
PMH 2	3820	2840	34.5	55.5	39411	2.29
Prakash	3260	2840	14.8	47.4	29608	1.99
Nainwan						
PMH 1	3720	2920	27.4	54.1	37661	2.24
PMH 2	3840	2920	31.5	55.8	39762	2.31
Prakash	3160	2920	8.2	45.9	27857	1.93

At Achalpur, pearlmillet variety FBC 16 gave maximum fodder yield (33600 kg/ha) with net returns of Rs.20381/ha and B:C ratio of 2.53 over the local cultivars. Similarly, at Nainwan, same variety FBC 16 gave maximum fodder yield (28077 kg/ha) with net returns of Rs.15317/ha and B:C ratio of 2.20. Improved blackgram variety Mash-114 recorded higher seed yield of 840 kg/ha at Achalpur village and 920 kg/ha at village Nainwan with higher net returns and B:C ratio. Improved greengram variety PAU 911 recorded higher seed yield of 680 kg/ha at Achalpur and 785 kg/ha at Nainwan. PAU 911

variety gave net returns and B:C ratio of Rs.16879/ha and 1.79 at village Achalpur and Rs. 22,846/ha and 2.14 at village Nainwan, respectively. In sesame, Pb-Til 2 variety recorded higher seed yield (349 and 410 kg/ha) at Achalpur and Nainwan, respectively (Table 1.2.23).

Table 1.2.23: Varietal performance of *kharif* crops under rainfed condition

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved variety/ hybrid	Farmers` variety				
Achalpur							
Pearlmillet (fodder)	FBC 16	33660	25040	40.9	-	20381	2.53
Blackgram	Mash 114	840	550	52	-	16253	1.72
Greengram	PAU 911	680	498	36.5	104.8	16879	1.79
Sesame	RT 346	340	-	-	68.0	18146	2.14
	Pb Til 2	349	-	-	69.5	18968	2.19
Nainwan							
Pearlmillet (fodder)	FBC 16	28077	21040	33.4	-	15317	2.20
Blackgram	Mash 114	920	620	48	-	19684	1.87
Greengram	PAU 911	785	498	57.6	121	22846	2.14
Sesame	RT 346	380	-	-	76.0	22146	2.40
	Pb Til 1	410	-	-	82.0	25068	2.57

Nutrient management

Among different integrated nutrient management practices in maize, application of N through combination of 75% inorganic + 25% organic source gave maximum yield (3580 and 3410 kg/ha), RWUE (52 and 49.5 kg/ha-mm) and net returns (Rs.34291 and Rs.31315/ha), respectively at Achalpur and Nainwan over farmers' practice. The increase in maize yield at Achalpur and Nainwan were 22.4 and 20.7% over farmers' practice

Table 1.2.24: Effect of integrated nutrient management on yield of maize

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	Farmers` variety				
Achalpur						
100% inorganic N	3489	2925	19.3	50.7	33993	2.14
50% inorganic N + 50% organic N	3230	2925	10.4	46.9	26869	1.83
75% inorganic N + 25% organic N	3580	2925	22.4	52.0	34291	2.10

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	Farmers` variety				
Nainwan						
100% inorganic N	3280	2825	16.1	47.6	30334	2.02
50% inorganic N + 50% organic N	3040	2825	7.6	44.1	23543	1.73
75% inorganic N + 25% organic N	3410	2825	20.7	49.5	31315	2.01

The maize equivalent yield in wild and stray animals' prone areas was 1867 and 1600 kg/ha with B:C ratios of 1.76 and 1.51 compared to sole yield of maize (1220 and 1030 kg/ha) at Achalpur and Nainwan, respectively. The damage by wild and stray animals was more in maize crop compared to sesame. Hence, sesame crop has potential for its cultivation in areas adjoining to forest and prone to stray/wild animal damage.

Table 1.2.25: Performance of sesame in wild animal damage prone area

Treatment	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)		B:C ratio	
	Sesame	Maize		Sesame	Maize	Sesame	Maize
Achalpur	280 (1867*)	1220	53	12068	-4055	1.76	0.85
Nainwan	240 (1600*)	1030	55	8068	-7332	1.51	0.72

*Maize equivalent yield

At Achalpur, transplanting the seedlings of ash gourd gave the average yield of 29500 kg/ha (45% higher over farmers' practice) with the net returns of Rs.44964/ha and B:C ratio of 4.20. However at Nainwan, average yield of ash gourd was 31200 kg/ha which was 44% higher over farmers' practice with net return of Rs.48364/ha with B:C ratio of 4.45. The direct sowing of seed of ash gourd gave average yield of 27500 and 28500 kg/ha at Achalpur and Nainwan, respectively.

Table 1.2.26: Performance of ashgourd at Achalpur and Nainwan villages

Treatment	Yield (kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio
Achalpur				
Direct seeding	27500	-	40964	3.92
Seedling transplanting	29500	7.3	44964	4.20
Nainwan				
Direct seeding	28500	-	42964	4.06
Seedling transplanting	31200	9.5	48364	4.45

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 800 mm. Annual potential evapotranspiration is 1100 mm. Length of growing period is 150-210 days.

b. On-station experiments

Experienced weather conditions during 2015-16

The annual rainfall recorded during the year 2015 was 1119.3 mm, which was deficit by 28.7 mm than the normal annual rainfall of 1148 mm. Out of the total rainfall, 648.3 mm was received during the *kharif* season (June to September) as against normal of 885.8 mm. In *rabi*, 47.1 mm rainfall was received which was 0.5 mm deficit than normal of 47.6 mm. In summer season, 313.7 mm rainfall was received which was deficit by 119.6 mm as against normal of 114.1 mm (Fig. 1.2.5).

Normal onset of monsoon	:	1 July
Onset of monsoon during 2015-16	:	5 July
Annual mean rainfall	:	1148 mm
Annual rainfall during 2015-16	:	1119.3 mm
Mean crop seasonal rainfall	:	885.8 and 47.6 mm, respectively during *kharif* and *rabi*
Crop seasonal rainfall during 2015-16	:	648.3 mm during *kharif* and 47.1 mm during *rabi*

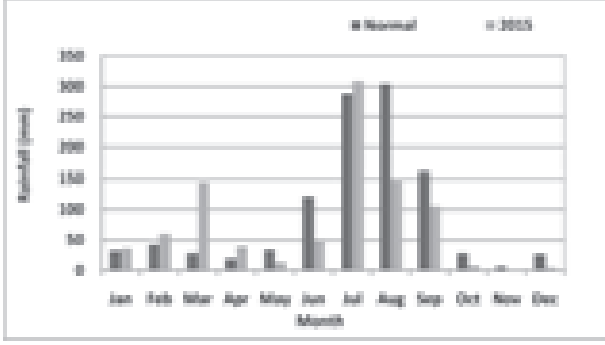


Fig. 1.2.5: Normal and actual (2015) monthly rainfall at Rakh Dhiansar

Dry spells during crop growing season (2015-16)

Dry spell/Wet spell		Crop	Stage of the crop
Duration (days)	Dates & months		
14	08 to 21 September	Maize, blackgram,	Vegetative/ reproductive
		sesame and pearlmillet	
21	24 September to 14 October	Maize, greengram,	Reproductive
		blackgram and sesame	

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Maize, greengram, blackgram and sesame	Reproductive	Protective irrigation, weeding, removal of lower leaves

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2015, the onset of monsoon was delayed by 9 days (6th July). During *kharif* season, 648.3 mm was received which was deficit by 237.5 was mm compared to normal 885.8 mm. The rainfall was deficit by 30% in June, 47.4% in August, 38.4% in September and excess by 0.2% in July compared to normal rainfall.

Among the four varieties of maize sown during *kharif* 2015, the hybrid Double Dekalb performed well under both events. Out of the four maize varieties sown during the onset of monsoon, the hybrid variety Double Dekalb produced maximum yield (2422 kg/ha) with higher net returns, B.C ratio and RWUE values of Rs.23981/ha, 2.22 and 5.63 kg/ha-mm, respectively. Likewise, among maize varieties sown one week after onset of monsoon, Double Dekalb produced maximum yield (2221 kg/ha) with higher net returns, B:C ratio and RWUE values of Rs.20975/ha, 2.13 and 5.15 kg/ha-mm, respectively (Table 1.2.27).

Table 1.2.27 : Performance of different maize varieties/hybrids as influenced by two monsoonal events

Event	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover			
Onset of monsoon	K-517	2165	4652	5.04	20445	2.10
	Double Dekalb	2422	5234	5.63	23981	2.22
	PC-55	1926	4561	4.48	16671	1.89
	Tip Top	2272	5023	5.28	21980	2.15
Mean		**2196.5**	**4868**	**5.11**	**20769**	**2.08**
1 week after onset of monsoon	K-517	2091	4625	4.85	19309	2.04
	Double Dekalb	2221	5094	5.15	20975	2.13
	PC-55	1824	4562	4.23	15163	1.81
	Tip Top	2096	4786	4.86	19019	1.99
Mean		**2058**	**4767**	**4.77**	**18572**	**1.99**

Intercropping

Intercropping of blackgram (Uttra) and greengram (SML 668) was done with maize (var. Double Dekalb) in additive series (2:1) with no extra fertilizers for intercrop. The yield to the tune of 2210 and 141 kg/ha was obtained for maize and blackgram crops, respectively. The intercropping system registered a maize equivalent yield of 2734 kg/ha with a B:C ratio of 2.22. The intercropping system of maize + greengram (2:1) registered a maize equivalent yield of 2677 kg/ha with a B:C ratio of 2.17. The rainwater use efficiency (RWUE) was 6.36 and 6.23 kg/ha-mm for two intercropping systems, respectively (Table 1.2.28).

Table 1.2.28: Performance of intercroppping systems

Intercropping system	Grain yield (kg/ha)		Stover yield (kg/ha)		MEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Maize	Intercrop	Maize	Intercrop				
Maize + blackgram (2:1)	2210	141	5214	395	2734	6.36	26584	2.22
Maize + greengram (2:1)	2164	138	5096	364	2677	6.23	25561	2.17

Seven different cropping sequences were evaluated under delayed onset of monsoon. During *kharif* season, maize under maize–wheat system recorded highest net returns of Rs.24423/ha along with B.C ratio and RWUE of 2.23 and 5.61 kg/ha-mm, respectively followed by maize under maize – mustard and pastoral-pastoral systems which produced net returns of Rs. 24157 and 20457/ha with B.C ratio of 2.22 and 2.75, respectively. However, lowest values of net returns and B:C ratio were observed in pulse based systems due to poor yield because of dry spell especially during flowering stage (Table 1.2.29).

Table 1.2.29 : Performance of *kharif* crops under different cropping sequencess

Cropping systems	Crop	Crop duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Grain	Stover			
Pulses-oilseed	Greengram	92	162	452	0.37	-5310	0.68
Pulses-pulses	Blackgram	92	182	497	0.42	-5415	0.64
Pulses-cereal	Greengram	93	164	512	0.38	-5170	0.68
Cereal-oilseeds	Maize	94	2398	5589	5.58	24157	2.22
Oilseed-oilseed	Sesame	92	189	535	0.44	7815	1.61
Pastoral-pastoral	Mixed fodder	71	32100		77.6	20457	2.75

Terminal drought

One supplemental irrigation from harvested rainwater in farm pond, of 5.08 cm depth was given to maize crop at cob formation stage on 11-09-2015 during dry spell. Maize yield was 2197 kg/ha with net returns of Rs.39805/ha and B:C ratio of 2.08 due to supplemental irrigation.

Preparedness

Energy management

Sowing of maize with maize planter resulted in maximum yield (2070 kg/ha), net returns (Rs.18116/ha) B:C ratio (2.03) and RWUE (3.17 kg/ha-mm) followed by line sowing with liner, with B:C ratio of 1.54 compared to broadcasting. Among the three treatments the maize planter gave the maximum output of 92636 MJ/ha and energy use efficiency (13.2). In case of Liner the energy output was 77810 MJ/ha and energy use efficiency of 11.1 (Table 1.2.30).

Table 1.2.30: Yield and economics of maize under different methods of sowing

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Energy (MJ/ha)		Energy use efficiency
	Grain	Stover				Input	Output	
Maize planter	2070	4960	18116	2.03	3.17	7008	92636	13.2
Broadcasting	1620	3820	9221	1.49	2.48	6650	71726	10.7
Liner	1760	4141	10629	1.54	2.69	6950	77810	11.1

C. On-farm demonstrations

Village profile

The program is being implemented 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. 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 were experienced during August, September and October 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% during *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. There was an increase in the maximum temperature during *kharif* season at the rate of 0.03^{0}C per year while during *rabi* season the mean temperature had also gone up by 0.04^{0}C per year. The day temperature in the district decreased by 0.7^{0}C from the last two decades, while the night temperature had gone up by 0.6^{0}C 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 had 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 2015-16

The annual rainfall recorded during the year 2015 was 1339.6 mm, which was 16.4% excess than the normal annual rainfall of 1151.1 mm. Out of total rainfall, 801.8 mm was received during the *kharif* season (June to September) as against normal of 896.9 mm. In *rabi*, 36.1 mm rainfall received which was 10.5 mm deficit than normal of 46.6 mm and in summer season, it was 398.4 mm which was deficit by 291.9 mm as against normal of 106.5 mm.

Normal onset of monsoon : 1 July

Onset of monsoon during 2015-16 : 29 June

Annual mean rainfall	:	1151.1 mm
Annual rainfall during 2015-16	:	1339.6 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	896.9 mm during *kharif* and 46.6 mm during *rabi*
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*)	:	801.8 mm during *kharif* and 36.1 mm during *rabi*

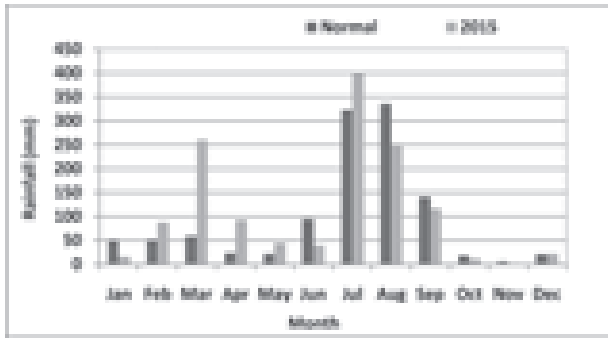


Fig. 1.2.6: Normal and actual (2015) monthly rainfall in Khaner village

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
14 days	8 to 21 September	Maize, greengram, blackgram, sesame, pearlmillet	Vegetative

Salient achievements of on-farm demonstrations

Real time contingency planning: Nil

Preparedness

Cropping systems

Among the four varieties of maize crop *viz.*, Tip-top, K-517, Double Dekalb and PSC 105, maximum mean grain yield and B:C ratio of 2164 kg/ha and 1.98 respectively was recorded by variety Double Dekalb over farmers' practice, followed by Tip-Top and K-517. The variety PSC 105 registered the minimum mean grain yield and B:C ratio of 1510 kg/ha and 1.48, respectively. Farmers' practice (FP) includes broadcasting of local maize variety with imbalanced dose of fertilizers (Table……).

Table 1.2.31: Performance of maize varieties/ hybrids under rainfed condition

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	Farmers` variety				
Tip Top	1955	1443	35	2.62	15951	1.83
K-517	1759		22	2.35	13803	1.74
Double dekalb	2164		49	2.90	19403	1.98
PC 55	1510		3	2.02	9080	1.48

Seven different cropping sequences were demonstrated at NICRA Village Khaner. During *kharif* season, maize under cereal-oilseed system recorded highest net returns of Rs.18133/ha along with B:C ratio and RWUE of 1.91 and 2.78 kg/ha-mm, respectively followed by maize under cereal-cereal and pastoral-pastoral systems which produced net returns of 17840/ha and Rs. 14087/ha with B:C ratio of 1.90 and 2.20, respectively. However, lowest values of net returns and B:C ratio were observed in pulse crop under pulse-oilseed, pulse-pulse and oilseed systems due to poor yield because of dry spell especially during flowering/grain filling stages (Table 1.2.32).

Table 1.2.32: Yield and economics of crops under various cropping systems

Crop/Cropping Sequence	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With normal practice				
Maize-cereal	Double dekalb	2044	1441	42.0	2.71	17840	1.90
Maize -oilseed	Double dekalb	2100	1456	44.0	2.78	18133	1.91
Greengram-cereal	SML 668	145 (685)*	102	42.0	0.19	-6500	0.60
Greengram-oilseed	SML 668	143 (673)*	96	48.4	0.18	-6675	0.59
Blackgram-pulse	Uttara	164 (609)*	112	46.4	0.22	-6405	0.58
Oilseed-sesame	PB Til-1	144 (1066)*	92	55.9	0.19	2890	1.22
Pastoral-pastoral (mixed fodder)	Local (maize)-M.P. Chary (sorghum)-local (pearlmillet)	26300 (1739)*	21400	22.8	41.5	14087	2.20

*MEY: Maize equivalent yield

Alternate land use

In aonla based agri-horti system, the maize yield under aonla + maize (100% NPK) system ranged from 1625 to 2058 kg/ha with mean yield of 1833 kg/ha. RWUE ranged from 2.78 to 3.52 kg/ha-mm with mean RWUE of 3.14 kg/ha-mm. The net returns ranged from Rs 9833/ha to Rs 17247 /ha with B:C ratio of 1.50 to 1.87. Farmers' practice (FP) included broadcasting of local maize variety with imbalanced dose of fertilizers. Broadcasting obviates earthing-up operation at knee high stage of maize crop.

The yield of mixed fodder on farmers' fields under aonla + mixed fodder system ranged from 21800 to 29000 kg/ha with mean yield of 24825 kg/ha. RWUE ranged from 43.61 to 49.60 kg/ha-mm with mean RWUE of 46.07 kg/ha-mm. The net returns ranged from Rs.10409/ha to Rs 17609/ha with B:C ratio of 1.91 to 2.55. Farmers' prefer sowing sole pearlmillet as fodder crop, using local seed with imbalanced fertilization (Table 1.2.33).

Table 1.2.33 : Mean yield and economics of mixed fodder sown with recommended dose of fertilization in alternate land use system (aonla + mixed fodder)

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	With normal practice				
Sole pearlmillet/ maize + sorghum + pearlmillet	21800	18500	15	46.16	10409	1.91
Sole pearlmillet/ maize + sorghum + pearlmillet	25500		27	43.61	14109	2.24
Sole pearlmillet / maize + sorghum + pearlmillet	29000		36	49.60	17609	2.55
Sole pearlmillet / maize + sorghum + pearlmillet	23000		20	44.93	11609	2.02
Mean	**24825**	**18500**	**25**	**46.07**	**13434**	**2.18**

1.3. Fingermillet Based Production System

1.3.1. Bengaluru

a. Agro-ecological setting

Bengaluru 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 is 926 mm. Length of growing period is 120-150 days.

b. On-station experiments

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was normal (1st of June). A rainfall of 1061.2 mm was received which was excess by 138.1 mm (15.0%) compared to normal (923.1 mm) (Fig.). During *kharif* season (June–September), 569.4 mm rainfall was recorded which was excess by 52.5 mm (10.2%) against normal of 516.9 mm. In *rabi* season, it was 181 mm which was deficit by 60.1 mm (24.9%) than the normal of 241.1 mm and in summer 310.8 mm rainfall was recorded and was excess by 155 mm (99.5%) than normal of 155.8 mm.

Normal onset of monsoon	:	2 June
Onset of monsoon during 2015-16	:	1 June
Annual mean rainfall	:	923.1 mm
Annual rainfall during 2015-16	:	1061.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	516.9 mm & 241.1 mm
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	569.4 mm & 181.0 mm

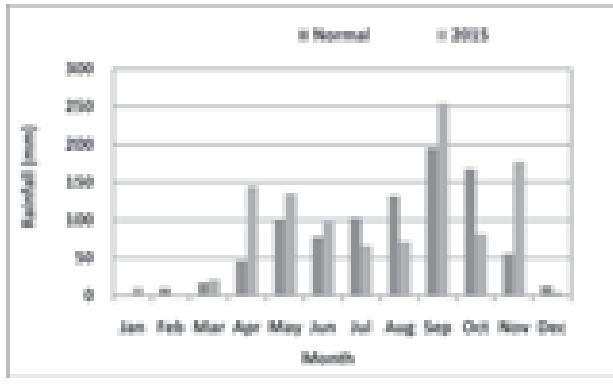


Fig. 1.3.1: Normal and actual (2015) monthly rainfall at Bengaluru

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
25	8 October to 1 November	Finger millet	Panicle initiation and flowering
		Pigeonpea	Flowering to pod filling
		Chilli	Flowering
		Field bean, cowpea	Pod filling
		Grain Amaranth	Flowering
		Fodder maize	Grand growth
		Castor	Capsule formation
		Minor millets	Panicle initiation
	4 December onwards	Chilli	Harvesting
		Pigeonpea	Pod filling to maturity
		Fingermillet, castor	Harvesting
		Horse gram	Maturity
		Minor millets	Harvesting

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCPimplemented
Terminal drought	Field bean, cowpea and pigeonpea	At maturity	Harvesting crop for vegetables
	Finger millet, maize and minor millet	At maturity	Harvesting crop for fodder

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

A dry spell of 25 days occurred during 8 October to 1 November coinciding with maturity of fingermillet. Application of 2% KCl (MOP) during drought when the plants started showing wilting symptom and thiourea @ 250 g/ha after retrieving drought was demonstrated in fingermillet. Among different foliar sprays, 2% KCl during drought recorded higher grain yield (3300 kg/ha), B:C ratio (3.17) and RWUE (5.24 kg/ha-mm) with 11.4% increase in yield and net returns of Rs.53318/ha as compared to foliar spray with thiourea and control (Table 1.3.1).

Table 1.3.1: Response of fingermillet to different foliar sprays

Treatment	Grain Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Thiourea	3140	4910	5.0	4.94	47263	2.85
2% KCl	3330	5810	11.4	5.24	53318	3.19
Without foliar spray	2990	4650	-	4.70	44063	2.75

Preparedness

Crops/ cropping systems

Among weed management treatments in groundnut, pre-emergence spray of alachlor + 1 hand weeding recorded higher pod yield (1802 kg/ha), RWUE (2.68 kg/ha-mm), net returns (Rs. 66469/ha) and B:C ratio (3.04) compared to manual weeding and control (Table 1.3.2).

Table 1.3.2: Yield of groundnut as influenced by weed management treatments

Treatment	Pod yield (kg/ha)	Net returns (Rs/ha)	B:C Ratio	RWUE (kg/ha-mm)
Pre-emergent spray of alachlor coupled with one hand weeding	1802	66469	3.04	2.68
Two hand weedings	1772	64254	2.94	2.64
Control	1534	54964	2.87	2.28

Fingermillet varieties including long (MR-1) (120-130 days), medium (GPU-28) (110-120 days) and short duration (GPU-48) (105-110 days) were sown at fortnightly interval during July and August. Long duration fingermillet variety MR-1 recorded higher grain yield (4060 and 4140 kg/ha) in August 1st and 2nd fortnight sowing, respectively compared to other medium and short duration varieties (Table 1.3.3).

Table 1.3.3: Performance of fingermillet varieties under different sowing dates

Sowing time	Variety	Duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Grain	Straw			
July first fortnight	GPU-48	105-110	3810	5950	5.51	63077	3.50
	GPU-28	110-120	3780	6300	5.47	62679	3.49
	MR-1	120-130	3220	5500	4.66	49759	2.97
July second fortnight	GPU-48	105-110	3390	5550	5.39	53537	3.12
	GPU-28	110-120	2890	4550	4.59	41787	2.66
	MR-1	120-130	2610	4500	4.15	35589	2.41
August first fortnight	GPU-48	105-110	3110	5300	5.60	47189	2.87
	GPU-28	110-120	2550	4700	4.59	34419	2.37
	MR-1	120-130	4060	6800	7.30	69214	3.75
August second fortnight	GPU-48	105-110	3660	5750	7.04	59627	3.37
	GPU-28	110-120	2290	3600	4.40	27874	2.11
	MR-1	120-130	4140	6250	8.04	71442	3.83

Among different methods of fingermillet establishment, higher grain yield (3241 kg/ha) was recorded with transplanting compared to direct sowing (3035 kg/ha). No significant difference in grain yield was observed with the planting geometry, but higher grain yield was recorded with recommended spacing of 30 cm × 10 cm (3250 kg/ha). Among the nutrient sources, significantly higher grain yield (3224 kg/ha) was recorded with application of recommended dose of FYM 7.5 t/ha + RDF (50:40:37.5 kg/ha) compared to application of FYM on N equivalent basis + FYM 7.5 t/ha (3052 kg/ha) (Table 1.3.4).

Table 1.3.4: Fingermillet yield as influenced by method of establishment, planting geometry and nutrient source

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)
Method of establishment (M)		
M1: Direct sowing	3035	4967
M2: Transplanting	3241	5193
CD @ 5%	133.35	191
Planting geometry (S)		
S1: Recommended spacing 30 cm × 10 cm	3250	5144
S2: 30 cm × 30 cm	3111	5063
S3: 45 cm × 30 cm	3051	5037
CD @ 5%	NS	NS
Nutrient source (N)		
N1: Recommended dose of FYM 7.5 t/ha + RDF (50:40:37.5 kg/ha)	3224	5181
N2: FYM on N equivalent basis + FYM 7.5 t/ha	3052	4981
CD @ 5%	133.35	191

Among different method of fingermillet establishment, drill sowing of fingermillet (MR-1) recorded higher grain yield (4400 kg/ha), Net returns (Rs.76431/ha) and B:C ratio (4.03) as compared to other methods of sowing (Table 1.3.5).

Table 1.3.5: Effect of method of fingermillet establishment on crop yield and economics

Treatment	DOS (Duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw				
Transplanting (GPU-28)	26 Jul (122)	3880	5500	49	4.94	63485	3.44
Dry sowing (MR-1)	13 Jul (136)	3650	5950	40	5.24	59362	3.34
DAP + seed drill sown (MR-1)	21 Jul (128)	4400	6450	69	4.55	76431	4.03
Normal method of sowing	21 Jul (128)	2610	4440	-	4.70	35544	2.41

Improved varieties of field bean, cowpea, horse gram, and rice bean were demonstrated as contingent crops for delayed sowing (5th September). Among pulses, field bean (HA-4) recorded higher field bean equivalent yield (1736 kg/ha), net return (Rs. 70990 ha^{-1}) and B:C ratio (3.90) compared to other pulses (Table 1.3.6).

Table 1.3.6: Performances of different pluses under late sowing

Crop/ variety	Duration (days)	Grain yield (kg/ha)	FBEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rice bean	100	720	393	0.76	3709	1.21
Field bean (HA-4)	113	1736	1736	3.36	70990	3.90
Cowpea (IT-38956-1)	100	813	739	1.43	17532	1.76
Cowpea (AV-6)	100	1274	1158	2.24	40616	2.76

FBEY=Field bean equivalent yield

Among millets sown on 5th September, kodo millet recorded higher yield (1173 kg/ha), net returns (Rs 15025/ha) and B:C ratio (1.75) compared to other small millets (Table 1.3.7).

Tabl 1.3.7: Performance of different minor millets under late sown conditions

Crop/variety	Duration (days)	Grain Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw			
Kodo millet (PSC-1)	110	1173	3093	2.27	15025	1.75
Foxtail millet (RS-118)	96	933	2724	1.81	7822	1.39
Little millet (OLM-203)	110	923	2539	1.79	7545	1.37
Proso millet (GPUP-21)	105	914	2724	1.77	7268	1.36

Grain amaranth is a photo insensitive crop grown throughout the year and one of the nutricereals in real time contingent crop planning. Both the varieties of grain amaranth performed better with higher yield even during delayed sowing in September (Table 1.3.8).

Table 1.3.8: Performance of different varieties of grain amaranth

Variety	Duration (days)	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Suvarna (White)	90	520	1.01	6574	1.27
KBGA-1 (Red)	90	609	1.19	11948	1.49

Among pulse based intercropping systems, pigeonpea (BRG-1) + cowpea (1:1) recorded higher pigeonpea equivalent yield (753 kg/ha), RWUE (1.10 kg/ha-mm), net returns (Rs. 45332/ha) and B:C ratio (2.51) (Table 1.3.9).

Table 1.3.9: Evaluation of intercropping systems

Cropping system	Yield (kg/ha)		PEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop					
Pigeonpea (BRG-1) + soybean (1:1)	536	141	599	44.19	0.88	30108	2.01
Pigeonpea (BRG 1) + cowpea (1:1)	416	676	753	81.33	1.10	45332	2.51
Pigeonpea (BRG 1) + field bean (1:1)	452	60.9	486	16.96	0.71	18332	1.61
Sole pigeonpea (BRG-1)	416	0	416	0.00	0.61	13977	1.51

PEY-Pigeonpea equivalent yield

In an assessment of fingermillet based cropping systems, fingermillet (MR-1) + direct sown pigeonpea (BRG-2) in 8:2 ratio with conservation furrow between paired rows of pigeonpea recorded higher fingermillet equivalent yield (4023 kg/ha), net returns (Rs. 61109/ha) and B:C ratio (3.23) as compared to farmers' practice (Table 1.3.10).

Table 1.3.10: Performance of fingermillet based intercropping systems

Cropping system	Yield (kg/ha)		FEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop					
Fingermillet + pigeonpea (DS)*	3600	93	4023	108	7.34	61109	3.23
Fingermillet + pigeonpea (TP)*	2200	222	3209	66	5.05	42494	2.51
Fingermillet + *Akkadi*	1930	-	1930	-	3.55	14354	1.51

*DS: Direct sown pigeonpea, TS: Transplanted pigeonpea, FEY= Fingermillet equivalent yield

Bi-modal distribution of rainfall in the southern part of the state encourages double cropping. Legumes used as green manures or in crop rotation help for maintenance of soil health and fertility. Vegetable cowpea followed by fingermillet recorded higher fingermillet equivalent yield (6948 kg/ha), net returns (Rs.109098/ha) and B:C ratio (3.28) compared to other double cropping systems demonstrated (Table 1.3.11).

Table 1.3.11: Double cropping for bimodal rainfall distribution

Treatment	Date of sowing	Duration	FEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cowpea (IT) - fingermillet	1st crop-18 May; 2nd crop-24 Aug	75 110	5475	6.70	78573	2.64
Vegetable cowpea (PKB-4) - fingermillet	1st crop-18 May; 2nd crop-14 Aug	67 115	6948	8.51	109098	3.28

Nutrient management

Among different nutrient management treatments, FYM (10 t/ha) + Rec. 100% N, P_2O_5 and K_2O + Zn + B + lime recorded higher fingermillet yield (3890 kg/ha net returns (Rs. 62814/ha), B:C ratio (3.21) and increase in yield over farmers' practice (50: 40: 25 kg NPK/ha) was 47% (Table 1.3.12).

Table 1.3.12: Integrated nutrient management for sustainable productivity of fingermillet

Treatment	Grain Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
FYM (10 t/ha) + Rec. 100 %N, P_2O_5 & K_2O + Zn + B + lime	3890	47	6.91	62814	3.21
Horse gram- finger millet (50% RDN+100 % P& K)	3500	33	4.29	44455	2.24
Glyricidia-finger millet (50% RDN + 100 % P& K)	3400	29	5.94	48180	2.61
FYM (10 t/ha) + Rec. 100 %N, P_2O_5 & K_2O	2640	-	4.68	35519	2.41

Recommended NPK (50: 40: 25 kg NPK/ha)

Alternate land use

In amla based agri-horti system involving cereals and pulses, leguminous intercrops *viz.*, field bean, cowpea and horsegram enhanced the growth parameters as compared to finger millet, grain amaranth and fodder maize (Table 1.3.13).

Table 1.3.13: Growth parameters of amla as influenced by intercrops

Treatment	Plant height (cm)	No. of branches	Collar diameter (cm)	Canopy spread (cm)	Biomass (kg/tree)
Amla + fingermillet	356.5	2.8	32.3	302.0	263.8
Amla + cowpea	380.8	3.1	42.0	313.3	365.2
Amla + horsegram	376.4	3.0	40.2	305.7	347.9
Amla + fieldbean	387.5	3.1	42.1	338.0	366.2
Amla + fodder maize	355.4	3.0	38.2	281.7	323.1
Amla + grain amaranth	320.0	3.0	35.1	290.3	291.0
Amla	379.7	3.1	40.8	308.3	353.3
CD at 5%	NS	NS	6.2	NS	66.0

Fingermillet was on par with cowpea and proved to be better intercrop in amla and registered significantly higher amla equivalent yield (1736 kg/ha) and net returns (Rs.43110/ha). Sole amla recorded higher B:C ratio (3.68) while intercropping of cowpea recorded higher RWUE (4.03 kg/ha- mm) (Table 1.3.14).

Table 1.3.14: Performance of intercrops in amla based system

Treatment	Amla yield (kg/ha)	Intercrop yield (kg/ha)	AEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Amla + fingermillet	776	1746	1736	43110	2.64	3.13
Amla + cowpea	1012	473	1604	39917	2.65	4.03
Amla + horsegram	816	247	1032	28876	3.33	1.86
Amla + field bean	1045	334	1504	34548	2.35	3.78
Amla + fodder maize	577	18057	1254	28499	2.31	3.25
Amla + grain amaranth	711	267	1112	18736	1.73	2.00
Fingermillet		2167	1192	22461	1.89	2.15
Cowpea		935	1169	23673	2.03	2.94
Horsegram		424	371	3542	1.31	0.67
Fieldbean		587	807	7785	1.32	2.03
Fodder maize		23070	577	2521	1.12	1.49
Grain amaranth		412	619	128	1.01	0.58
Amla	999		999	29094	3.68	0.94
CD at 5%	185.55		168.73			

AEY: Amla equivalent yield

In custard apple based Agri-horti system involving cereals and pulses, significantly higher custard apple equivalent yield (2050 kg/ha) was recorded with fodder maize compared to other intercrops in custard apple based agri-horti system. Fodder maize also recorded higher net returns, B:C ratio and RWUE (Table 1.3.15).

Table 1.3.15: Performance of intercrops in custard apple based system

Treatment	Custard apple yield (kg/ha)	Intercrop yield (kg/ha)	CEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
Custard apple + fingermillet	1130	2276	1965	89945	4.22	3.31
Custard apple + fodder maize	1092	38323	2050	102446	5.99	5.75
Custard apple + field bean	1350	547	1851	86592	4.54	4.48
Custard apple + niger	989	202	1192	53603	3.99	2.51
Custard apple + green chilli	1116	3346	1952	88089	4.03	3.60
Custard apple + cowpea	1167	643	1703	79113	4.43	4.12
Custard apple + foxtail millet	1006	497	1255	55120	3.73	2.29
Custard apple	1141		1141	49652	3.64	1.14
Fingermillet		2500	917	29794	2.18	1.54
Fodder maize		41509	692	20960	2.02	1.94
Field bean		727	666	15473	1.63	1.61
Niger		345	345	2818	1.16	0.73
Green chilli		4767	1192	42477	2.46	2.20
Cowpea		865	721	20150	1.87	1.74
Foxtail millet		868	434	5885	1.29	0.79
CD at 5%	172		199.8			

CEY: Custard apple equivalent yield

On-farm demonstrations

Village profile

The program is being implemented in Chikkamaranahalli cluster villages (Mudalapalya, Hosapalya, Chikkamaranahalli, Chikkamaranahalli colony and Chikkaputtayanapalya), Nelamangala taluk, 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) has shifted to June 2nd week, followed by erratic rainfall and north-east monsoon is 40th SMW. For the past 15 years, the dry spells during crop season were experienced in June, July, August,

September and October and at vegetative and reproductive stages of the major rainfed crops. The soil moisture status is deficit during vegetative and reproductive stages of major rainfed crops. The extreme events like unusual and high intensity rainfall/ hail storm in short span are occurring during *kharif* and *rabi* seasons.

Experienced weather conditions during 2015-16

During the year 2015, in Chikkamaranahalli villages, onset of monsoon was normal. A rainfall of 1094.4 mm was received which was excess by 357 mm compared to normal (737.4 mm). Out of total rainfall, *kharif* season received 448.1 mm, which was excess by 38.4 mm (9.4%) compared to normal of 409.7 mm. *Rabi* season received 271.3 mm which was excess by 29.1 mm (29.1%) than normal of 242.2 mm and in summer, it was 375 mm against normal of 81.9 mm (excess by 357.9%).

Normal onset of monsoon	:	2 June
Onset of monsoon during 2015-16	:	1 June
Annual mean rainfall	:	737.4 mm
Annual mean rainfall during 2015-16	:	1094.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	409.7 mm & 89.1 mm
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	448.1 mm & 271.3 mm

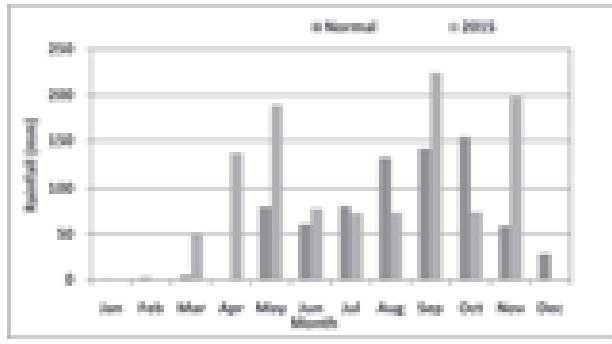


Fig. 1.3.2: Normal and actual (2015) monthly rainfall at Chikkamaranahalli

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
20	13 October to 1 November	Fingermillet	Panicle initiation
		Pigeonpea	Flowering
		Horsegram	Grand growth
	1 December Onwards	Fingermillet	Harvesting
		Pigeonpea	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented	No. of farmers	Area (ha)
Early season drought	Groundnut, pigeonpea	Groundnut + pigeonpea (8:2) with conservation furrow	40	10.9
	Finger millet, pigeonpea	Fingermillet + pigeonpea (8:2) with conservation furrow	3	0.6

Salient achievements of on-farm demonstration

Real time contingency planning

Intercropping of fingermillet (MR-1) + pigeonpea (BRG-2) in 8:2 with conservation furrow between paired rows of pigeonpea recorded higher fingermillet grain equivalent yield, net returns and B:C ratio (3807 kg/ha, Rs. 55875/ha and 3.00, respectively) compared to farmers' practice of fingermillet + *Akkadi* cropping with an yield increase of 62% (Table 1.3.16).

Table 1.3.16: *In-situ* moisture conservation in fingermillet + pigeonpea (8:2) intercropping system

Crop	Date of sowing	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation practice	With normal practice (*Akkadi*)				
Fingermillet + pigeonpea (8:2)	24 July	3807	2356	62	6.69	55875	3.00

Preparedness

Rainwater management

Farm ponds have been excavated in NICRA villages and the harvested water was used by the farmers for cultivation of vegetable crops (earned income up to Rs.9000) and no watering of horticulture plants grown around the pond . During 2015, runoff causing rainfall was 911.5 mm which contributed average runoff of 78.03 mm in 33 runoff events (Table 1.3.17) in the farm pond at NICRA village.

Table 1.3.17: Performance of vegetable crops grown around the farm pond

Name of the farmer	Vegetable	Yield (kg)	Income (Rs.)
Mr. Krishnappa, Chikkaputtayanapalya	Tomato	600	9000
	Leafy vegetables	50	3000
Mr. Ravikumar & Mudalapalya	Nourishing papaya plants grown around the farm pond		

After implementing groundwater recharge treatment, the average discharge rate of bore well with filter bed was 11.4 l/min throughout the year and in the rainy season discharge rate was 12.8 l/min and 9.4 l/min in summer season. The discharge rate was increased during the commencement of rainy season and declined towards the end of rainy season (Table 1.3.18).

Table 1.3.18: Discharge rate of bore well (with filter bed) after recharging

Months	Discharge (l/min)	Discharge (l/min)
January	9.6	Summer season
February	8.9	9.4
March	8.8	
April	9.4	
May	10.5	
June	11.2	Rainy season
July	12.6	12.8
August	13.6	
September	13.5	
October	13.4	
November	13.5	
December	12.0	

Cropping systems

Short duration variety (GPU-48) of fingermillet recorded higher grain yield, net returns and B:C ratio (2900 kg/ha, Rs. 41782 and 2.66, respectively) compared to other medium and long duration verieties. Though the onset of monsoon was normal, there was drought during panicle initiation stage for long duration variety. Good rainfall during November month facilitated higher yield of short duration variety GPU-48 (Table 1.3.19).

Table 1.3.19: Performance of different fingermillet varieties

Variety	Date of sowing	Duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Grain	Straw			
MR-1	24 July	134	2500	4370	4.39	33072	2.31
GPU-28	23 August	111	2600	4150	5.11	35107	2.39
GPU-48	13 September	100	2900	4250	8.12	41782	2.66

Transplanted fingermillet (MR-1) recorded higher grain yield (2667 kg/ha), Net returns **(**Rs**.** 35492/ha) and B:C ratio (2.37) as compared to direct sown fingermillet (2500 kg/ha, Rs**.** 33072/ha and 2.31, respectively) (Table 1.3.20).

Table 1.3.20: Performance of fingermillet under different establishment methods

Treatment	DOS/ DOT	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw			
Transplanting	23rd Aug	2667	4100	5.24	35742	2.37
Direct sown	24th Jul	2500	4370	4.39	33072	2.31

Among different pulse based intercropping systems, pigeonpea (BRG-1) + field bean (HA-4) recorded higher pigeonpea seed equivalent yield (1030 kg/ha), RWUE (1.48 kg/ha-mm), net returns (Rs. 72773/ha) and B:C ratio (3.40) compared to farmers' practice of pigeonpea (sole crop) (795 kg/ha) (Table 1.3.21).

Table 1.3.21 : Performance of different intercropping systems

Intercropping system	Duration days	PEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Pigeonpea + cowpea (1:1)	181	993	25	1.52	69309	3.31
Pigeonpea + field bean (1:1)	192	1030	30	1.48	72773	3.40
Sole pigeonpea	192	795	-	1.14	51926	2.88

PEY= Pigeonpea equivalent yield

In an assessment of fingermillet based cropping systems, fingermillet (MR-1) + pigeonpea (BRG-2) in 8:2 row proportion, recorded higher fingermillet equivalent yield, net returns and B:C ratio (3642 kg/ha, Rs 55617/ha and 3.03, respectively) as compared to farmers' practice (2356 kg/ha, Rs. 27128 and 1.97, respectively) (Table 1.3.22).

Table 1.3.22: Yield and economics as influenced by intercropping systems

Cropping system	FEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Fingermillet + pigeonpea (8:2)	3642	55	5.81	55617	3.03
Fingermillet + Akkadi	2356	-	3.76	27128	1.97

Nutrient management

Fingermillet (MR-1) + pigeonpea (BRG-2) (8:2), intercropping system with 100% recommended dose of fertilizer + 12.5 kg/ha of $ZnSO_4$ recorded maximum grain equivalent yield (3790 kg/ha), net returns (Rs. 59089/ha) and B:C ratio (3.12) compared to application of only 100% recommended dose of fertilizer (3642 kg/ha). Similarly, groundnut (ICGV-9111-4) + pigeonpea (BRG-1) (8:2), intercropping system with 100% recommended dose of fertilizer + 12.5 kg/ha of $ZnSO_4$ recorded higher (14%) groundnut pod equivalent yield (2121 kg/ha), net returns (Rs. 79191/ha) and B:C ratio (3.11) compared to application of only 100% recommended dose of fertilizer (1855 kg/ha).

Energy management

Sowing fingermillet with modified bullock drawn seed drill recorded higher grain yield (2500 kg/ha), net returns (Rs. 33072/ha) and B:C ratio (2.31) compared to Farmer's practice (2356 kg/ha). Modified seed drill facilitated optimum plant population, easy inter-cultivation, less weed menace and increased yield.

Alternate land use

Under alternate land use system in farmers' field, intercropping fingermillet and horsegram in mango orchard for efficient land use was demonstrated in one farmer's field covering an area of 0.2 ha. Mango + fingermillet recorded higher mango equivalent yield 1870 kg/ha, with net returns of Rs. 28594 ha and B:C ratio of 2.04, compared with intercropping of horsegram in mango. Since the mango trees are five years' old, no economic yield was recorded (Table 1.3.23).

Table 1.3.23: Performance of intercrops in mango orchard

Crop	Grain /seed yield (kg/ha)	Mango equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Mango + fingermillet	2550	1870	3.29	28594	2.04
Mango + horsegram	600	700	1.96	6711	1.47

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

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was early by 7 days (25 June). A rainfall of 519 mm was received which was deficit by 143.5 mm compared to normal (662.5 mm). During south-west monsoon (*kharif*), 233.2 mm rainfall was received which was deficit by 354 mm (60%) as against normal of 587.1 mm. During north-east monsoon (October-December), 45.6 mm rainfall was received which was excess by 17.1 mm compared to normal (28.5 mm). During summer (January-March), 192.4 mm of rainfall was received which was excess by 169.1 mm compared to normal (23.4 mm) (Fig. 1.4.1). The crop experienced dry spell of 25 days from 13th July to 6th August at vegetative stage of crops and second dry spell of 14 days was experienced from 29th August to 11th September and another dry spell of 40 days during 19th September to 27th October adversely affecting the crop yields.

Normal onset of monsoon	:	2 July
Onset of monsoon during 2015-16	:	25 June
Annual mean rainfall	:	662.5 mm
Annual rainfall during 2015-16	:	519 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	587.1 and 28.5 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*)	:	233.2 and 45.6 mm, respectively

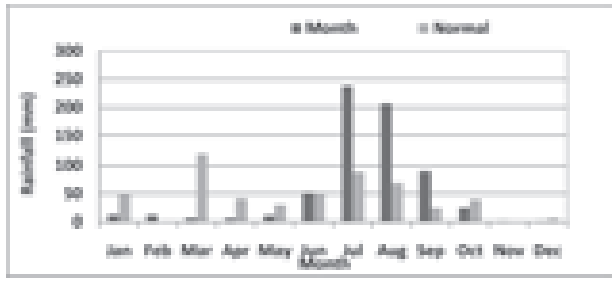


Fig. 1.4.1: Normal and actual (2015) monthly rainfall at Agra

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
25	13 July to 6 August	Pearlmillet, sesame, clusterbean, greengram, blackgram	Vegetative
14	29 August to 11 September	Pearlmillet, sesame, clusterbean, greengram, blackgram	Grand growth stage, grain filling/seed formation
40	19 September to 27 October	Pearlmillet, sesame, clusterbean, greengram, blackgram	Seed formation/maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Pearlmillet	Jointing/ear emergence	Foliar spray
	Sesame	Capsule formation	Intercultural operation by dryland weeder every week
	Clusterbean, greengram, blackgram	Pod formation	Intercultural operation by dryland weeder every week
Terminal drought	Pearlmillet	Ear emergence to maturity	No runoff water was there in the pond, hence protective life saving irrigation was not given; crop failed
	Sesame	Capsule formation to maturity	Intercultural operation by dryland weeder every week; crop failed
	Clusterbean	Pod formation to maturity	Intercultural operation by dryland weeder every week; crop failed
	Greengram, blackgram	Maturity	Intercultural operation by dryland weeder every week; crop failed

Salient achievements of on-station experiments

Real time contingency planning

Situation: Midseason drought

During 2015, there were three dry spells during crop season which affected the crop growth. A dry spell of 14 days occurred during 29 August to 11 September coinciding with the vegetative stages of rainfed crops (pearlmillet, sesame, clusterbean, greengram, blackgram). To protect the crops from midseason drought, foliar sprays of different chemicals were done. Among various foliar sprays, maximum stover yield of pearlmillet (4615 kg/ha) was recorded with foliar spray of 2% urea + 2% KNO_3 followed by foliar sprays of 2% KNO_3 and 2% KCl with 4430 and 4225 kg/ha, respectively. Higher B:C ratio (0.44) was recorded with foliar spray of 2% urea + 2% KNO_3 compared to other treatments (Table 1.4.1). However, no grain yield was recorded in all the treatments.

Table 1.4.1: Response of pearlmillet to foliar sprays during midseason drought

Treatment	Stover yield (kg/ha)	% increase in yield	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1: Control (60:40 NP kg/ha)	2440	-	11240	-7580	0.33
T_2: RDF (60:40:40 NPK kg/ha)	4060	39.9	13960	-7870	0.44
T_3: T_1 + foliar spray of 1% water soluble fertilizer (19:19:19 NPK)	4210	42.0	14780	-8465	0.43
T_4: T_1+ foliar spray of 2% KNO_3	4430	44.9	15740	-9095	0.42

Treatment	Stover yield (kg/ha)	% increase in yield	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_5: T_1+ foliar spray of 2% KCl	4225	42.3	14708	-8370	0.43
T_6: T_1+ foliar spray of 2% urea + 2% KNO_3	4615	47.1	15900	-8977	0.44

Preparedness

Nutrient management

Among different nutrient management treatments in pearlmillet, the higher mean grain yield of pearlmillet (3116 kg/ha) was recorded with application of 50% N through fertilizer + 50% N through FYM compared to other nutrient management treatments. (Table 1.4.2). Similarly, the maximum stover yield (4167 kg/ha) and B:C ratio of 0.43 were recorded with the same treatment against all other treatments.

Table 1.4.2: Nutrient management in pearlmillet

Treatment	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio
	Grain* (2015)	Mean (6 yrs)	Stover (2015)		
Control	-	1350	1628	10998	0.22
RDF (60 kg N+40 kg P_2O_5/ha)	-	2392	4025	7923	0.43
50% N through fertilizer + 50% N through farm residue	-	2893	4076	8286	0.42
50% N through fertilizer + 50% N through FYM	-	3116	4167	8250	0.43
Farmer's method (10-15 kg N/ha)	-	1681	1975	8463	0.26

* Crop failed

Energy management

The mean higher grain yield of pearlmillet (2638 kg/ha) was recorded with tillage operations through MB Plough compared to other implements. Similarly, higher energy use efficiency (10.9 MJ/ha) and B:C ratio (0.38) were recorded with the same implements. However, the crop failed during 2015 due to prolonged dry spells (Table 1.4.3).

Table 1.4.3: Effect of tillage implements on pearlmillet yield and economics

Treatment	Yield (kg/ha)			Field capacity (ha/hr)	Energy		Energy use Efficiency (MJ/ha)	Net returns (Rs/ha)	BC ratio
	Grain* (2015)	Mean (3 yrs)	Stover (2015)		Input (MJ/ha)	Output (MJ/ha)			
Cultivator	-	2085	2355	1.0	6201.46	45990	7.4	10302	0.25
Harrow	-	2210	2575	0.5	6314.08	49950	7.9	10077	0.27
Disc plough	-	2503	3758	0.25	6820.87	71244	10.4	9563	0.37
MB plough	-	2638	3916	0.25	6820.87	74088	10.9	9326	0.38

* Crop failed

Maximum mean grain yield of pearlmillet was recorded under sowing with ridger seeder (2680 kg/ha) followed by raised bed planter, seed drill and broadcasting with 2656, 2303 and 1797 kg/ha grain yield, respectively. The lower mean grain yield of pearlmillet (1797 kg/ha) was recorded with broadcast sowing. The increase in yield was 49% when sowing was done by ridger seeder over broadcasting. However, the net returns were negative in all the treatments due to crop failure (broadcasting) (Table 1.4.4).

Table 1.4.4: Response of pearlmillet to different sowing methods

Treatment	Yield (kg/ha)			Field capacity (ha/hr)	Energy		Energy use Efficiency	Net returns (Rs/ha)	BC ratio
	Grain* (2015)	Mean (3 yrs)	Stover (2015)		Input (MJ/ha)	Output (MJ/ha)			
Broadcasting	-	1797	2441	0.13	6356.32	47538	7.47	10657	0.25
Seed drill	-	2303	2511	0.75	6412.63	48798	7.60	10652	0.26
Raised bed planter	-	2656	3760	0.40	6694.18	71280	10.60	9078	0.38
Ridge seeder	-	2680	3891	0.40	6694.18	73638	11.00	8882	0.39

* Crop failed

Deep off-season tillage before pre-monsoon showers ensured better moisture conservation and lesser weed intensity. Deep tillage with MB plough in pearlmillet gave higher fodder yield of 3916 kg/ha, net returns of Rs. -9326/ha and B:C ratio of 0.38 over tillage with cultivator. The increase in fodder yield with deep tillage by MB plough was 66% compared to cultivator (Table 1.4.5).

Table 1.4.5: Effect of deep tillage on pearlmillet under terminal drought condition

Implement	Fodder yield (kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio
MB plough	3916	39	-9326	0.38
Cultivator	2355	-	-10302	0.25

c. On-farm demonstrations

Village profile

The programme is being implemented in village Nagla Dulhe Khan of Faziyatpura Block, Tehsil Kheragarh in District Agra. 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"to77°42'30" East longitude, its distance from Agra city is about 65 km. 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 in *kharif* are pearlmillet, pigeonpea, greengram, blackgram and sesame and in *rabi* are mustard, barley, chickpea, lentil and linseed. The numbers of small, medium and large farmers are 326, 256 and 37, respectively. The ground water table is 40 m, which is saline in nature. The source of irrigation is bore wells 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 (27th SMW). The temperature reaches 48^{0}C in June and as low as up to 1.0^{0}C or below during January. Heat wave during summer and cold wave during winter are 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, 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, 2006 in 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 15th July 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 was registered in three years i.e. 1979 (11th August), 2001 (26th August) and 2006 (16th August).

Experienced weather conditions during 2015-16

During 2015, in Nagla Dulhe Khan village, onset of monsoon was normal (1st July). A rainfall of 550.4 mm was received which was deficit by 112.1 mm compared to normal (662.5 mm) (Fig.). During south-west monsoon (*kharif*), 348.8 mm rainfall was received which was deficit by 238.3 mm as against 587.1 mm; during *rabi* (October-December), there was no rainfall as against normal of 28.5 mm. During summer (March-May), there was 143.3 mm of rainfall which was excess by 119.9 mm compared to normal (23.4 mm).

Normal onset of monsoon	:	2 July
Onset of monsoon during 2015-16	:	1 July
Annual mean rainfall	:	662.5 mm
Annual rainfall during 2015-16	:	550.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	587.1 and 28.5 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*)	:	348.8 mm during *kharif* and in *rabi* there was no rain

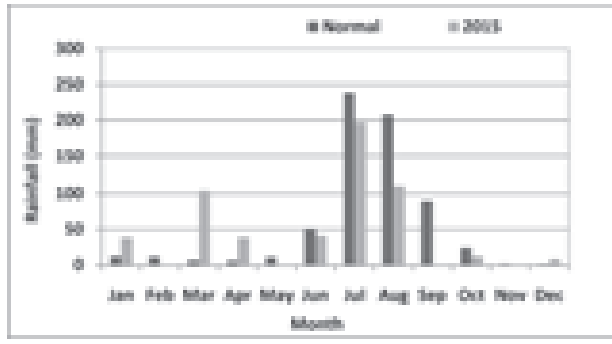


Fig. 1.4.2: Normal and actual (2015) monthly rainfall in Nagla Dulhe Khan Village

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
17	21 July to 6 August	Pearlmillet, sesame, clusterbean	Early growth stage to vegetative
60	29 August to maturity (till harvest)	Pearlmillet, sesame, clusterbean	Flowering to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought	Pearlmillet, sesame, clusterbean	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

Among two varieties of clusterbean, the highest mean seed yield of 380 kg/ha was recorded with RGC-1017 as compared to mean seed yield recorded BY HG-220 (320 kg/ha). The net returns of Rs. -141/ha and B:C ratio of 0.98 was obtained with RGC-1017 as compared to net returns of Rs.-2241/ha and B:C ratio 0.83 recorded with HG-220, respectively. Higher RWUE of 1.33 kg/ha-mm was recorded with RGC-1017 variety of clusterbean. The negative net returns and B:C ratio registered in net returns and BC ratio with both varieties due to cost of cultivation was higher and low sale price in market (Table 1.4.6).

Table 1.4.6: Performance of clusterbean varieties under terminal drought

Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
HG-220	320	1.12	-2241	0.83
RGC-1017	380	1.33	-141	0.98

Note: Farmers gave supplemental irrigation during terminal drought.

Preparedness

Rainwater management

Demonstrations were conducted on pearlmillet sowing on shoulder of ridges by ridger seeder. Maximum grain yield of pearlmillet was recorded under sowing with ridger seeder (1320 kg/ha) as compared to sowing without ridger seeder (1008 kg/ha). Higher net returns (Rs.7343/ha), B:C ratio of 1.45 and RWUE of 4.83 kg/ha-mm were also recorded with sowing by ridger seeder over farmers' practice (Table 1.4.7).

Table 1.4.7: Response of pearlmillet (Proagro-9450) to *in-situ* moisture conservation practice

Treatment	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Ridger seeder	1320	30.9	4.83	7343	1.45
Without ridger seeder(Farmers' practice)	1008	-	3.69	2019	1.12

Note: Farmers gave supplemental irrigation during dry spells.

In-situ moisture conservation through compartmental bunding was demonstrated on farmers' fields. Compartmental bunding facilitated more time for entry of rainwater into soil and higher amount of water available for field crops. On an average, compartmental bunding gave 12% higher yield over farmers' practice (958 kg/ha). The higher net return (Rs.3020/ha) and B:C ratio of 1.18 were also recorded with compartmental bunding compared to farmers' practice (Table 1.4.8).

Table 1.4.8: Performance of pearlmillet under compartmental bunding

Treatment	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Compartmental bunding	1075	12.2	3.93	3020	1.18
Farmers' practice	958	-	3.50	997	1.06

Note: Farmers gave supplemental irrigation during dry spells.

Cropping systems

Demonstration on pearlmillet hybrids were conducted at farmer's fields with two hybrids. The mean yield of pearlmillet was Proagro-9450 (961 kg/ha) and 86 M 88 (875 kg/ha) (Table 1.4.9). The higher mean net returns of Rs.1177/ha, B:C ratio of 1.07 and RWUE of 3.52 kg/ha-mm were recorded with Proagro-9450 as compared to net returns of Rs.-974/ha and B:C ratio of 0.97 were recorded by 86 M 88, respectively. The increase in grain yield of pearlmillet (Proagra-9450) was 10% over 86 M 88.

Table 1.4.9: Performance of different pearlmillet hybrids

Hybrid	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Proagro-9450	961	10	3.52	1177	1.07
86 M 88	875	-	3.20	-974	0.97

Note: Farmers gave supplemental irrigation during dry spells.

The sesame seed yield of 360 kg/ha was recorded with Shekhar variety compared to HT-01 (307 kg/ha). Similarly, the higher RWUE (1.31 kg/ha-mm), net returns (Rs.15826/ha) and B:C ratio (2.21) were recorded with Shekhar variety (Table 1.4.10).

Table 1.4.11: Performance of sesame varieties on farmers' fields

Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Shekhar	360	1.31	15826	2.21
HT-01	307	1.11	11439	1.86

The highest mean pearlmillet equivalent yield of 1163 kg/ha was recorded in pearlmillet + clusterbean (4:4) grown in strip cropping system, which was 26.4% more than pearlmillet grown as sole (920 kg/ha). The highest net returns of Rs.3511/ha and B:C ratio of 1.23 was obtained under strip cropping as compared to net returns of Rs. 464/ha and B:C ratio of 1.03 recorded with pearlmillet as sole system.

Table 1.4.11: Performance of strip cropping system of pearlmillet + clusterbean (4:4)

Crop	Variety	Yield (kg/ha)	PEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	LER	MAI
Pearlmillet + clusterbean (4:4)	Proagro-9450+RGC-1017	534+209	1163	26.4	--	3511	1.23	1.27	788
Pearlmillet (sole)	Proagro-9450	920	920		3.36	464	1.03	--	--

Note: Farmers gave supplemental irrigation during dry spells.

The highest mean pearlmillet equivalent yield of 1931 kg/ha was obtained when pearlmillet was grown with sesame in 4:4 row ratio, which was 119.4% more compared to sole pearlmillet (880 kg/ha) at farmer's field. The mean highest net return of Rs.12238/ha and B:C ratio 1.84 was obtained under pearlmillet + sesame strip cropping as compared sole pearlmillet (Table 1.4.12).

Table 1.4.12: Effect of strip cropping system demonstrated under normal onset of monsoon conditions

Crop	Variety	Yield (kg/ha)	PEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	LER	MAI
Pearlmillet + sesame (4:4)	Proagro-9450 + Sekhar	540 + 240	1931	119.4	--	12238	1.84	1.27	2396
Pearlmillet (sole)	Proagro-9450	880	880		3.22	-182	0.98	--	--

Note: Farmers gave supplemental irrigation during dry spells.

Nutrient management

Demonstrations were conducted on split application of nitrogen in pearlmillet in farmers' fields. Nitrogen was applied 1/3rd at sowing, 1/3rd at tillering and rest 1/3rd at jointing stage of pearlmillet, respectively. The highest grain yield of 1085 kg/ha was recorded with split N (N of RDF split three time equally) as compared to mean yield recorded with farmers' practice (950 kg/ha) and gave higher net returns of Rs.3208/ha and B:C ratio of 1.20 (Table 1.4.13).

Table 1.4.13: Effect of split application of N on pearlmillet (Proagro-9450)

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Split N equally (three times)	1085	14.21	3.97	3208	1.20
Farmers practice	950	-	3.48	983	1.06

Note: Farmers gave supplemental irrigation during dry spells.

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

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was normal (24th June) and a rainfall of 536.4 mm was received which was excess by 124.4 mm (30.2%) compared to normal (412 mm) (Fig. 4.3). During *kharif* season, 326.4 mm rainfall was received which was deficit by 9.4 mm (2.8 %) than normal of 335.8 mm. In *rabi*, 11.5 mm rainfall was received which was 2.3 mm excess than normal of 9.2 mm and in summer, rainfall was excess by 167.1 mm than normal of 8.3 mm.

Normal onset of monsoon	:	1st week of July
Onset of monsoon during 2015-16	:	24th June
Annual mean rainfall	:	412 mm
Annual rainfall during 2015-16	:	536.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	335.8 (*kharif*) and 9.2 mm (*rabi*)
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	326.4 mm (*kharif*) and 11.5 mm (*rabi*)

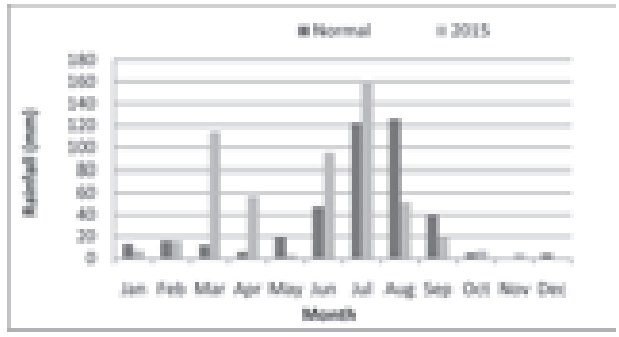


Fig. 4.3: Normal and actual (2015) monthly rainfall at Hisar

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	22 July to 2 August	Pearlmillet Greengram, clusterbean	Tillering Branching
29	20 August to 18 September	Pearlmillet, greengram, clusterbean	Flowering/ grain formation

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Pearlmillet, clusterbean, greengram,	Tillering/branching	Mechanical weeding/ hoeing with kasola and wheel hand hoe; Spray water on crops to avoid white fly
Terminal drought	Pearlmillet, clusterbean, greengram	Flowering/ grain formation/maturity	Applied light irrigation to save the crop wherever harvested water was available

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

During *kharif* season, 326.4 mm rainfall was received which was deficit by 9.4 mm (2.8%) than normal of 335.8 mm. The rainfall was excess by 101.3% in June, 31.4% in July but deficit by 59.2% in August and 53.0% in September compared to normal rainfall. There was long dry spell of 29 days from 20 August to 18 September coinciding with the flowering and grain filling stage of rainfed crops. Supplemental irrigation from harvested rainwater in pearlmillet (Cv.HHB-67) recorded higher grain yield of 1166 kg/ha with higher RWUE (4.5 kg/ha-mm), net returns (Rs.878/ha) and B:C ratio (1.1) over without supplemental irrigation (883 kg/ha) (Table 1.4.14).

Table 1.4.14: Performance of pearlmillet under supplemental irrigation

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
With supplemental irrigation	1166	32.1	4.5	878	1.1
Without supplemental irrigation	833	-	4.2	-3537	0.80

Preparedness

Cropping systems

Among different pearlmillet hybrids, HHB-197 recorded highest grain yield (2333 kg/ha) and RWUE of 10.1 kg/ha-mm compared to other hybrids. Similarly, among the five clusterbean varieties, HG-2-20 recorded higher seed yield of 144 kg/ha with RWUE of 0.63 kg/ha-mm compared to other varieties. Among the four varieties of mungbean, MH-318 recorded higher seed yield of 189 kg/ha with RWUE of 0.82 kg/ha-mm over other varieties (Table 1.4.15).

Table 1.4.15: Performance of improved varieties/hybrids of different *kharif* crops

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)
Pearlmillet	HHB-67(I)	1386	6.0
	HHB-197	2333	10.1
	HHB-223	1533	6.6
	HHB-226	1467	6.3
	HHB-234	2178	9.4
	HHB-272	2133	9.2
Clusterbean	HG-365	128	0.55
	HG-563	133	0.58
	HG-2-20	144	0.63
	HG-870	89	0.38
	HG-884	83	0.36
Greengram	Satya	178	0.77
	Basanti	111	0.48
	MH-421	178	0.77
	MH-318	189	0.82

c. On-farm demonstrations

Village profile

Balawas

The program is being implemented 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 *rabi* crops 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.

Budhshelly

The program is being implemented in the village of Budhshelly, 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 *rabi* crops are mustard, chickpea barley and rapeseed. 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% rainfall from winter. The historical rainfall data of 30 years indicated 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 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^{0}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 in Balawas and Budhshelly during 2015-16

During 2015, in Balawas village, onset of monsoon was normal. A rainfall of 538 mm was received which was excess by 238 mm (79.3%) mm compared to normal of 300 mm (Fig…..). During *kharif*, 299 mm rainfall was received which was excess by 88.3 mm (41.9%) than the normal rainfall of 210.7 mm; *rabi* season recorded 3 mm rainfall as against normal of 22 mm and in summer, rainfall received was 215 mm which was excess by 171.9 mm than normal of 43.1 mm.

Normal onset of monsoon	:	1st week of July
Onset of monsoon during 2015-16	:	24th June
Normal annual mean rainfall	:	300 mm
Actual annual rainfall during 2015-16	:	538.0 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	:	210.7 and 22 mm, respectively
Crop seasonal rainfall during 2015-16 *(kharif* and *rabi)*	:	299 and 3 mm, 2015 respectively

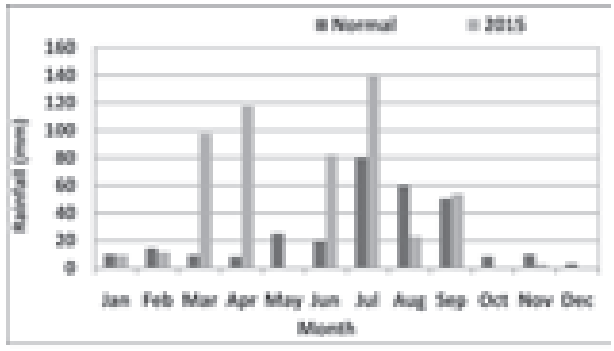


Fig. 1.4.4: Normal and actual monthly rainfall (2015) at Balawas

During 2015, in Budhshelly village, onset of monsoon was normal. A rainfall of 505.5 mm was received which was excess by 205.5 mm (68.5%) compared to normal of 300 mm (Fig.....). During *kharif*, 254 mm rainfall was received which was deficit by 43.3 mm (20.6%) than the normal rainfall of 210.7 mm; there was no rainfall during *rabi* season and in summer rainfall received was 232 mm which was excess by 188.9 mm than normal of 43.1 mm.

Normal onset of monsoon	:	1st week of July
Onset of monsoon during 2015-16	:	25th June
Normal annual mean rainfall	:	300 mm
Actual annual rainfall during 2015-16	:	505.5 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	210.7 and 22 mm, respectively
Crop seasonal rainfall during 2015 (*kharif* and *rabi)*	:	254 mm in *kharif* and no rainfall in *rabi*

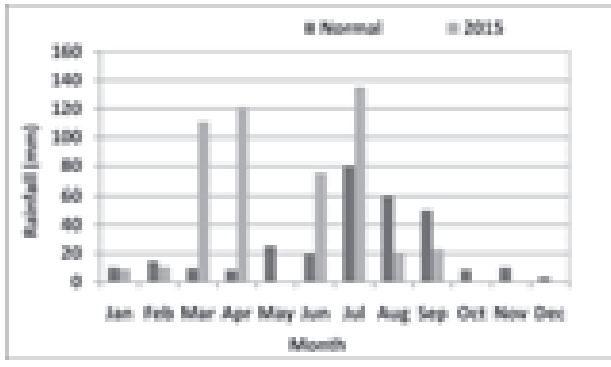


Fig. 1.4.5: Normal and actual monthly rainfall (2015) at Budhshelly

Dry spells during crop growing season (2015-16)

Village	Dry spell (Village Budhshelly)		Crop	Stage of the crop
	Duration (days)	Dates & months		
Budhshelly	21	20 July to 9 August	Pearlmillet Clusterbean, greengram	Tillering Branching
	34	15 August to 17 September	Pearlmillet clusterbean, greengram	Flowering/grain formation/ maturity,
Last rainfall recorded in village Budhshelly: **20/9/2015**				
Balawas	21	20 July to 9 August	Pearlmillet clusterbean, greengram	Tillering Branching
	30	19 August to 17 September	Pearlmillet, clusterbean, greengram	Flowering/ grain/ seed filling

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented	No. of farmers	Area (ha)
Mid season drought	Pearlmillet Clusterbean Greengram	Mechanical weeding/ hoeing with kasola and wheel hand hoe Spray water on crops to avoid white fly	55	22
Terminal drought	Pearlmillet Clusterbean Greengram	Applied light irrigation to save the crop	25	10

Situation: Mid season drought

During 2015, there was one dry spell of 30-40 days from 15/17 August to 17th September coinciding with the flowering and grain filling stage of rainfed crops in both the villages. Demonstrations were conducted on interculture with kasola or wheel hand hoe (WHH) in pearlmillet, clusterbean and greengram. Weeding with wheel hand hoe (WHH) gave higher grain/seed yield (758, 354 and 308 kg/ha) compared to Kasola (740, 340 and 295 kg/ha) in pearlmillet, clusterbean and mungbean, respectively. However, the net returns were negative from all the crops due to very low yields as a result of prolonged dry spells during flowing to maturity stages of crops.

Preparedness

Cropping systems

Demonstrations were conducted on strip cropping of pearlmillet with clusterbean. The higher clusterbean equivalent yield was recorded in pearlmillet + clusterbean (1388 kg/ha) with net return of Rs.1711/ha, B:C ratio of 1.10 and RWUE of 14.5 kg/ha as compared to sole pearlmillet. The increased in yield with strip cropping of pearlmillet + clusterbean (8:4) was 80.5% over sole pearlmillet (Table 1.4.16).

Table 1.4.16: Performance of pearlmillet + clusterbean (8:4) strip cropping system

Cropping system	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Pearlmillet sole (HHB-226)	769	-	14.5	-5254	0.71
Pearlmillet + clusterbean (8:4)	1388 (CEY)	80.5	26.2	1711	1.10

CEY: Clusterbean equivalent yield

Adoption of recommended package of practices in pearlmillet and clusterbean resulted in higher yield (789 and 307 kg/ha, respectively) as compared to farmers' practice and the increase in yields were 19.8 and 12.8%, respectively. Similarly, higher RWUE (12.73 and 5.40 kg/ha-mm) and B:C ratio (0.73 and 0.77) were recorded with adoption of recommended package of practices, respectively (Table 1.4.17).

Table 1.4.17: Performance of pearlmillet and clusterbean under different management practices

Crop/ variety		Grain/seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Pearlmillet (HHB-226)	IP	789	19.8	12.73	4906	0.73
	FP	659	-	10.38	5107	0.69
Clusterbean (HG-563)	IP	307	12.8	5.4	4332	0.77
	FP	272	-	4.80	3936	0.76

IP: Improved practice; FP: Farmer's practice

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 638 mm.

b. On-station experiments

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was delayed by 31 days (26th July). A rainfall of 960.7 mm was received which was excess by 322.7 mm compared to normal (638 mm) (Fig. 1.4.6). During south-west monsoon (*kharif*), 931.2 mm rainfall was received which was excess by 333.1 mm than normal rainfall of 598.1 mm; during north-east monsoon (October-December), no rains were received compared to normal rainfall of 27.1 and in summer (March-May), 27 mm rainfall was received which was excess by 18.2 mm compared to normal rainfall of 8.8 mm. Terminal drought in different crops occurred due to early withdrawal of monsoon.

Normal onset of monsoon	:	25 June
Onset of monsoon during 2015-16	:	26 July
Annual mean rainfall	:	638 mm
Annual rainfall during 2015-16	:	960.7 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	:	598.1 and 27.1 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	931.2 and 0 mm, respectively

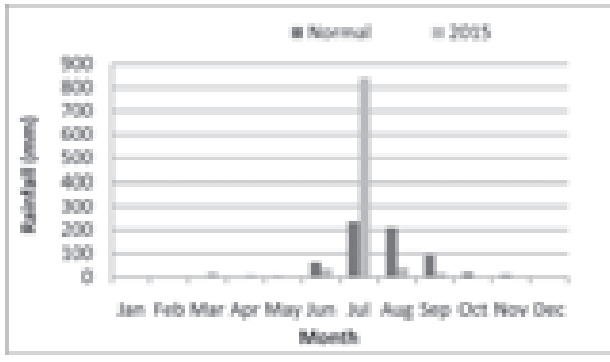


Fig. 1.4.6: Normal and actual (2015) monthly rainfall at SK Nagar

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
34	16 August to 18 September	Pearlmillet, pulses	Vegetative
	24 September onwards till crop harvest	Pearlmillet Pulses Castor	Grain filling to maturity At maturity Seed filling to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Pearlmillet, greengram, blackgram, clusterbean, sorghum (fodder)	-	Improved varieties were grown
Mid season drought	Pearlmillet	Tillering & earhead initiation	Soil and foliar application of nutrients
Terminal drought	Castor	Flowering & capsule formation	Life saving irrigation given from ex-situ water harvested

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2015, the onset of monsoon was delayed by 31 days (26th July). The rainfall was excess in July (257.8%) and deficit in June (43.3%), August (80.9%) and September (81.6%). Among different pearlmillet hybrids, GHB 558 recorded highest grain (445 kg/ha) and fodder (1215 kg/ha) yield over GHB 538 with higher net returns (Rs.2070/ha), B:C ratio (0.25) and RWUE (0.48 kg/ha-mm) (Table 1.4.18).

Table 1.4.18: Performance of pearlmillet hybrids

Hybrid	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder				
GHB 558	445	1215	13	0.48	2070	0.25
GHB 538	395	1135	-	0.42	1080	0.13

Similarly, among the two greengram varieties, GM-4 recorded highest seed and stover yield of 405 and 1030 kg/ha, respectively compared to GM-3. Higher net returns (Rs.24590/ha), B:C ratio (3.59) and RWUE (0.43 kg/ha-mm) were also recorded by GM-4 compared to GM-3 (Table 1.4.19).

Table 1.4.19: Performance of greengram varieties under delayed onset of monsoon

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stover				
GM 3	325	940	-	0.35	18770	2.76
GM 4	405	1030	25	0.43	24590	3.59

Among the two clusterbean varieties Guj. Guar 2 recorded higher seed and stalk yield of 325 kg/ha and 685 kg/ha, respectively over control. The higher net returns Rs. 7520/ha, B:C ratio 1.43 and RWUE (0.35 kg/ha-mm) were recorded by variety of Guj. Guar 2 (Table 1.4.20).

Table 1.4.20: Performance of clusterbean varieties under delayed onset of monsoon

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Straw				
GG 1	250	600	-	0.27	4900	0.95
GG 2	325	685	30.00	0.35	7520	1.43

Improved variety of sorghum (CSV 21) recorded higher fodder yield (4280 kg/ha) with higher net returns (Rs. 5990/ha), B:C ratio (0.87) and RWUE (4.60 kg/ha-mm) compared to local (Sundhiya) (Table 1.4.21).

Table 1.4.21: Performance of fodder sorghum varieties under delayed onset of monsoon

Variety	Fodder yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
CSV 21	4280	35.67	4.60	5990	0.87
Local variety (Sundhiya)	3155	-	3.39	3115	0.49

Situation: Midseason drought

During *kharif* 2015, the rainfall was excess in July (257.8%) and deficit in June (43.3%), August (80.9%) and September (81.6%). A dry spell of 34 days occurred during 16 August to 18 September. Among different soil and foliar application treatments, N application @ 20 kg/ha (at 20-25 DAS) recorded significantly highest grain (600 kg/ha) and fodder (1360 kg/ha) yields than all the other treatments, except 2% urea spray and 1000 ppm thiourea. The higher net returns (Rs.5861/ha), B:C ratio (0.81) and RWUE (0.64 kg/ha-mm) were also recorded with application of N @ 20 kg/ha (at 20-25 DAS) (Table 1.2.22).

Table 1.4.22: Effect of different soil and foliar nutrition treatments on pearlmillet

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder			
Urea spray (1%)	475	1125	0.51	3408	0.48
Urea spray (2%)	560	1235	0.60	5009	0.71
Thiourea 1000 ppm	530	1205	0.57	4387	0.61
N @ 20 kg/ha (at 20-25 DAS)	600	1360	0.64	5861	0.81
N @ 20 kg/ha (at 40-45 DAS)	425	990	0.46	2126	0.29
$ZnSO_4$ spray (0.5%)	460	1045	0.49	3086	0.44
CD at 5%	96	193	-		

Situation: Terminal drought

During 2015, due to early withdrawal of monsoon, no rainfall was received from 24 September onwards till crop harvest. Supplemental irrigation of 50 mm at flowering to capsule development stage in castor recorded higher seed and stalk yields of 1055 and 1785 kg/ha, respectively over no supplemental irrigation. The higher net returns (Rs.23713/ha), B:C ratio (1.82) and RWUE (1.02 kg/ha-mm) were also recorded with supplemental irrigation (Table 1.4.23).

Table 1.4.23: Effect of supplemental irrigation in castor (GCH 7) on yield and economics

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Supplemental irrigation	1055	1785	1.02	23713	1.82
Without irrigation	456	760	0.49	5734	0.56

Note: Two life saving irrigations were given from farm pond through MIS

Preparedness

Rainwater management

The *in-situ* moisture conservation with compartmental bunding in pearlmillet recorded highest grain and fodder yields of 665 and 1785 kg/ha, respectively over local practice of no compartmental bunding with highest net returns (Rs.6480/ha), B:C ratio (0.73) and RWUE (0.71 kg/ha-mm)compared to local practice (Table 1.4.24).

Table 1.4.24: Effect of compartmental bunding in pearlmillet (GBH 558) on yield and economics

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder			
Compartmental bunding	665	1785	0.71	6480	0.73
Local practice	395	1115	0.42	1020	0.12

Similarly, the ridge & furrow method of *in-situ* moisture conservation in castor recorded higher seed (620 kg/ha) and stalk (1150 kg/ha) yields over local practice of flat sowing. The higher net return (Rs.9925/ha), B:C ratio (0.85) and RWUE (0.67 kg/ha-mm) were also recorded with ridge and furrow method (Table 1.4.25).

Table 1.4.25: Effect of ridge & furrow method in castor (GCH 7) on yield and economics

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Ridge & furrow	620	1150	0.67	9925	0.85
Local practices	435	780	0.47	5030	0.50

Cropping systems

Among different castor varieties evaluated, GCH-7 recorded higher seed (475 kg/ha) and (910 kg/ha) stalk yields of castor, respectively compared to GCH-5. The higher net returns (Rs.6455/ha), B:C ratio (0.64) and RWUE (0.51 kg/ha-mm) were also recorded with GCH-7 over GCH-5 (Table 1.4.26).

Table 1.4.26: Performance of castor hybrids

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk				
GCH 5	405	825	-	0.43	4033	0.40
GCH 7	475	910	17	0.51	6455	0.64

Intercropping system (castor + greengram) recorded higher CEY (876 kg/ha) over sole castor (484 kg/ha) with higher net returns of Rs. 16450/ha, B:C ratio (1.23) and RWUE (0.42 kg/ha-mm).

Table 1.4.27: Performance of castor + greengram intercropping system

Normal crop	Variety	Yield (kg/ha)				CEY	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Castor		Greengram					
		Seed	Stalk	Seed	Stover				
Castor + Greengram (1:1)	GCH 7 + GM 4	390	840	205	590	876	0.42	16450	1.23
(1:1)	Castor sole	470	985	--	--	484	0.50	6323	0.62

CEY: Castor equivalent yield

Nutrient management

Among various nitrogen management treatments in castor, application of 50% RDN through urea + 50% RDN through FYM recorded significantly highest seed and stalk yields of 575 and 1230 kg/ha, respectively over rest of the treatments. Similarly, higher net returns (Rs.6162/ha) and RWUE (0.62 kg/ha-mm) were also recorded with application of 50% RDN through urea + 50% RDN through FYM (Table 1.4.28).

Table 1.4.28: Effect of nitrogen management on yield and economics of castor

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Control	325	720	0.35	3810	0.50
Farmer's method	370	830	0.40	3089	0.31
100% RDN (Urea)	410	975	0.44	6022	0.72
50% RDN (FYM)	390	870	0.42	95	0.01
50% RDN (Urea) + 50% RDN (FYM)	575	1230	0.62	6162	0.44
CD at 5%	81	190	-		

c. On-farm demonstrations

Village profile

The program is being implemented in Kalimati/Dholiya village, taluka Amirgadh, Banaskantha district and Chandanki village, Taluk Becharaji in Mehsana District, Gujarat. The total cultivated area is 652.91 ha (Kalimati/Dholiya) out of which 322.91 ha is rainfed. The mean annual rainfall is 873 mm (Kalimati/Dholiya) with seasonal rainfall of 782.8 mm 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 numbers of small, marginal, medium and large farmers are 83, 49, 75 and 39. The source of irrigation is well, tube well, canal, check dam and farm ponds covering 51.05% of cultivated area.

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 873 mm. The historical rainfall data (of 30 years) indicated that there was variability in rainfall during south-west monsoon. The onset (south-west) 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 monsoon has 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 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 (27 to 28 SMWs) of pearlmillet, greengram, sorghum, clusterbean, maize, castor, cotton etc.

Experienced weather conditions during 2015-16

During 2015, in Kalimati village, onset of monsoon was normal (25th June). A total rainfall of 972 mm was received which was excess by 99 mm compared to normal (873 mm). Out of total rainfall, *kharif* season received 972 mm, excess by 189 mm (24.2%) than normal of 783 mm. In *rabi* and summer season there was no rain.

Normal onset of monsoon	:	20-25 June
Onset of monsoon during 2015-16	:	25 June
Annual mean rainfall	:	873 mm
Annual rainfall during 2015-16	:	972 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	:	783 & 23.1 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif*)	:	972 & 0 mm, respectively

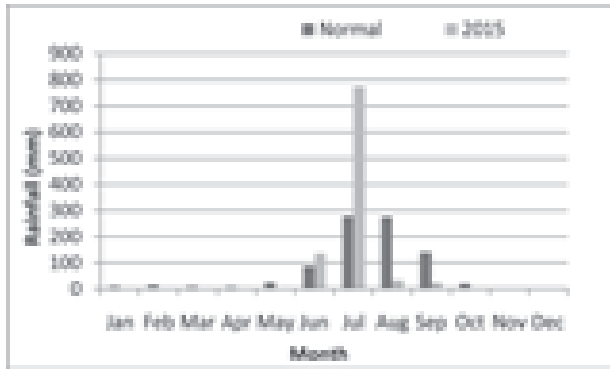


Fig. 1.4.7 : Normal and actual (2015) monthly rainfall in Kalimati village

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
15	4 to 18 July	Pearlmillet, maize, greengram, blackgram, clusterbean, sorghum (fodder)	Seedling
12	27 August to 7 September	Greengram, blackgram, clusterbean	Maturity
-	1 October onwards	Castor	Seed filling to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought Terminal drought	Pearlmillet Castor	Seedling Flowering & capsule formation	Soil and foliar application of nutrients Life saving irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During *kharif* 2015, a dry spell of 15 days (4-18 July) occurred coinciding with seedling stage of pearlmillet. Among different soil and foliar application treatments in pearlmillet, soil application of N @ 20 kg/ha (at 40-45 DAS) recorded significantly highest grain (1215 kg/ha) and fodder (2760 kg/ha) yields than all other treatments except 2% urea spray and N @ 20 kg/ha (at 20-25 DAS) (Table 1.4.29). The highest net return (Rs.17786/ha), B:C ratio (2.04) and RWUE (1.25 kg/ha-mm) were also recorded with soil application of N @ 20 kg/ha (at 40-45 DAS).

Table 1.4.29: Effect of different soil and foliar application treatments on yield and economics of pearlmillet

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder			
Urea spray (1%)	930	2125	0.96	11733	1.37
Urea spray (2%)	1085	2450	1.12	15029	1.75
Thiourea 1000 ppm	965	2290	0.99	12667	1.46
N @ 20 kg/ha (at 20-25 DAS)	1130	2510	1.16	15761	1.81
N @ 20 kg/ha (at 40-45 DAS)	1215	2760	1.25	17786	2.04
$ZnSO_4$ spray (0.5%)	855	2025	0.88	10451	1.24
CD at 5%	221	428	-	-	-

Situation: Terminal drought

During 2015, no rainfall was received from 1 october onwards affecting seed filling and maturity stage of castor. Two supplemental irrigations given at flowering and capsule formation recorded higher seed and stalk yields of 1170 and 2315 kg/ha, respectively over no irrigation. The highest net returns (Rs. 26488/ha), B:C ratio (1.83) and RWUE (1.20 kg/ha-mm) were also recorded with supplemental irrigation (Table 1.4.30).

Table 1.4.30: Effect of supplemental irrigation on yield and economics of castor

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Supplemental irrigation	1170	2315	1.20	26488	1.83
Local practice	485	960	0.50	5520	0.48

Note: Two life saving irrigations were given from the harvested rainwater in farm pond through MIS

Preparedness

Rainwater management

The *in-situ* moisture conservation practice (compartmental bunding) in pearlmillet recorded significantly highest grain (1348 kg/ha) and fodder (3640 kg/ha) yields over local practice (no compartmental bunding) along with higher net returns of Rs.18222/ha, B:C ratio (1.87) and RWUE (1.39 kg/ha-mm) (Table 1.4.31).

Table 1.4.31: Effect of *in-situ* moisture conservation on yield and economics of pearlmillet

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder			
Compartmental bunding	1348	3640	1.39	18222	1.87
Local practice	870	2265	0.90	8798	0.97
CD at 5%	132	293			

Similarly, the *in-situ* moisture conservation practice (ridge & furrow) in castor recorded highest seed (830 kg/ha) and stalk (1625 kg/ha) yields over local practice of flat method of sowing. The highest net return (Rs. 16416/ha), B:C ratio (1.30) and RWUE (0.85 kg/ha-mm) were also recorded with ridge and furrow method (Table 1.4.32).

Table 1.4.32: Effect of *in-situ* moisture conservation on yield and economics of castor

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Ridge & furrow	830	1625	0.85	16416	1.30
Local practice	465	940	0.48	5222	0.47
CD at 5%	72	161	-	-	-

Cropping systems

Among different hybrids of castor, GCH 7 recorded higher seed and stalk yields of 748 and 1785 kg/ha, respectively over local variety (GHC 4). The highest net return of Rs. 14553/ha, B:C ratio (1.24) and RWUE (0.77 kg/ha-mm) were recorded with GCH 7 (Table 1.4.33).

Table 1.3.33: Performance of different castor hybrids

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
GCH 5	623	1545	0.64	10198	0.87
GCH 7	748	1785	0.77	14553	1.24
Local variety	487	1130	0.50	5680	0.50

Among different pearlmillet hybrids, GHB 558 (75-85 days) recorded significantly highest grain (910 kg/ha) and fodder (2475 kg/ha) yields, over local variety (MH 179). The highest net returns of Rs.9780/ha, B:C ratio (1.07) and RWUE (0.94 kg/ha-mm) were also recorded with GHB 558 (Table 1.4.34).

Table 1.4.34: Performance of different pearlmillet hybrids

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder			
GHB 558	910	2475	0.94	9780	1.07
GHB 538	785	2040	0.81	6944	0.76
Local variety	595	1680	0.61	3677	0.42
CD at 5%	54	169			

Short duration (90-110 days) hybrids (GM 2 and HQPM 1) of maize were demonstrated on farmers' fields. HQPM 1 recorded significantly highest grain (2215 kg/ha) and stalk (3960 kg/ha) yields compared to other hybrids along with higher net returns of Rs.34134/ha, B:C ratio (3.38) and RWUE (2.28 kg/ha-mm) compared to other varieties/hybrids (Table 1.4.35).

Table 1.4.35: Performance of different maize hybrids

Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder			
GM 2	1540	2875	1.58	22710	2.72
HQPM 1	2215	3960	2.28	34134	3.38
Local variety	985	1910	1.01	11995	1.49
CD at 5%	150	254			

Land race/*Desi* maize was taken as local varieties with crop duration of 105-115 days

Similarly, blackgram variety Guj. Urad 1 (90-110 days) recorded significantly highest seed and stover yields of 515 and 1340 kg/ha over local check (T 59), along with highest net returns of Rs.45911/ha, B:C ratio (4.76) and RWUE (0.53 kg/ha-mm) . Short duration (90-110 days) Gujarat Mung 4 variety of greengram recorded significantly highest seed (465 kg/ha) and stover (1215 kg/ha) yields over local variety (K 851) with highest net returns of Rs.28556/ha, B:C ratio (3.73) and RWUE (0.48 kg/ha-mm). The Gujarat Guar 2 variety of clusterbean recorded significantly the highest seed (325 kg/ha) and straw (845 kg/ha) yields, respectively over local variety (HG 75) (Table 1.4.36). CSV 21 variety of sorghum recorded higher (8750 kg/ha) fodder yield of sorghum over local variety and the increase in yield was 35%. The higher net returns Rs.17901/ha, B:C ratio (2.14) and RWUE (9.00 kg/ha-mm) were recorded by CSV 21.

Table 1.4.36: Performance of crop varieties

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw			
Blackgram	GU 1	515	1340	0.53	45911	4.76
	Local variety	390	1025	0.40	33246	3.77
	CD at 5%	41	110	-	-	-
Greengram	GM 4	465	1215	0.48	28556	3.73
	Local variety	350	945	0.36	20017	2.72
	CD at 5%	33	97	-	-	-
Clusterbean	GG2	325	845	0.33	7022	1.12
	Local variety	240	610	0.25	4065	0.72
	CD at 5%	22	66	-	-	-

Castor + greengram (1:1) intercropping system recorded significantly higher castor equivalent yield (1394 kg/ha) with higher RWUE (1.43 kg/ha), net returns (Rs.31872/ha) and B:C ratio (2.05) over sole castor with yield of 911 kg/ha (Table 1.4.37).

Table 1.4.37: Performance of castor + greengram (1:1) intercropping system

Cropping system	Castor equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Castor + greengram (1:1)	1394	1.43	31872	2.05
Castor sole	911	0.94	17707	1.33
CD at 5%	95	-	-	-

Energy management

Demonstrations were conducted on different implements for sowing of greengram in farmers' fields. Roto till drill recorded significantly higher seed (665 kg/ha) and stover yield (1560 kg/ha) than other sowing implements. The highest net returns of Rs.43402/ha, benefits cost ratio (5.53) and RWUE (0.68 kg/ha-mm) were recorded with roto till drill, followed by strip till drill (Table 1.4.38).

Table 1.4.38: Effect of different sowing implements on yield and economics of greengram

Sowing implement	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stover			
Roto till drill	665	1560	0.68	43402	5.53
Strip till drill	590	1430	0.61	37744	4.81
Zero till drill	520	1215	0.54	32207	4.10
Local practice	445	1025	0.46	26786	3.60
CD at 5%	66	139	-	-	-

1.5 Sorghum Based Production System

1.5.1 VIJAYAPUR

a. Agro-ecological setting:

Vijayapur is in Karnataka Plateau (AESR 3). The climate is hot arid. Potential evapo-transpiration is 622 mm. The 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, 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-Nil

Experienced weather conditions during 2015-16

During 2015, a rainfall of 651.1 mm was received which was excess by 56.7 mm (9.5%) compared to normal (594.4 mm). Out of total rainfall in 2015 (651.1 mm), *kharif* season (June- September) recorded 432.6 mm which was excess by 44 mm (11.3%) than seasonal normal of 388.6 mm. During *rabi*, it was 106.9 mm which was deficit by 27.3 mm (20.3%) than normal of 134.2 mm and in summer 107 mm was recorded and was excess by 41.4 mm (63.1%) than normal of 65.6 mm.

Normal onset of monsoon	:	7 June
Onset of monsoon during 2015-16	:	1 June
Annual mean rainfall	:	594.4 mm
Annual rainfall during 2015-16	:	651.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	*kharif* 388.6 mm and *rabi* 134.2 mm
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	*kharif* 432.6 mm and *rabi* 106.9 mm

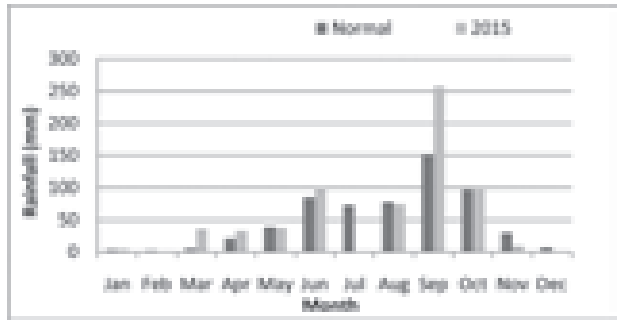


Fig. 1.5.1: Normal and actual (2015) monthly rainfall at Vijayapur

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
41	22 June to 3 August	Pearlmillet, pigeonpea and greengram	Seedling
46	8 October to 22 November	Pigeonpea, sunflower, sorghum, safflower, linseed and chickpea	Seedling to vegetative stage

c. On-farm demonstrations

Village profile

The program is being implemented by AICRPDA Centre, Vijayapur in Kavalagi village, Vijayapur Tehsil in Vijayapur 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 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 variability in rainfall during South-west monsoon was manifested in delayed onset of monsoon and drought.

Experienced weather conditions during 2015-16

During the year 2015 the onset of monsoon was normal (7 June), in Kaulagi village. A rainfall of 433.5 mm was received which was deficit by 160.9 mm (27.1%) than normal of 594.4 mm. During *kharif*, there was a rainfall of 239 mm, deficit by 123.6 mm (31.9%) than normal of 387.5 mm and in *rabi* season 56.3 mm rainfall was recorded which was deficit by 77.7 mm (58%) against normal of 134 mm and during summer it was 113.3 mm, excess by 47.2 mm (71.4%) than normal of 66.1 mm.

Normal onset of monsoon	:	7 June
Onset of monsoon during 2015-16	:	7 June
Annual mean rainfall	:	594.4 mm
Annual rainfall during 2015-16	:	433.5mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	*kharif* 387.5 mm and *rabi* 134.0 mm
Crop seasonal rainfall during 2015-16	:	*kharif* 239 mm and *rabi* 56.3 mm

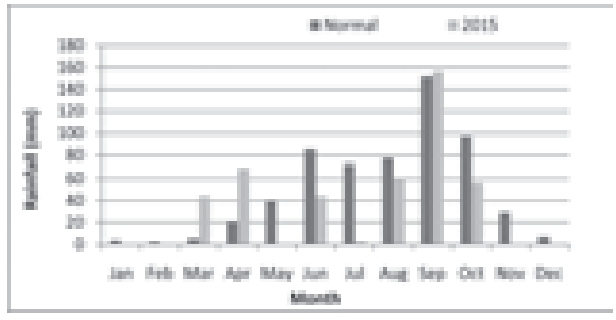


Fig.: Normal and actual (2015) monthly rainfall at Kavalagi village

Table…..: Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
23	14 June – 7 July	Pigeonpea, pearlmillet, groundnut, greengram, horsegram, mothbean, onion and chilli	Seedling
28	9 July – 7 August	Pigeonpea, pearlmillet, groundnut, greengram, horsegram, mothbean, onion and chilli	Vegetative
12	8 August–20 August	Pigeonpea, horsegram, mothbean,	Vegetative to grand growth stage
22	12 September to 2 October	Pigeonpea, horsegram, mothbean, sunflower, sorghum, chickpea, safflower	Grand growth to flowering stage, and seedling stage (sorghum, chickpea, safflower)

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Early season drought	Pearlmillet	Thinning of weak seedlings
	Groundnut	Intercultivation
	Pigeonpea	KNO_3 spray (0.5%)
	Sunflower	Thinning of weak seedlings
	Rabi sorghum	Intercultivation
Midseason drought	Pigeonpea	Intercultivation
	Greengram	KNO_3 spray (0.5%)
	Rabi sorghum	Intercultivation
	Safflower	KNO_3 spray (0.5%)

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During *kharif* 2015, a dry spell of 41 days occurred during 22 June to 3 August coinciding with seedling and vegetative stage of field crops. Demonstration was taken up on improved practice (repeated intercultivation) and farmers' practice (without intercultivation) in pigeonpea. Repeated interculture operations were done for soil moisture conservation and weed management during the cropping season. Pigeonpea variety TS 3R gave higher yield (1325 kg/ha), net returns (Rs.77922/ha) and RWUE (3.99 kg/ha-mm) compared to farmers' practice (933 kg/ha).

Situation: Mid season drought

During August 2015, a 12 day dry spell while in September, a 22 day dry spell occurred coinciding with the vegetative and flowering stage of pearlmillet, pigeonpea and greengram.Foliar spray of KNO_3 @ 0.5% during dry spell and urea @ 2% immediately after receipt of rains for relief from drought was demonstrated in pigeonpea and greengram. The improved practice (foliar spray) gave higher yield, net returns and B:C ratio compared to farmers' practice. The improved practice has given 36 % higher yield over the Farmers practices.

Table 1.5.1: Effect of foliar spray on crop yield and economics

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray				
Pigeonpea	TS 3R	1000	788	26.90	3.01	56797	7.92
Greengram	GBS-9	328	275	19.27	1.19	13088	2.60

Preparedness

Rainwater management

The formation of set furrows helped in conserving moisture and resulted in mitigating the dry spells during crop growing period. Significantly higher seed yield of pigeonpea was recorded in set furrow with residue + glyricidia incorporation (433 kg/ha) as compared to flat bed sowing (293 kg/ha) and other treatments. Significantly higher net returns of pigeonpea + pearlmillet was recorded with set furrow with residue + glyricidia incorporation (Rs.67044 + 42044/ha, respectively) (Table 1.5.2).

Cropping systems

Demonstrations on improved crop varieties were taken up in four farmers' field. Improved pigeonpea variety Maruti gave higher yield (1600 kg/ha) and net returns (Rs.95797/ha) compared to farmers' practice (Gulyal). Greengram (GBS-9) gave 11.8% higher yield (350 kg/ha) compared to local variety (313 kg/ha) (Table 1.5.3).

Table 1.5.2: Performance of crops under *in-situ* moisture conservation

Treatment	Seed/grain yield (kg/ha)		RWUE (kg/ha-mm)		Total net returns (Rs/ha)	Pigeonpea equivalent yield (kg/ha)
	Pigeonpea	Pearlmillet	Pigeonpea	Pearlmillet		
Set furrow with residue + Glyricidia incorporation	433	589	0.849	1.155	42044	536
Set furrow with silt + residue + Glyricidia incorporation	416	585	0.821	1.147	39830	519
Set furrow without any GLM and crop residue incorporation	379	576	0.743	1.129	37598	481
Flat bed sowing	293	503	0.574	0.986	25729	382

Table 1.5.3: Performance of improved varieties of pigeonpea and greengram

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)
		Improved variety	Local variety			
Pigeonpea	Maruti (145-155 days)	1600	1165	37.33	6.33	95797
	TS 3R (135-145 days)	975	913	6.79	2.94	55172
	TS 3R (135-145 days)	1013	850	19.17	3.05	57610
Greengram	GBS-9	350	313	11.82	1.27	14548

Farmers' practice: Pigeonpea variety Gulyal local, duration 135-145 days. Greengram local variety, duration 85-90 days

Nutrient management

Demonstrations were taken up integrated nutrient management (INM) in pigeonpea and greengram. Improved practice (INM) gave higher yield, net returns and B:C ratio compared to farmers' practice (without INM).

Table 1.5.4: Effect of nutrient management on crop yield and economics

Crop	Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain seed (2015)	Stover/ stalk				
Pigeonpea	Improved practice (TS 3R)	1350	2721	9000	78750	9.75	4.07
	Farmers' practice	428	1050	8200	20018	2.4	1.42
Greengram	Improved practice (GBS-9)	350	770	8250	14500	2.76	1.27
	Farmers' practice	300	660	7200	12000	2.60	1.09

Details of farmers' practice for pigeonpea and greengram: DAP 100 kg/ha and Urea 100 kg/ha, No organic manures were used. Improved practice for pigeonpea: 25:50:0 NPK kg/ha; FYM: 6 t/ha, seed treatment: *Rhizobium* 500 g/ha), for greengram: 12.5:25:0 NPK kg/ha; FYM: 6 t/ha, seed treatment: *Rhizobium* 500 g/ha, PSB: 1250 g/ha).

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.

b. On-station experiments: Nil

Experienced weather conditions during 2015-16

During 2015, a rainfall of 343.4 mm was received which was deficit by 377.9 mm compared to normal of 721.3 mm. During *kharif*, 143.8 mm rainfall was recorded, which was deficit by 387.3 mm than normal of 531.1 mm; *rabi* recorded 67.8 mm which was deficit by 57.7 mm than normal rainfall of 125.5 mm and in summer, 119.8 mm rainfall was received which was 67.2 mm excess rainfall as against normal of 52.6 mm.

Normal onset of monsoon	:	20 June
Onset of monsoon during 2015-16	:	8 June
Normal annual rainfall	:	721.3 mm
Annual rainfall during 2015-16	:	343.3 mm

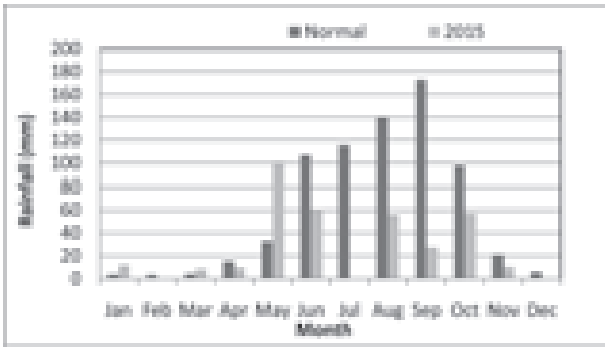


Fig. 1.5.3: Normal and actual (2015) monthly rainfall at Solapur

Mean crop seasonal rainfall	:	531.1 and 125.5 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2015-16	:	43.8 and 67.8 mm during *kharif* and *rabi*, respectively

c. On-farm demonstrations

Village profile

The program is being implemented 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 554.75 mm with seasonal rainfall of 535.1 mm during *kharif* (June-September) which was deficit by 25.45 mm as compared to normal rainfall (535.1 mm). 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 554.75 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 28 SMW (July).

Experienced weather conditions during 2015-16

During 2015, in Narotiwadi village, a rainfall of 205 mm was received which was deficit by 516.4 mm compared to normal (721.4 mm). During *kharif* season, 47 mm rainfall was recorded which was deficit by 448.1 mm than normal of 535.1 mm, *rabi*

recorded 155 mm rainfall which was excess by 29.5 mm than normal of 125.5 mm. During summer, there was no rainfall.

Normal onset of monsoon	:	20 June
Onset of monsoon during 2015-16	:	9 July
Normal annual rainfall	:	721.4 mm
Annual rainfall during 2015-16	:	205 mm
Mean crop seasonal rainfall	:	535.1 and 125.5 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2015-16	:	47 and 155 mm during *kharif* and *rabi*, respectively

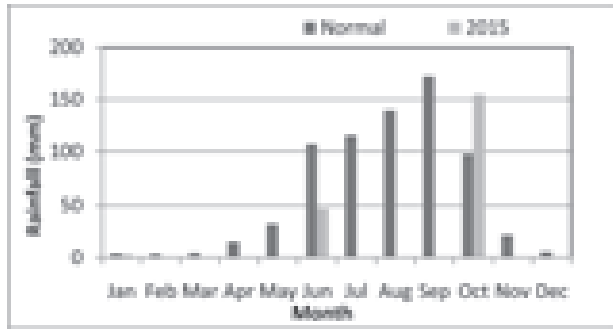


Fig. 1.5.4: Normal and actual (2015) monthly rainfall at Narotiwadi

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
111	12 June to 30 September	No sowing was done in *kharif*	-
-	5 October till crop harvest	Sorghum and chickpea	Vegetative to crop maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Sorghum, chickpea	Vegetative	Interculture Foliar spray
Terminal drought	Sorghum, chickpea	Grain/seed filling and maturity	Protective irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

During 2015, no rainfall was received after 5th October in Narotiwadi village. One weeding at 21 days stage, and hoeing at 3rd, 5th and 8th week after sorghum sowing with peg tooth hoe was done to create dust mulch. The sorghum grain yield was higher by 11.7% (757 kg/ha) with weeding/ interculture and gave higher net returns (Rs 3743/ ha), B:C ratio (1.34) and RWUE (11.65 kg/ha-mm) compared to no weeding/interculture (678 kg/ha). Similarly, foliar spray of KNO3 1% at 30 and 45 DAS in chickpea and DAP 2% in sorghum at 30-45 DAS gave 28% higher chickpea yield (960 kg/ha) and 14% higher sorghum yield (800 kg/ha) compared to no foliar spray (Table 1.5.5).

Table 1.5.5. Effect of foliar spray on yield and economics of sorghum and chickpea

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray				
Chickpea	Digvijay	960	750	28	6.19	16160	1.91
Sorghum	Anuradha	800	700	14	5.16	4500	1.23

Situation: Terminal drought

During 2015, no rainfall was received after 5th October in Narotiwadi village. One life saving irrigation given in chickpea at seed filling stage gave 51% higher seed yield (1250 kg/ha) with net returns of Rs 25975/ha, B:C ratio of 2.45 and RWUE of 8.05 kg/ha-mm compared to without live saving irrigation (825 kg/ha). Similarly, in sorghum, two life saving irrigations given during flag leaf and grain filling stages gave 52% higher grain yield (1100 kg/ha), net returns (Rs 12600/ha), B:C ratio (1.3) and RWUE (7.1 kg/ha-mm) compared to without life saving irrigation (725 kg/ha).

Preparedness

Rainwater management

In-situ moisture conservation during *kharif* with formation of ridges and furrows followed by *rabi* sorghum cultivation gave 15% higher grain yield with net returns of Rs 3960/ha and B:C ratio of 1.27 compared to farmers' practice of two harrowing (Table 1.5.6).

Table 1.5.6 Effect of *in-situ* moisture conservation on sorghum yield and economics

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Ridges and furrow in *kharif* followed by *rabi* sorghum	692	14340	3960	1.27	6.92
Farmers' practice (two harrowing)	602	12300	1750	1.14	6.02

Cropping systems

Among different varieties of sorghum, Phule Vasudha gave higher grain yield (830 kg/ha), net returns (Rs 5810/ha) and B:C ratio (1.39) followed by Phule Suchitra (740 kg/ha) (Table 1.5.7).

Table 1.5.7 Performance of sorghum varieties in farmers' fields

Variety	Grain yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Improved variety	Local variety				
Phule Suchitra	740	660	12.1	3300	1.12	12.1
Phule Vasudha	830	730	13.7	5810	1.39	5.35
Phule Anuradha	700	620	12.9	2400	1.15	4.51

Nutrient management

Application of recommended dose of fertilizers in sorghum gave 21% higher grain yield (850 kg/ha) with higher net returns of Rs 6050/ha and B:C ratio (1.40) compared to farmers' practice with grain yield of 700 kg/ha, net returns of Rs 3300/ha and B:C ratio of 1.20.

Alternate land use

Among different fodder species demonstrated in the farmers' fields, Phule Jayawant gave higher fodder yield (2864 kg/ha) followed by stylo (2713 kg/ha). However, the net returns (Rs 28326/ha) and B:C ratio (2.13) were highest with stylo cultivation (Table 1.5.8).

Table 1.5.8. Performance of different fodder crops in farmers' fields

Crop/variety	Fodder yield (Kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Phule Jaywant	2864	22065	20882	1.93	13.97
Madras Anjan	2500	24025	16311	1.67	12.19
Stylo	2713	26119	28326	2.13	13.23
Fodder sorghum	1700	17000	5000	1.41	7.11

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

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was normal on 25 June (26th SMW). A rainfall of 717.6 mm was received which was deficit by 99.9 mm compared to normal (817.5 mm). During *kharif*, 567.7 mm rainfall was received which was deficit by 174.7 mm than normal (742.3 mm). During north-east monsoon (October- December), 38.4 mm of rainfall was received which was excess by 8 mm than normal (29.8 mm) and during summer (March-May), 61.4 mm of rainfall was received which was excess by 37.2 mm compared to normal (24.2 mm). No rainfall was recorded during August 20 to 27 October.

Normal onset of monsoon : 25 June

Onset of monsoon during 2015-16 : 25 June (26th SMW)

Annual mean rainfall : 817.5 mm

Annual rainfall during 2015-16 : 717.6 mm

Mean crop seasonal rainfall during *kharif* and *rabi* : 742 and 30 mm, respectively

Crop seasonal rainfall during 2015-15 (*kharif* and *rabi*) : 567.7 and 38.4 mm, respectively

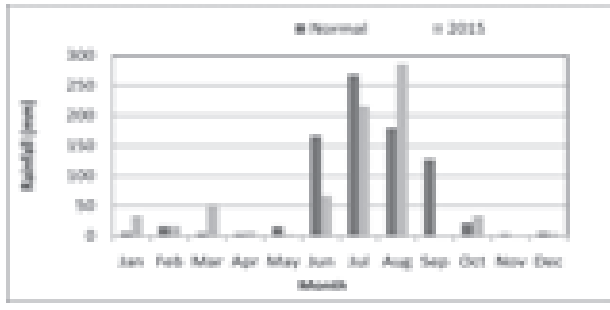


Fig. 1.5.5: Normal and actual (2015) monthly rainfall at Jhansi

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
>40	20 August to 27 October	Blackgram, groundnut, sesame	Pod development & maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Blackgram, sesame	Pod development	Dust mulching and life saving irrigation
	Groundnut	Pod development	Life saving irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During 2015, the rainfall was deficit in June (59.2%), July (19.9%), September (100%) and excess in August (58.5%). There was a prolonged dry spell during 20 August to 27 October coinciding with pod development and maturity stage of crops.

Supplemental irrigation was given at pod development stage in blackgram, groundnut and sesamum whereas in sorghum/maize life saving irrigation was given at harvesting stage. Supplemental irrigation in sesame + blackgram recorded higher grain yield of 553 kg/ha with higher RWUE (1.01 kg/ha-mm), net returns (Rs.36460/ha) and B:C ratio (1.92) over without supplemental irrigation (516 kg/ha) compared to other treatments (Table 1.5.9).

Table 1.5.9: Performance of different crops under supplemental irrigation

Cropping system	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With irrigation	Without irrigation				
Sesame +blackgram	553	516	7.1	1.01	36460	1.92
Sorghum	412	401	2.7	0.77	21207	1.12
Sorghum+ guar	221	205	7.8	0.41	2261	0.12
Groundnut	488	451	8.1	0.91	34873	1.84
Pigeonpea + blackgram	176	162	8.6	0.31	-433	-0.02
Leucaena + blackgram	229	214.	6.7	0.41	3542	0.19

c. On-farm demonstrations

Village profile

The program is being implemented in Kadesara Kalan village Talbehat Block/Mandal/Taluk/ Tehsil 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. During 2014, the mean annual rainfall was 621 mm with seasonal rainfall of 515.5 mm during *kharif* (June-September), 32.5mm during *rabi* (October-December) and there were no rains during summer (March-May). 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 818 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. For the past 15 years, the dry spells during crop season had been experienced, during August & September and at different 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. The maximum/ minimum temperature during crop season was Tmax (*kharif*) =33.6^{0}C, Tmin (*kharif*) =23.9^{0}C; & Tmax (*rabi* =28.7^{0}C; Tmin (*rabi*) =10.5^{0}C 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 is 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.

Experienced weather conditions during 2015-16

The onset of monsoon was on 23rd June (26th SMW) which was normal. During 2015, in Kadesara kalan village, a rainfall of 508 mm was received which

was deficit by 309.5 mm compared to normal of 817.5 mm. During south-west monsoon (*kharif*), 387 mm rainfall was received which was 355.3 mm deficit compared to normal of 742.3 mm and during north-east monsoon (October to December), there were no rains as against of normal 29.8 mm. During summer, 70.9 mm rainfall was received which was 46.7 mm excess by normal 24.2 mm.

Normal onset of monsoon : 25 June

Onset of monsoon during 2015-16 : 23 June

Annual mean rainfall : 817.5 mm

Annual rainfall during 2015-16 : 508 mm

Mean crop seasonal rainfall during *kharif* and *rabi* : 742.3 and 29.8 mm, respectively

Crop seasonal rainfall during 2015-16 : 387 mm in *kharif* and no rainfall in *rabi*

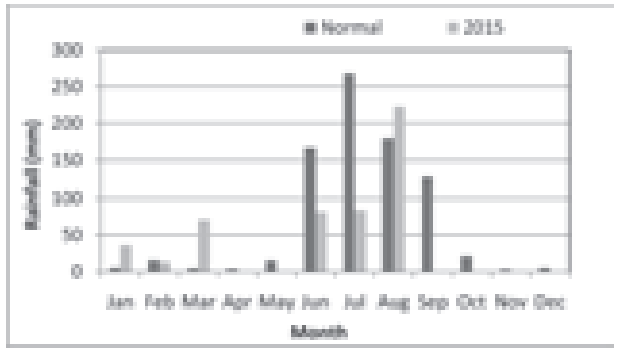


Fig. 1.5.6: Normal and actual (2015) monthly rainfall at Kadesara Kalan village

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
-	20 August to harvesting	Blackgram, groundnut, sesame	Pod development & maturity
		Sorghum	Grain filling & maturity

Salient achievements of on-farm demonstrations

Real time contingency planning: Nil

Preparedness

Cropping systems

During *kharif* 2015, drought tolerant variety of groundnut (Utkarsh) was demonstrated in farmers' fields. The variety Utkarsh recorded higher pod yield of 863 kg/ha, net returns of Rs.18397/ha, B:C ratio of 1.12, and RWUE of 1.12 kg/ha-mm compared to local variety (724 kg/ha; Rs. 12795/ha, 1.78, 2.00, respectively). Similarly, improved variety of blackgram Sekhar recorded higher seed yield of 796 kg/ha, net returns of Rs.23790/ha, B:C ratio of 1.50 and RWUE of 2.20 kg/ha-mm compared to local variety (485 kg/ha).

During *kharif* 2015, the drought tolerant varieties of blackgram were demonstrated in farmers' fileds. Among different varieties, Azad- 3 recorded higher seed yield of 781 kg/ha, net returns of Rs.324642/ha, B:C ratio of 1.50, and RWUE of 2.16 kg/ha-mm compared to other varieties and local check (Table)

Table: Performance of improved varieties of blackgram

Variety	Seed yield (kg/ha)	Stover yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Azad- 3	781	2148	18.3	2.16	24642	1.50
Sekhar -1	683	2445	8.5	1.89	21190	1.29
Uttara	760	2407	16.2	2.10	24469	1.49
Local	598	2268	-	1.66	16899	1.03

1.6 Soybean Based Production System

1.6.1 INDORE

a. Agro-ecological setting

The Indore centre is located in Central highlands (Malwa) Gujarat plain Kathiawar peninsula semi-arid eco region (AESR 5.1) and Malwa plateau in Madhya Pradesh. The climate is hot dry semi-arid and annual rainfall is 944 mm.

b. On-station experiments

Experienced weather conditions during 2015-16

During 2015, an annual rainfall of 1252.4 mm was received which was excess by 294.4 mm compared to normal (958 mm) (Fig.). During South-west monsoon (*kharif),* the rainfall received was 1174.1 mm whereas the normal was 854.5 mm which was excess by 319.61 mm (37.4%). During North-east monsoon (October-December), 4.5 mm rainfall was received which was deficit by 60.0 mm (93%) compared to normal (64.5 mm). During summer, 13.2 mm rainfall was received which was deficit by 17.5 mm (56.9%) compared to normal (30.6 mm). The onset of monsoon was normal (14 June).

Normal onset of monsoon	:	12 June
Onset of monsoon during 2015-16	:	14 July
Annual mean rainfall	:	958 mm
Annual rainfall during 2015-16	:	1252.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	854.5 and 64.5 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi)*	:	1174 and 4.5 mm, respectively

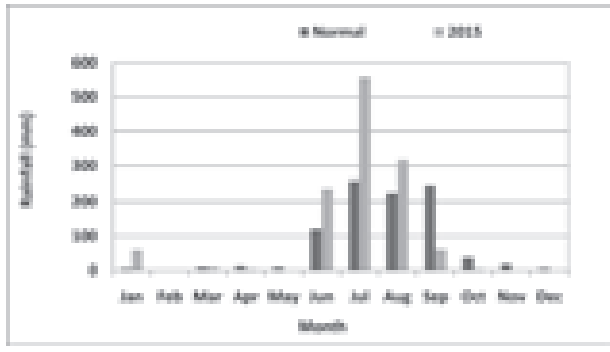


Fig. 1.6.1: Normal and actual (2015) monthly rainfall at Indore

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop	Remark
Duration (days)	Dates & months			
24	26 June-18 July	Soybean, maize pigeonpea	Seedling & vegetative	-
31	13 August-13 September	Soybean, maize	Reproductive (Flowering; and pod formation in soybean)	61.8 mm rainfall was received from 14-19 September 2015. (4 days)
10	20 - 30 September	Soybean, maize Pigeonpea	Grain filling vegetative	

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Soybean	Seedling	In-situ moisture conservation Weeding/intercultural operations
Mid season drought	Soybean	late vegetative	Supplemental irrigation Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

The onset of monsoon during the year was normal (14 June). However, a 3 dry spell of 24 days (26 June-18 July) occurred at seedling stage which affected soybean, maize and pigeonpea.

The intervention of *in-situ* soil moisture conservation with plastic mulching gave higher, soybean (JS 95-60) seed yield by 129% (385 kg/ha), RWUE of 0.56 kg/ha-mm and B:C ratio of 0.77 compared to farmers' practice (168 kg/ha). However, the net returns were negative (Rs.3680/ha) due to lo crop yield.

Soybean (JS 93-05) with one supplemental irrigation (at seedling stage, 80 mm) recorded highest seed yield (465 kg/ha) over without irrigation (375 kg/ha) with an yield increase of 24%, WUE and B:C ratio of 0.59 kg/ha-mm and 0.93, respectively. However, the severe drought at late vegetative phase and moisture stress at grain filling stage reduced the overall productivity of soybean which resulted negative net returns (Rs.1120/ha).

The intercultural operation at early stage of the soybean with hand hoe recorded 17.8% higher seed yield (248 kg/ha) but intercultural operation twice with bullock drawn *doura* enhanced the productivity by 80% over without intercultural operation (250 kg/ha). However, long drought experienced by the crop reduced the overall seed yield (Table 1.6.1).

Table 1.6.1 : Effect of weeding/intercultural operation on soybean under early season drought

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With weeding/ interculture	Without weeding/ interculture				
One intercultural operation with hand hoe on 2 July 2015						
JS95-60 (DOS: 14 June)	248	154	17.8	0.36	-8064	0.50
Intercultural operation using bullock drawn *doura* twice (17 July and 27 July 2015						
JS95-60 (DOS: 25 June)	450	250	80.0	0.65	-1600	0.90

Spraying of chemicals increased the seed yield by 17-89%. The highest seed yield (318 kg/ha) was recorded with foliar spray of KCl 1% followed by thiourea and VAM C. However, very low productivity of soybean was due to very high intensity rains along with severe drought and pest attack on the crop (Table 1.6.2)

Table 1.6.2 : Effect of foliar spray of chemicals on soybean under early season drought

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
Thiourea 1%	239	168	42.3	0.35	-8352	0.48
KCl 1%	318	168	89.3	0.46	-5824	0.64
KNO_3 1%	198	168	17.8	0.29	-9664	0.40
Cholormequet ethyl 50% SL (VAM C) @ 375 ml/ha	240	168	42.8	0.35	-8320	0.48

Situation: Mid season drought

In 2015, the rainfall was excess by 40.8% in August and deficit by 75% in September. During *kharif* season, one dry spell of 31 days was recorded during 13 August to 13 September at reproductive stage of soybean. One supplemental irrigation given on 25 August (initiation of flowering; 60-90 mm) improved the soybean yield (400 kg/ha) by 33.3% in JS 335 and through flood (350 kg/ha) by 27.3% in RVS 2001-04 over without irrigation. (Table 1.6.3).

Table 1.6.3 : Effect of supplementary irrigation on soybean seed productivity under mid season drought

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With Irrigation	Without Irrigation				
JS 335	400 (Sprinklers)	300	33.3	0.53	-3200	0.80
RVS 2001-04	350 (Flood)	275	27.3	0.44	-7200	0.70

Foliar spray with thiourea @ 1% done during mid season drought (branching and early flowering stage of soybean) gave higher seed yield of 333 kg/ha, with B:C ratio of 0.66 and RWUE of 0.48 kg/ha-mm followed by KNO_3 1% and KCl 2% with yield increase by 39.9, 37.4 and 22.2% respectively (Table 1.6.4).

Table 1.6.4 : Effect of foliar spray of chemicals on soybean under mid season drought

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
Thiourea 1% sol.	333	238	39.9	0.48	-5344	0.66
KCl 2%solution	306	238	22.2	0.44	-6208	0.61
KNO_3 1% solution	327	238	37.4	0.47	-5536	0.65

Preparedness

Rainwater management

Soybean with raised bed (90 cm width with 3 rows/bed) planting gave higher yield 542 kg/ha with net returns, B:C ratio and RWUE of Rs. 1344/ha, 1.08 and 0.78 kg/ha-mm, respectively.

Cropping systems

In an assessment of soybean based cropping systems, maize + soybean system recorded soybean crop equivalent yield, net returns, and B:C ratio of 1896 kg/ha, Rs. 40672/ha and 2.03, respectively with a RWUE of 6.64 kg/ha-mm. Soybean - chickpea cropping sequence provided highest soybean equivalent yield (1249 kg/ha), net returns (Rs 11976/ha), B:C ratio of 1.43 and RWUE of 1.81 kg/ha-mm.

Under the weather situation of *kharif* 2015, where 2 long dry spells and 4 high intensity rain events occurred, among all the crops tested, maize (NK 6240)/Patidar 999 gave highest soybean equivalent yield (925 kg/ha), net returns (Rs.7601/ha) and RWUE (1.33 kg/ha-mm) than other crops (Table 1.6.5).

Among the four soybean varieties, JS20-29 recorded highest soybean equivalent yield (578 kg/ha), net returns (Rs. 2496/ha), B:C ratio (1.15) and RWUE of 0.84 kg/ha-mm, followed by JS 20-34, NRC 86 and Soybean 1025, respectively even under the adverse climatic conditions (Table 1.6.6).

Table 1.6.5: performance of different crops during *kharif* season

Crops	Yield (kg/ha)	SEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Maize (NK 6240)/Patidar 999	2277	925	7601	1.34	1.33
Pearlmillet	1374	558	3862	1.27	0.81
Sorghum	1577	591	4924	1.35	0.85
Soybean (JS 93-05)	72	72	-13696	0.1	0.01
Greengram	99	185.6	-10040	0.30	0.26
Blackgram	230	431	-4800	0.65	0.62

Table 1.6.6: Performance of soybean varieties under aberrant weather conditions

Variety	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
JS 20-29	578	2496	1.15	0.84
NRC 86	193	-9824	0.39	0.27
JS 20-34	355	-4640	0.71	0.53
Soybean 1025	132	-11776	0.26	0.19

Among the 3 sowing methods of chickpea *viz.*, sowing on residual soil moisture, presowing irrigation (*Palewa*) and dry sowing and come up irrigation, chickpea (RVS 202) with dry sowing and come up irrigation gave highest yield, net returns and B:C ratio of 797 kg/ha , RS. 25850/ha and 2.85 respectively, whereas under sowing on residual soil moisture, chickpea variety JG 593 performed well with respect to seed yield (618 kg/ha), net returns (Rs.16900/ha) and B:C ratio (2.21) among all varieties (Table 1.6.7).

Table 1.6.7: Performance of chickpea varieties under aberrant weather conditions

Variety	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Sowing on residual soil moisture (01-10-2015)			
JAKI 9218	282	100	1.01
JG 130	290	500	1.04
JG 412	321	2050	1.15
JG 6	396	5800	1.41
JG 593	618	16900	2.21
UJJAIN 21	511	11550	1.82
Pre sowing irrigation (Palewa) (DOS: 06-11-2015)			
Digvijay	474	9700	1.69
Dry sowing and come up irrigation (DOS: 10-11-2015)			
RVS 203	667	19350	2.38
RVS 202	797	25850	2.85

c. On-farm demonstrations

Village profile

The program is being implemented in Nignoti village in Indore district, Madhya Pradesh. The total cultivated area is 248 ha out of which 100 ha is rainfed. The mean annual rainfall is 958 mm with seasonal rainfall of 1082.8 mm during *kharif* (June-September 2015). 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 958 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 the 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 as the rains have accrued between 22-42 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 has 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 has been considerable shift in the rainfall pattern and sowing window for soybean is from 23-25 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 2015-16

During 2015, a rainfall of 1082.8 mm was received which was excess by 157 mm compared to normal (925.8 mm) (Fig.). During South-west monsoon (*kharif)*, 1082.8 mm of rainfall was received where as the normal was 857.6 mm which was excess by 225.2 mm (26.3%). During North-east monsoon and summer, there was no rainfall.

Normal onset of monsoon	:	12 June
Onset of monsoon during 2015-16	:	11 June
Annual mean rainfall	:	925.8 mm
Annual rainfall during 2015-16	:	1082.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	857.6 and 48.5 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*)	:	1082.8 mm and no rainfall, respectively

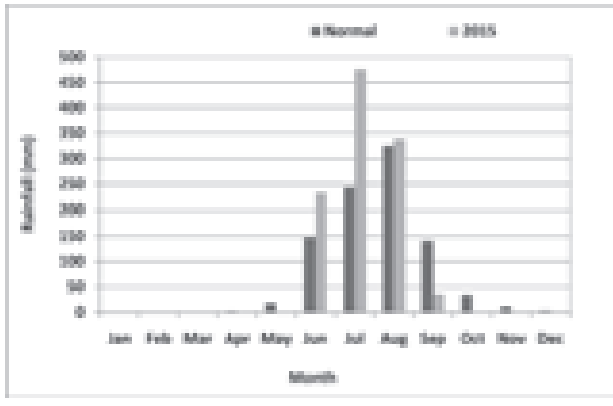


Fig. 1.6.2: Normal and actual (2015) monthly rainfall at Nignoti village

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop	Remark
Duration (days)	Dates & months			
27	24 June-19 July	Soybean, maize, pigeonpea	Seedling vegetative	-
29	16 August -13 September	Soybean, maize	Reproductive stage	-
10	19 – 30 September	Soybean, maize	Grain filling	35.9 mm rainfall was received during 13-18 September 2015
		Pigeonpea	vegetative	

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Early season drought	Soybean	Supplemental irrigation
		Weeding/intercultural operation
		Foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During 2015, in Nignoti village, in *kharif* 1082.8 mm of rainfall was received whereas the normal was 857.6 mm which was excess by 225.2 mm (26.3%). There were a dry spells of 27 days from 24 June -19 July, 29 at seedling stage which affected soybean and maize. The seed yield of soybean was 1080 kg/ha with a net returns and B:C ratio of Rs.18560/ha and 2.16 respectively, and the yield increased by 22.7% due to supplemental irrigation at early vegetative stage over without irrigation (880 kg/ha).

The seed yield of soybean cv. JS 93-05 (1060 kg/ha), increased by 8% due to weeding/intercultural operation over without weeding (980 kg/ha). The crop with intercultural operation recorded net returns of Rs 17920/ha and B:C ratio of 2.12.

The spraying of chlormequet chloride (VAM-C) 50 SL @ 375 ml/ha and thiourea @ 250 g/ha using 400 lit water/ha at 50-55 DAS increased seed yield by 6-8% and 3-50% respectively over without foliar spray. Among the soybean varieties JS 95-60 gave highest yield (950 kg/ha), net returns (RS.14100/ha) and B:C ratio (0.86) with the spray of chloromequate chloride(VAM-C) 50 SL @375 ml/ha. However, foliar spray with thiourea @ 250 g/ha on soybean (BS-2) gave highest yield (1240 kg/ha), net returns (Rs. 23680/ha) and B:C ratio 1.48 over the other varieties (Table 1.6.8).

Table 1.6.8: Effect of foliar spray of chlormequat chloride (VAM-C) and thiourea on soybean

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
Chloromequate chloride (VAM-C) 50 SL @ 375 ml/ha						
Soybean 1025	853	787	8.5	1.10	11007	0.68
JS 95-60	950	875	8.4	1.23	14100	0.86
JS 93-05	907	853	6.7	1.17	12713	0.78
Thiourea @ 50 g/ha						
Soybean 1025	780	720	9.9	1.005	8960	0.56
JS-95-60	1000	960	4.4	1.205	16000	1.00
JS 93-05	840	780	7.8	1.08	10880	0.68
BS-2	1240	1200	3.3	1.60	23680	1.48
RVS 2001-4	720	480	50	0.93	7040	0.44

Preparedness

Rainwater management

Sowing of soybean with broad bed furrow planting system gave maximum yield (600 kg/ha) with a net returns and B:C ratio of Rs. 3200/ha and 0.20 respectively. The yield was 7.1% higher compared to farmer's practice of flat sowing (560 kg/ha).

Cropping systems

Among different soybean varieties cv JS 95-60 produced maximum seed yield (867 kg/ha), net returns (Rs. 15744/ha), B:C ratio (2.31) and RWUE (1.12 kg/ha-mm) followed by JS93-05, JS 335 and RVS 2001-04. Among all the varieties, JS 95-60 was short duration (95 Days) harvested earlier and escaped from the terminal moisture stress (Table 1.6.9).

Table 1.6.9: Performance of soybean varieties

Variety	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
RVS 2001-04	688	6016	1.83	0.89
JS95-60	867	15744	2.31	1.12
JS 335	720	11040	1.92	0.93
JS 93-05	800	13600	2.13	1.03

Nutrient management

Sulphur supplementation on the basis of soil tests along with RDF (T_1) produced higher soybean yield (1094 kg/ha), net returns (Rs.18708/ha) and B:C ratio (1.15) as compared to farmers practice (T_2- 50 kg DAP applied at the time of sowing) (Table 1.6.10).

Table 1.6.10: Soil test based nutrient management in soybean

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Nitrogen supplement					
T1	876	830	11632	0.71	1.136
T2	830	775	10560	-	1.072
Phosphorus supplement					
T1	896	960	12272	0.75	1.159
T2	892	935	12544	-	1.153
Sulphur supplement					
T1	1094	1025	18708	1.15	1.414
T2	978	915	15296	-	1.266

T_1 –Nutrient supplement on the basis of soil tests RDF
T_2- Farmers' practice (50 kg DAP applied at the time of sowing)

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

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was delayed by 10 days (02nd July). A rainfall of 1064 mm was received which was deficit by 2.4% compared to normal rainfall of 1090 mm. The rainfall during *kharif* season was 857.6 mm as against normal rainfall of 965.1 mm. During *rabi* season, the rainfall was excess by 129.9 % (115.2 mm) compared to normal rainfall of 50.1 mm (Fig.).

Normal onset of monsoon : 23 June

Onset of monsoon during 2015-16 : 02 July

Normal annual rainfall : 1090 mm

Annual rainfall during 2015-16 : 1064 mm

Normal crop seasonal rainfall during *kharif* & *rabi* : 965.1 mm and 50.1 mm

Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*) : 857.6 mm and 115.2 mm

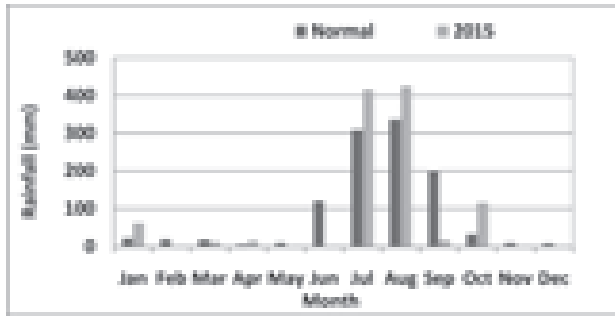


Fig. 1.6.3: Normal and actual (2015) monthly rainfall at Rewa

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
20	2 - 21 September	Soybean Paddy Sorghum Maize Pigeonpea Sesamum	Vegetative Tillering Knee high stage Silking and tasseling Branching Flowering
30	23 September - 21 October	Soybean Rice Sorghum Maize Sesamum	Flowering and pod development Panicle initiation /flowering Grain filling Cob formation and grain filling Capsule formation

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Soybean, paddy, greengram, blackgram	-	Use of early maturing varieties
Mid season drought	Soybean, paddy	Flower initiation / panicle initiation	Weeding, interculture, life saving irrigation
Terminal drought	Soybean	Seed/grain filling	Hoeing , life saving irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

The onset of monsoon was delayed by 10 days i.e. 2nd July 2015 and the rainfall received 1064 mm was deficit by 2.4% compared to normal rainfall of 1090 mm. Under delayed monsoon situation, early maturing varieties of soybean and pulses were evaluated. Among soybean varieties, JS 20-29 recorded higher seed yield (1016 kg/ha) with a net returns of Rs. 29720/ha, RWUE 1.18 kg/ha-mm and B:C ratio of 2.85. Similarly improved varieties of blackgram (PU 30), greengram (TJM 12), sesame (TKG 21) and pigeonpea (Asha) also gave higher yield, net returns and B:C ratio compared to farmers local varieties (Table 1.6.11).

Table 1.6.11: Performance of crop varieties under delayed onset of monsoon

Crop	Variety/ duration (days)	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Soybean	JS 335 (130)	457	0.53	4565	1.28
	JS 93-05 (115)	889	1.03	24005	2.50
	JS 95-60 (110)	346	0.40	-430	0.97
	JS 20-29 (100)	1016	1.18	29720	2.85

Crop	Variety/ duration (days)	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Blackgram	PU 30 (65)	632	0.73	38560	4.21
	JU 2 (62)	581	0.67	34480	3.87
	DU 4 (65)	477	0.55	26160	3.18
Greengram	HUM 1 (65)	478	0.55	28630	3.38
	TARM 18 (67)	425	0.50	24125	3.01
	TJM 12 (63)	467	0.54	27695	3.82
Sesame	TKG 21 (85)	350	0.40	11200	2.06
Pigeonpea	Asha (185)	1780	2.07	64100	5.00

Situation: Mid season drought

One dry spell of 20 days was recorded (2-21 September) at maximum vegetative stage of soybean, maximum tillering stage of paddy, silking and tasseling stage of maize and branching stage of pigeonpea. Blackgram and greengram crops were at maturity stages and were not affected much.

In-situ soil moisture conservation through interculture (9-12 September) with hand hoe and wheel hoe gave 149.3% higher seed yield (910 kg/ha) with net returns of Rs. 24950/ha, RWUE of 1.06 kg/ha-mm and B:C ratio of 2.55 compared to farmer's practice. Similarly pigeonpea gave higher seed yield of 1810 kg/ha, net returns Rs. 65450/ha and B:C ratio of 5.09 as compared to farmer's practice (1465 kg/ha) (Table 1.6.12).

Table 1.6.12: Effect of interculture on crop yield and economics

Crop	Variety /duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation	With normal practice			
Soybean	JS 335 (130)	470	255	0.54	5150	1.32
	JS 93-05 (115)	910	-	1.06	24950	2.55
	JS 95-60 (110)	415	-	0.48	2675	1.16
	JS 20-29 (100)	1120	-	1.30	34400	3.15
Pigeonpea	Asha (185)	1810	1465	2.11	65450	5.09

Foliar spray of KNO_3 (1% solution) done on soybean crop at 30 and 60 days of after crop establishment (8 August and 6 September 2015) gave higher seed yield of 1210 kg/ha, with net returns of Rs.38450 /ha, B:C ratio of 3.40 and RWUE of 1.41 kg/ha-mm compared to without foliar spray (650 kg/ha).

c. On-farm demonstrations

Village profile

The program is being implemented in the village Raura and Patuna, 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 950 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 Patuna 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 2015-16

During 2015, the onset of monsoon was delayed by 7 days (30th June). The rainfall was deficit by 45.9% compared to total rainfall of 1080 mm and 53% deficit during *kharif* season compared to seasonal rainfall (965 mm). However, during *rabi*, 45 mm rainfall was received against normal rainfall of 50 mm (Fig. 1.6.4).

Normal onset of monsoon	:	23rd June
Onset of monsoon during 2015	:	30th June
Annual mean rainfall	:	1090 mm
Annual rainfall during 2015	:	590.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	965.1 and 50.1 mm, respectively
Crop seasonal rainfall during *kharif* and *rabi*	:	454 & 45 mm, 2015 respectively

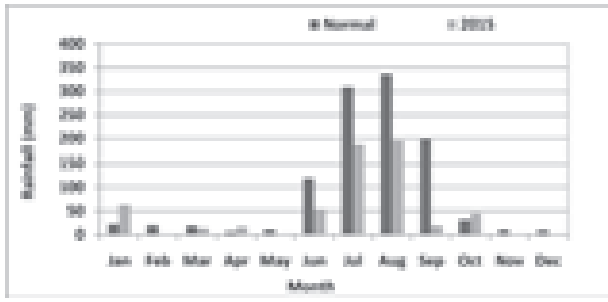


Fig. 1.6.4: Normal and actual (2015) monthly rainfall at Patuna and Raura villages

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
21	01 - 21 September	Soybean Rice Pigeonpea Sesamum	Maximum vegetative Maximum tillering Branching Flowering
30	21 September - 22 October	Soybean Rice Pigeonpea Sesamum	Flowering and pod development Panicle initiation / flowering Branching Capsule formation / seed development

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented	No. of farmers	Area (ha)
Delayed onset of monsoon (Delayed by 7 days)	Soybean	Use of early maturing varieties		
		JS 335	03	1.2
		JS 93-05	03	1.2
		JS 95-60	03	1.2
	Greengram	HUM 1	03	0.6
	Blackgram	PU 30	02	0.8
		JU 2	02	0.8
		DU 4	02	0.8
Mid season drought	Soybean, rice	Hoeing /life saving irrigation	06	2.4
Terminal drought	Soybean, rice	Hoeing /life saving irrigation	06	2.4

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2015, the onset of monsoon was delayed by 7 days (30th June). Under such situation drought tolerant and early maturing varieties of soybean, blackgram, pigeonpea and paddy were introduced. Among three varieties of soybean, JS 93-05 recorded highest seed yield (750 kg/ha) as compared to JS 335 and JS 95-60. Similarly, among the three paddy varieties, Sahabhagi recorded highest grain yield of 1810 kg/ha, along with highest net return (Rs. 13150/ha), B:C ratio (1.93) and RWUE (1.45 kg/ha-mm) over other varieties. In blackgram, variety PU 30 gave highest seed yield (650 kg/ha) over farmers' variety (530 kg/ha). In pigeonpea, variety Asha gave higher seed yield of 1650 kg/ha as compared to farmers' variety (1465 kg/ha) (Table 1.6.13).

Table 1.6.13: Performance of improved varieties of crops under delayed onset of moonsoon

Crop	Variety /duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With normal practice			
Soybean	JS 335(130)	350	255	0.78	750	1.05
	JS 93-05 (115)	750	365	1.68	18750	2.25
	JS 95-60(110)	325	180	0.73	-375	0.97
Blackgram	PU 30 (65)	650	530	1.46	41000	4.72
	JU 2 (70)	610	480	1.37	37800	4.43
	DU 4 (70)	510	392	1.15	29800	3.70
Pigeonpea	Asha (185)	1650	1465	3.71	74750	5.67
Rice	Shahbhagi (110)	1810	1620	1.45	13150	1.93
	Danteshwari (108)	1780	1560	4.00	12700	1.90
	IR 64 (110)	1650	1485	3.71	10750	1.76

Situation: Mid season drought

There was a dry spell of 21 days (01 to 21 September) coinciding with flower initiation in soybean and panicle initiation in rice. The *in- situ* moisture was conserved through hoeing with the help of hand hoe in soybean and paddy. Among three varieties of soybean, JS 93-05 recorded highest seed yield (860 kg/ha) as compared to JS 95-60 and JS 335. Similarly, among the three paddy varieties, Sahabhagi recorded highest grain yield of 2050 kg/ha, net returns (Rs. 16750/ha), B:C ratio (2.20) and RWUE (4.61 kg/ha-mm) over other varieties (Table 1.6.14)

Table 1.6.14: Performance of improved varieties of crops under *in-situ* moisture conservation

Crop	Variety/ duration (days)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation	With normal practice				
Soybean	JJS 335 (130)	280	255	49.0	0.85	2100	1.14
	JS 93-05 (115)	860	365	135.6	1.93	23700	2.58
	JS 95-60 (110)	475	180	163.9	1.06	6375	1.42
Rice	Shahbhagi (110)	2050	1620	26.5	4.61	16750	2.20
	Danteshwari (108)	1855	1560	18.9	4.17	13825	1.98
	IR 64 (110)	1720	1485	15.8	3.87	11800	1.84

Life saving irrigation was provided from collected water in bunded fields during 10-15 September 2015 to soybean and rice. Among different varieties of soybean JS 93-05 recorded maximum seed yield (1065 kg/ha), net returns (Rs. 32925/ha) and B:C ratio (3.19) followed by JS 335 and JS 95-60 over without irrigation. Similarly, Shahbhagi variety of paddy recorded highest grain yield (2215 kg/ha) with supplemental irrigation as compared to no irrigation (1620 kg/ha). The highest RWUE (4.98 kg/ha-mm), net returns (Rs.19225/ha) and B:C ratio (2.37) were also recorded with Shahbhagi as compared to Danteshwari and IR-64 (Table 1.6.15).

Table 1.6.15: Performance of soybean and rice varieties under supplemental irrigation

Crop	Variety/ duration (days)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With Irigation	Without irrigation				
Soybean	JS 335	550	255	115.7	1.23	9750	1.65
	JS 93-05	1065	365	191.8	2.40	32925	3.19
	JS 95-60	510	180	183.3	1.14	7950	1.53
Rice	Sahabhagi	2215	1620	36.7	4.98	19225	2.37
	Dantashwari	2080	1560	33.3	4.68	17200	2.22
	IR 64	1865	1485	25.6	4.20	13975	2.00

Preparedness

Cropping systems

In an on-farm demonstration of different intercropping systems, soybean+ pigeonpea (4:2) and wheat+ mustard intercropping systems recorded in maximum crop equivalent yield, net returns and B:C ratio than the farmer's practice (mixed cropping of soybean + pigeonpea and wheat + mustard) (Table 1.6.16).

Table 1.6.16: Yield and economics of intercropping systems

Treatment	Yield (kg/ha)		MCEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop				
Soybean+ pigeonpea (4:2)	285	1450	2057	72565	4.62	4.63
Wheat+ mustard	2680	400	3730	44680	3.97	-
Soybean + pigeonpea (mixed)	150	1110	1506	55770	5.64	
Wheat + mustard (mixed)	1850	230	2453	28248	3.56	

Among different relay cropping systems, relay cropping involving rice -wheat system with improved practices recorded higher yield of rice (1850 kg/ha) and wheat (2785 kg/ha), net returns and B:C ratio of Rs.42310/ha and 2.41 respectively. Similarly soybean-chickpea recorded higher yield of soybean (315 kg/ha) and chickpea (1440 kg/ha), net returns (Rs.58175/ha) and B:C ratio (3.07) than the farmers practice (Table 1.6.17).

Table 1.6.17: Yield and economics of double/relay cropping systems

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Crop 1	Crop 2			
Rice –wheat	1850	2785	30000	42310	2.41
Soybean -chickpea	315	1440	28000	58175	3.07
Rice – lentil	1755	1110	27000	65925	3.44
Farmers' practice*					
Rice-wheat	1660	2433	28000	35828	2.27
Soybean-chickpea	260	1215	27000	51525	2.90

Nutrient management

The recommended dose of nutrients applied to rice during *kharif* along with 0.1% solution of urea during maximum tillering stage (42 DAS) gave higher grain yield (2125 kg/ha), stover yield (3850 kg/ha), net returns (Rs.16875/ha) and B:C ratio (2.12) than the farmer's practice (1725 kg/ha). During *rabi*, wheat crop applied with 2% solution of urea at 45 DAS gave highest gran yield with net returns and B:C ratio (3215 kg/ha, Rs.34940/ha and 3.11, respectively) over without foliar nutrition (2375 kg/ha).

Table 1.6.18: Effect of foliar nutrition on yield and economics of different crops

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw				
Foliar nutrition of urea 0.1% in rice	2125	3850	15000	16875	2.12	4.78
Foliar nutrition of urea 2% in wheat	3215	4865	16500	34940	3.11	
Farmers' practice*						
Rice	1725	5510	11000	14875	2.35	3.88
Wheat	2375	4110	13000	25000	2.92	

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. Anantapur is basically a groundnut region but to a little extent sorghum is grown. Groundnut is grown with pigeonpea as an intercrop. Water erosion is of high severity with moderate loss of top soil, affecting 51-100% area. The predominant soils are shallow red soils. Available water capacity is low to medium. The dominant rainfed crops during *kharif* are groundnut and pigeonpea.

b. On-station experiments

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was timely (6th June). A total rainfall of 641 mm was received which was excess by 71 mm (12.5%) compared to normal (570 mm). Out of total rainfall 311.4 mm was received in *kharif* season which was 40.6 mm deficit (11.6%) than normal of 352 mm. In *rabi*, it was 152.8 mm and was excess by 8.8 mm (6.1%) than normal of 144 mm and in summer season, 176.8 mm rainfall was received which was excess by 105.3 mm (147.3%) than normal of 71.5 mm.

Normal onset of monsoon	:	1-5 June
Onset of monsoon during 2015-16	:	6 June
Annual mean rainfall	:	570 mm
Annual rainfall during 2015-16	:	641 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	352 & 144 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*)	:	311.4 & 152.8, respectively

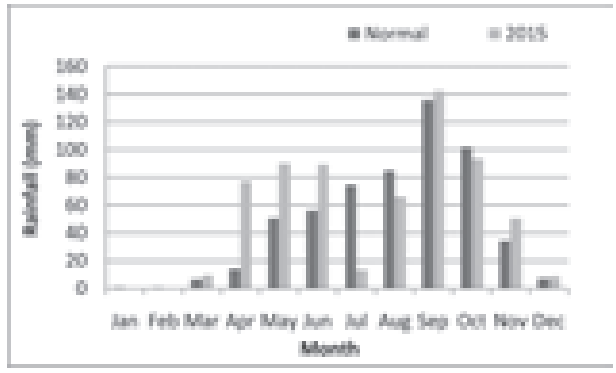


Fig. 1.7.1: Normal and actual (2015) monthly rainfall at Anantapur

Dry spells during crop growing season (2015-16)

Date of sowing	Crop	Dry spell		Stage of the crop
		Duration (days)	Dates & months	
17 June 2015	Groundnut	25	20 June to 14 July	Vegetative
		17	16 July to 1August	Flowering to pegging
	Pigeonpea	25	20 June to 14 July	Vegetative
		17	16 July to 1August	Vegetative
		25	17 October to 10 November	Flowering
		30	02 to 31 December	Pod development
	Castor	25	20 June to 14 July	Vegetative
		17	16 July to 1August	Vegetative

Date of sowing	Crop	Dry spell		Stage of the crop
		Duration (days)	Dates & months	
		25	17 October to 10 November	Spike emergence to capsule development
		30	02 to 31 December	Capsule development to maturity
03 August 2015	Pigeonpea	25	17 October to 10 November	Vegetative
		30	02 to 31 December	Flowering to pod initiation
	Castor	25	17 October to 10 November	Vegetative
		30	02 to 31 December	Spike emergence to capsule development
	Clusterbean	25	17 October to 10 November	Pod development to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season	Groundnut	Vegetative	Conservation furrows in between groundnut drought rows for *in-situ* soil moisture conservation at 20 DAS.
			Weeding at 20 DAS with tractor drawn (slim tyres) intercultivation implement
	Pigeonpea, castor	Vegetative	*In-situ* moisture conservation through conservation furrows and mulching with groundnut shells
Mid season drought	Groundnut	Flowering	Conservation furrows in between groundnut rows for *in-situ* soil moisture conservation at 40 DAS.
			Weeding at 40 DAS with tractor drawn (slim tyres) intercultivation implement
	Groundnut Pigeonpea Maize	Pod initiation Vegetative	Foliar spray *In-situ* moisture conservation through conservation furrows and mulching with groundnut shells
Terminal drought	Pigeonpea	Pod filling	Supplemental irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

When monsoon is delayed, sowing with contingent crops such as clusterbean, sorghum and horsegram is recommended instead of groundnut. During *kharif* 2015 there was no delay in monsoon. However, on receipt rainfall during August, contingent crops were sown on 3.8.2015. There was one dry spells during 17th October to 10th November i.e. 25 days coinciding with vegetative stage of pigeonpea, castor and pod development stage in clusterbean. Among different crops sown on 3.8.2015, pearlmillet gave higher grain yield (1295 kg/ha), with higher net returns (Rs.21858/ha), B:C ratio (1.90) and RWUE (3.69 kg/ha-mm) compared to other crops (Table 1.7.1).

Table 1.7.1: Yield of contingent crops sown in August (D.O.S: 3.8.2015)

Crop	Yield (kg/ha)	GEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Jowar	538	275	2.50	13170	1.26
Horsegram	529	223	1.47	7544	1.11
Foxtail millet	642	357	2.12	17587	2.50
Pigeonpea	392	697	1.09	19314	1.60
Clusterbean	536	322	1.77	7657	0.63
Greengram	268	357	0.89	10767	0.96
Bajra	1295	489	3.69	21858	1.90
Groundnut (check)	796	796	2.54	19782	0.94

Situation: Early season drought

During 2015, the rainfall was deficit by 4.9% in June, 86.4% in July and 31.5% in August. During this period, 1 dry spell of 25-30 days duration was experienced which mainly coincided with seedling and vegetative stages of different crops.

In groundnut intercultivation with tractor drawn (slim tyres) intercultivation implement was taken up at 20 DAS instead of weeding with *danthulu* which resulted 2.5% yield improvement compare to normal practice. Groundnut (K-6) gave higher pod yield (2069 kg/ha), net returns (Rs.62768/ha), B:C ratio (3.13) and RWUE of 2.2 kg/ha-mm, compared to normal practice (2018 kg/ha).

Situation: Midseason drought

In 2015, two dry spells during 17th October to 10th November i.e. 25 days and 2 to 31 December i.e. 30 days were experienced which coincided with flowering, pegging and pod development stages of groundnut, pigeonpea, castor and pod development stage in clusterbean.

In groundnut, spraying of KNO_3 @ 1% during pod initiation stage recorded higher yield (1447 kg/ha) and B:C ratio (2.20) over control. In groundnut + pigeonpea intercropping systems (7:1), spraying of KNO_3 @ 1% during pod initiation stage recorded higher groundnut yield (1454 kg/ha) and pigeonpea yields (1444 kg/ha) compared to no foliar spray. However, spraying with KCl @ 1% recorded higher B:C ratio (2.31).

Table 1.7.2 : Yield of crops as influenced by foliar spray

Crop	Variety	Chemical sprayed	Pod yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With foliar spray	Without foliar spray				
Groundnut (sole)	K-6	KNO_3 1%	1447	1316	10.0	4.03	49098	2.20
		KCl 1%	1370	1316	4.1	3.81	45655	2.15
Groundnut +	K-6	KNO_3 1%	1454	1243	17.0	4.05	49025	2.19
pigeonpea	LRG-41	KCl 1%	1444	1243	16.2	4.02	49167	2.31

Situation: Terminal drought

In 2015, the rainfall was deficit in October (8.5%) and excess by 46.8% in November and 17.8% in December. Two dry spells during 17th October to 10th November i.e. 25 days and 2 to 31 December i.e. 30 days were experienced which coincided with pod development to maturity stages of groundnut, pigeonpea and castor.

Due to receipt of rainfall in the month of September and October months farm ponds were filled, using this water supplemental irrigation (20 mm) was given to pigeonpea at flowering and pod development stage. Supplemental irrigation to pigeonpea gave higher seed yield (651 kg/ha) net returns (Rs 37034/ha), B:C ration (2.46) and RWUE (1.57 kg/ha-mm) over no supplemental irrigation (424 kg/ha).

Due to receipt of rainfall on 27.9.2015, horsegram sowing was taken up on 23.8.2015 as succeeding crop after harvesting of clusterbean and which gave 396 kg/ha additional yield over clusterbean alone (781 kg/ha) with higher net returns (Rs.14543/ha) and B:C ratio of 0.93 (Table 1.7.3).

Table 1.7.3: Yield of horsegram as succeeding crop after harvesting of clusterbean

Crop	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Clusterbean	Horsegram			
Clusterbean alone	781	-	2.74	9949	0.89
Clusterbean - horsegram	781	396	2.55	14543	0.92

Preparedness

Rainwater management

In-situ moisture conservation through conservation furrow and mulching with groundnut shell were done in pigeonpea (LRG-41) and castor (Haritha). In pigeonpea, higher seed yield of pigeonpea (610 kg/ha) was recorded with *in-situ* moisture conservation through conservation furrow and mulching with groundnut shell over control (270 kg/ha). The increase in yield was 126% over control. Higher RWUE (1.48 kg/ha-mm), net returns (Rs.36754/ha) and B:C ratio (3.05) were recorded with conservation furrow + mulching compared to control (Table....). Similarly, *in-situ* moisture conservation through conservation furrow and mulching with groundnut shell in castor recorded higher seed yield (620 kg/ha) over control (250 kg/ha) and the increase in yield was 148% (Table1.7.4).

Table 1.7.4: Performance of crops under *in-situ* moisture conservation practices

Crop/variety	Intervention	Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Pigeonpea (LRG-41)	Conservation furrows+mulching	610	126	1.48	36754	3.05
	Conservation furrows	325	20	0.78	13954	1.16
	Only mulching Control	354	31	0.85	16274	1.35
		270	-	0.65	9554	0.79
Castor (Haritha)	Conservation furrows+mulching	620	148	1.73	5660	0.35
	Conservation furrows	310	24	0.87	-5190	-0.32
	Only mulching Control	460	84	1.28	60	0.003
		250	-	0.70	-7290	-0.45

Cropping systems

Among groundnut varieties K-1811 gave higher pod yield (2192 kg/ha) with higher net returns (Rs.97741/ha), B:C ratio (4.44) and RWUE (4.78 kg/ha-mm) followed by Dharani (1820 kg/ha) and Harithandhra (1809 kg/ha) compared to other varieties (Table 1.7.5).

Table 1.7.5 : Performance of groundnut varieties under rainfed *Alfisols*

Variety	Pod yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With supplemental irrigation	Without supplemental irrigation				
K6	2192	1833	19.59	4.78	97741	4.44
K9	1459	1109	31.56	3.18	66728	3.03
Harithandra	1809	1478	22.40	3.95	94757	4.31
Dharani	1820	1225	48.57	3.97	81731	3.72

Similarly, groundnut variety K-1812 gave higher pod yield (2114 kg/ha) with higher net returns (Rs.81598/ha), B:C ratio (3.87) and RWUE (5.73 kg/ha-mm) were recorded followed by K1811 (2047 kg/ha) and K 1805 (1990 kg/ha) compared to other varieties (Table 1.7.6).

Table 1.7.6 : Performance of groundnut varieties under rainfed *Alfisols*

Variety	Pod yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Narayani	1342	3.64	52236	2.48
K 1805	1990	5.39	78615	3.73
K1809	1967	5.33	75261	3.57
K1811	2047	5.54	77529	3.68
K1812	2114	5.73	81598	3.87

Among foxtail millet varieties, Sri Lakshmi gave higher grain yield (815 kg/ha), net returns (Rs.23444/ha), B:C ratio (3.34) and RWUE (3.08 kg/ha-mm) followed by SIA 3085 (Table 1.7.7).

Table 1.7.7 : Performance of foxtailmillet varieties under rainfed *Alfisols*

Variety	Gain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Narasimharaya	664	2.50	18926	2.70
Krishnadevaraya	487	1.84	11856	1.69
Sri Lakshmi	815	3.08	23444	3.34
SIA 3085	697	2.63	19424	2.77
Prasad	313	1.18	5748	0.82
Suryanandi	547	2.07	13691	1.95

c. On-farm demonstrations

Village profile

The program is being implemented in Vannedoddi villages in Gooty Mandal, Ananthapuramu district, Andhra Pradesh. The total geographical area of the village is 2025 acres. Out of this, gross cropped area is 985 acres, forest area 40 acres, barren and uncultivable lands 48 acres, others used 154 acres and current fallows is 154 acres. Predominant rainfed crops in this village are groundnut, red gram, castor, setaria, cotton and sorghum. Groundnut occupied 65-70% of total rainfed area.The mean annual rainfall is 657.7 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 657.7 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 has 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 2015-16

During 2015, in Vannedoddi village, onset of monsoon was 1st June and total rainfall received was 626.8 mm which was excess by 8.8 mm than normal of 618 mm. Out of the total annual rainfall received, *kharif* season recorded 333.2 mm (22.5% deficit than normal of 430 mm) and *rabi* season recorded 175 mm which was excess by 42 mm against normal of 133 mm and summer rainfall was 118.6 mm over normal rainfall of 53 mm.

Normal onset of monsoon	:	7-8 June
Onset of monsoon during 2015-16	:	1 June
Annual mean rainfall	:	618 mm
Annual rainfall during 2015-16	:	626.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	430 and 133 mm, respectively
Crop seasonal rainfall during 2015-16 *(kharif* and *rabi)*	:	333.2 mm and 175 mm, respectively

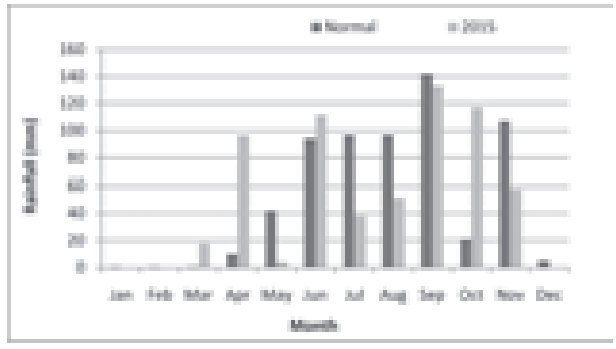


Fig. 1.7.2: Normal and actual (2015) monthly rainfall at Vannedoddi village

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
13 days	1 to 14 July	Groundnut, castor, cotton, pigeonpea	Vegetative
15 days	16 July to 02 August	Groundnut, castor, cotton, pigeonpea	Vegetative
25 days	09 October to 04 November	Groundnut	Maturity
		Castor, Cotton	2nd to third picking stage
		Pigeonpea	Pod development stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented	No. of farmers	Area (ha)
Early season drought	Groundnut	Drought tolerant variety (K-6)	15	12
	Castor	Improved varieties /Hybrids (GCH-111)	10	7
	Pigeonpea	Improved pigeonpea varieties PRG-158 and LRG-41	100	78
	Setaria	Improved setaria variety suryanandi	30	9
	Castor and pigeonpea	Conservation furrows in castor and groundnut	10	4
Mid season drought	Cotton and tomato	Micronutrient sprays	10	4
	Castor	Carbendazim spraying against botrytis	10	4
	Cotton	Pheromone traps for pink bollworm	6	2.7

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During 2015, in Vannedoddi village, onset of monsoon was 1st June and total rainfall received was 626.8 mm which was excess by 8.8 mm than normal of 618 mm. The rainfall was excess by 18.1% in June and deficit in 60.8% in July and 47.2% in August and 6.3% in September. There was one dry spells (1st to 14h July) of 13 days coinciding with vegetative stage of groundnut, pigeonpea, castor and cotton.

Among different crops groundnut (K-6) gave higher pod yield (1588 kg/ha), with higher net returns (Rs.54525/ha), B:C ratio (2.1) and RWUE (4.6 kg/ha-mm) compared to other crops. Conservation furrows improved yield in groundnut (5%), castor (11.3%), pigeonpea (9.2%) and cotton (6.4%). Due to formation of conservation furrows, additional net returns of Rs.820, Rs. 4650 and Rs.1350 were realized in castor, pigeonpea and cotton respectively when compared to control plots. (Table 1.7.8).

Table 1.7.8: *In-situ* moisture conservation with conservation furrows

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
		Conservation furrows	With normal practice		IP	FP	IP	FP	IP	FP
Groundnut	K-6	1588	1510	5	4.6	4.4	54525	52565	2.1	1.9
Castor	GCH-4	512	460	11.3	1.3	1.1	6920	6100	1.6	1.6
Pigeonpea	LRG-41	738	676	9.2	1.8	1.6	40350	35700	3.7	3.4
Cotton	Jadu	500	470	6.4	1.2	1.1	2500	1150	1.1	1.0

IP: Conservation furrow; FP: Farmers' practice

Situation: Mid season drought

During 2015, in Vannedoddi village, *kharif* season recorded 333.2 mm (22.5% deficit than normal of 430 mm). There was one dry spell 16 July to 2 August of 15 coinciding with flowering of groundnut, vegetative stage in pigeonpea, castor and cotton. To overcome these problems foliar sprays had were taken up. Continues rain in the month of August (51.2 mm in 8 rainy days), September (133 mm in 8 rainy days) and October (117.2 mm in 6 rainy days) at

flowering to maturity stages of castor resulted in occurrence of botrytis. Spraying of carbendazim to castor reduced botrytis intensity and improved yield by 7% (510 kg/ha) with net returns (Rs.2850/ha) compared to control (Rs.1660/ha).

Carbendazim and mancozeb spraying in groundnut improved yield by 8% (1365 kg/ha) compared to control and also recorded higher net returns (Rs.43250/ha) compared to no spray (Rs.36250/ha).

The micronutrient spraying containing $ZnSO_4$ 1%, $MgSO_4$ 1%, Boron 0.5% and 19:19:19 1% at flowering and 20 days after flowering resulted in reduction of reddening by 25% in rainfed cotton compared to no spraying. The micronutrient management resulted in 6% higher yield (500 kg/ha), net returns (Rs.2500/ ha), B:C ratio (1.1) and RWUE (1.2 kg/ha-mm) compared to without foliar spray (470 kg/ha).

Preparedness

Rainwater management

Tomato nursery was raised in field by using harvested rainwater with receipt rainfall of 22.8 mm on September 04th and then continuous rains (96.6 mm in 7 rainy days). Tomato was transplanted on 16th September in half an acre near farm pond. The farm pond was filled by the receipt of rainfall of 58.4 mm on 26.09.15. The harvested water was useful for pot watering at flowering stage of tomato. Tomato yield was recorded higher (3350 kg/ha), with higher net returns (Rs.15800/ha), B:C ratio (2.6) and RWUE (42 kg/ha-mm) compared to farmers' practice (Table 1.7.9).

Table 1.7.9: *Ex-situ* rainwater management in tomato

Treatment	Tomato yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
Farm pond	3350	11000	15800	2.6	42
Farmers' practice	3000	10000	14000	2.4	37

Cropping systems

Improved variety Kadiri-6 (1588 kg/ha) exhibited superiority over TMV-2 (1510 kg/ha). Highest RWUE was observed in Kadiri-6 (4.6 kg/ha-mm) over TMV-2 (4.4kg/ha-mm). Higher net returns were realized with Kadiri-6 (Rs.54525/ha) than TMV-2 (52625/ha).

In castor, hybrid GCH-4 performed better than local variety. GCH-4 recorded higher bean yield (550 kg/ha) with higher net returns (Rs.9250/ha), B:C ratio (1.9) and RWUE (1.1 kg/ha-mm) than local castor variety (480 kg/ha).

In pigeonpea, improved variety PRG-158 performed better than LRG-41 and local variety. Among three varieties of pigeonpea, PRG-158 recorded 22% higher yield (724 kg/ha) and LRG-41 (695 kg/ha) by 18% higher than local variety (590 kg/ha). PRG-158 recorded higher net returns of Rs.39300/ha than other varieties (Table 1.7.10).

Table 1.7.10: Performance of drought tolerant pigeonpea varieties

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
		With improved variety	With local variety		IP	FP	IP	FP	IP	FP
Pigeonpea	PRG-158	724	590	22	1.81	1.4	39300	29250	3.6	2.9
	LRG-41	695		18	1.71		37125		3.4	

IP: improved varieties of pigeonpea; FP: Local variety

In setaria, improved variety suryanandi performed better than local setaria variety. Suryanandi recorded 4 % higher yield (1125 kg/ha) than local setaria variety (1080 kg/ha). With higher net returns (Rs.23750/ha), B:C ratio (3.3) than local (3.2).

Intercropping of groundnut and pigeonpea (11:1) intercropping system realized higher GEY of 1748 kg/ha and net returns of Rs.57530/ha with the B:C ratio of 2.9 and RWUE of 3.7 kg/ha-mm compared to groundnut and pigeonpea at 20:1 ratio with GEY of 1568 kg/ha, net returns of Rs.49625/ ha and B:C ratio of 2.7 (Table 1.7.11).

Table 1.7.11: Performance of groundnut + pigeonpea intercropping system

Treatment	Yield (kg/ha)		GEY (kg/ha)	Cost of cultivation	Net Returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop					
Groundnut + pigeonpea (11:1)	1286	308	1748	29870	57530	2.9	3.7
Farmers' practice* (groundnut + pigeonpea (20:1)	1305	175	1568	28750	49625	2.7	3.3

GEY: Groundnut equivalent yield

Energy management

Sowing with bullock drawn seed planter is highly beneficial when showing window is narrow. The cost of operation is not only cheaper than normal sowing but also covers more area within short period. The advantage of mechanization was observed over farmers' practice with higher filed efficiency (4 hr/ha), energy input (3042.5 MJ/ha) and output (63404 MJ/ha) and energy use efficiency (20.8) when compared to farmers' practice of manual sowing.

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

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was early by 2 days (14th June). A rainfall of 587.2 mm was received which was deficit by 0.5 mm was compared to normal 590.4 mm (Fig.1.7.3). During south-west monsoon (*kharif*), 587.2 mm rainfall was received which was excess by 29.27 mm (5.2%) than normal of 557.9 mm. During *rabi* and summer there were no rainfall occurred compared to normal 24.5 mm and 6 mm, respectively.

Normal onset of monsoon	:	16 June (24th SMW)
Onset of monsoon during 2015-16	:	14 June 2014 (24th SWM)
Annual mean rainfall	:	590.4 mm
Annual rainfall during 2015-16	:	587.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	557.9 and 24.5 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* & *rabi*)	:	587.2 and during *rabi* there was no rainfall

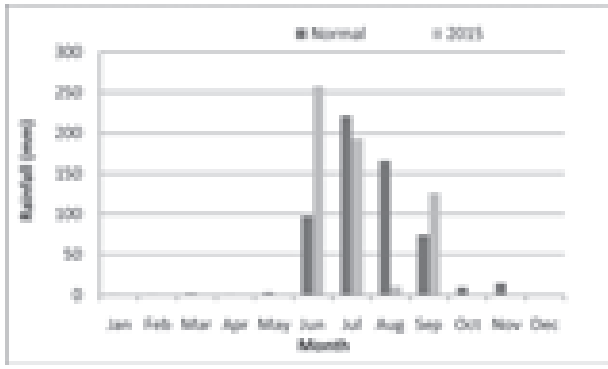


Fig. 1.7.3: Normal and actual (2015) monthly rainfall at Rajkot

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
26	26 June to 21 July	Groundnut, cotton, sesame, greengram, blackgram, castor	Vegetative
18	30 July to 16 August	Groundnut	Pegging & pod formation
		Cotton	Square formation
		Sesame	Flowering and capsule formation
		Greengram, blackgram	Flowering & pod development
		Castor	Vegetative
14	20 August to 3 September	Groundnut	Pod development
		Cotton	Boll formation
		Sesame, greengram, blackgram	Maturity
		Castor	Flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought 26 June to 21 July (26 days)	Groundnut, cotton, greengram, blackgram, castor, sesame	Vegetative	Interculturing, weeding
Mid season drought 30 July to 16 August (18 days)	Groundnut	Pegging & pod formation	Interculturing & supplemental irrigation
	Cotton	Square formation	Supplemental irrigation
	Sesame	Flowering and capsule formation	Interculturing, weeding
	Greengram, blackgram	Pod setting	Interculturing, weeding
	Castor	Vegetative	Interculturing, weeding
Terminal drought 20 August to 3 September (14 days)	Groundnut	Pod development	Supplemental irrigation
	Cotton	Boll formation	Supplemental irrigation
	Sesame, greengram, blackgram	Maturity	Harvesting of mature plant

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

The monsoon commenced in time with the first effective precipitation of 64.0 mm on 14th June. Dry spell occurred during 26th June to 21st July (26 days).

Addition of murrum in medium black soil for *in-situ* rainwater harvesting was demonstrated. The pod yield of groundnut was increased by 38.4% due to application *murrum* @ 20 t/ha compared to normal

practice. Similarly, higher net returns (Rs. 44720/ha), B:C ratio (2.46) and rainwater use efficiency (2.04 kg/ha-mm) was also recorded with application *murrum* @ 20 t/ha (Table 1.7.12).

Table 1.7.12 : Effect of application of *murrum* on yield of groundnut

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With murrum @ 20 t/ha	With normal practice				
GG 20	1200 (3570)	-	38.4	2.04	44720	2.46
	-	867 (2580)	-	1.48	26795	1.97

Figures in parentheses are haulm yield of groundnut

The seed cotton yield (1850 kg/ha) was increased by 17.1% due to furrow opening (45 cm wide) for *in-situ* moisture conservation in cotton at vegetative stage as compared to without furrow. It also recorded higher net returns (Rs.58575/ha), B:C ratio (2.00) and rainwater use efficiency (3.15 kg/ha-mm) compared to without furrow (Table 1.7.13).

Table 1.7.13: Effect of furrow opening on cotton yield and economics

Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Furrow opening	With normal practice				
G.cotton-8 BGll (140)	1850	-	17.1	3.15	58575	2.00
	-	1580	-	2.69	46750	1.65

In-situ moisture conservation through mulching in cotton revealed that seed cotton yield was increased to the tune of 19.4 and 30.6% with plastic mulching and groundnut shell mulching, respectively compared to control. Higher net returns (Rs.64688/ha) and B:C ratio (2.05) was recorded with groundnut shell mulching compared to other treatments (Table 7.1.14).

Table 1.7.14: Effect of mulching on yield of cotton

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Plastic mulching	1850	19.4	3.15	56375	1.79
Groundnut shell 5 t/ha	2025	30.6	3.45	64688	2.05
Control	1550	-	2.64	45325	1.60

During early season drought, the beneficial effect of interculture and weeding was observed on pod (1425 kg/ha) and haulm (3560 kg/ha) yield of groundnut. The increase in pod yield of groundnut was 14.9% compared to normal practice. Similarly, seed cotton yield (1750 kg/ha) was increased by 18.2% due to weeding and interculture practices as compared to normal practice. It also recorded higher net returns (Rs.53825/ha), B:C ratio (2.84) and rainwater use efficiency (2.98 kg/ha-mm) (Table 1.7.15).

Table 1.7.15: Effect of interculture and weeding on groundnut and cotton

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Inter-culture and weeding	With normal practice				
Groundnut	GG20	1425(3560)	-	14.9	2.43	57800	3.09
		-	1240 (3100)	-	2.11	46700	2.69
Cotton	G.cotton-8 BGll	1750	-	18.2	2.98	53825	2.84
		-	1480	-	2.52	42000	2.48

Figures in parentheses are haulm yield of groundnut

Foliar spray of Kaolin @ 2% in groundnut increased pod yield by 6.61% compared to control. The beneficial effect of antitranspirant was also observed on higher net returns (Rs.52856/ha), B:C ratio (2.91) and RWUE (2.33 kg/ha-mm) (Table 1.7.16).

Table 1.7.16: Effect of foliar spray of Kaolin on yield of groundnut (GG20)

Treatment	Pod yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
Kaolin @ 2%	1370		6.61	2.33	52856	2.91
Control		1285		2.19	47087	2.70

Situation: Mid season drought

Dry spell occurred during 30 June to 16 July (18 days) affecting groundnut (pegging & pod formation), cotton (square formation), sesame (flowering and capsule formation) and greengram/blackgram (pod setting & pod development). To overcome this, *in-situ* moisture conservation measure like interculture and weeding was taken-up.

Interculture and weeding recorded higher pod yield of groundnut (1550 kg/ha) with higher net returns (Rs.57242/ha), B:C ratio (3.07) and RWUE (2.64 kg/ha-mm). The groundnut yield was increased by11.7% and that of seed cotton yield by 9.5% due to weeding& interculture practices as compared to normal practice (Table 1.7.17).

Table 1.7.17: Effect of interculture and weeding on groundnut and cotton

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Inter-culture and weeding	With normal practice				
Groundnut	GG20	1430	-	11.7	2.44	44325	2.51
		-	1280		2.18	38913	2.38
Cotton	G.cotton-8 BGll	1550	-	9.5	2.64	57242	3.07
		-	1415	-	2.41	47564	2.72

Situation: Terminal drought

During 2015, dry spell occurred during 20 August to 3 September (14 days) effecting groundnut (pod development), cotton (boll formation), sesame, greengram and blackgram (maturity) and castor (flowering). To overcome this, supplemental irrigation was given in groundnut and mature pods were harvested. The pod yield (1740 Kg/ha) was increased by 43.5, 51.3 and 31.3% due to supplemental irrigation through raingun, mini sprinkler and flood over without irrigation, respectively. Similarly, higher net returns (Rs.72568/ha), and B:C ratio (3.53) was also recorded with supplemental irrigation through mini sprinkler compared to other treatments (Table 1.7.18).

Table 1.7.18 : Effect of supplemental irrigation and method of irrigation on yield of groundnut (GG-20)

Supplemental irrigation through	Yield (kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio
Rain gun	1650 (3800)	43.5	68320	3.38
Mini sprinkler	1740(3920)	51.3	72568	3.53
Flood	1510 (3620)	31.3	61494	3.18
Control	1150 (2875)	-	41300	2.49

Figure in parenthesis indicated haulm yield of groundnut

In cotton, in case of flood, two irrigations each of 50 mm was applied at flowering and boll formation. In case of drip, 25 mm water was applied at flowering boll formation and boll development stages. Seed cotton yield was increased to the tune of 78.4 and 32% due to supplemental irrigation through drip and flood over without irrigation, respectively. Similarly, higher net returns (Rs.77125/ha), B:C ratio (3.68) and rainwater use efficiency (3.25 kg/ha-mm) was also recorded with supplemental irrigation either through drip irrigation (Table 1.7.19).

Table 1.7.19: Effect of supplemental irrigation and method of irrigation on yield of Bt cotton (G.cotton-8 BGII)

Supplemental irrigation through	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Drip	2230	78.4	3.25	77125	3.68
Flood	1650	32.0	2.24	49574	2.72
Control	1250		2.13	31075	2.10

Preparedness

Cropping systems

Three major crops and their varieties were demonstrated under normal onset of monsoon. Among different varieties of groundnut bunch type varieties of (GG-2, GG-5, GG-9 and TGA-37A) recorded 27.8, 39.1, 15.8 and 36.1% higher pod yield as compared to semi-spreading varieties GG-20, respectively. In case of sesame, seed yield was increased to the tune of 47.9, 31.4 and 14.3% with G.Til-2, G.Til-3, and G.Til-4 as compared to that of G.Til-1. About 9.0% higher seed cotton yield was obtained with short duration Bt cotton G.cotton Hy-8 BGll in comparison to G.cotton Hy-6 BGll. Among different crops, higher B:C ratios (4.94 to 7.78) was obtained with sesame compared to groundnut (3.17 to 3.81) and cotton (1.43 to 1.65) (Table 1.7.20).

Table 1.7.20: Performance of crops and their varieties under normal onset of monsoon

Crop	Variety	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Groundnut	GG-2	1700	27.8	2.90	69200	3.50
	GG-5	1850	39.1	3.15	77750	3.81
	GG-9	1540	15.8	2.62	60080	3.17
	TGA-37A	1810	36.1	3.08	75470	3.72
	GG20	1330	-	2.26	57686	3.08
Sesame	G.Til-2	2070	47.9	3.53	128400	7.78
	G.Til-3	1840	31.4	3.13	112300	6.81
	G.Til-4	1600	14.3	2.72	95500	5.79
	G.Til-1	1400	-	2.38	81500	4.94
Bt cotton	G.Cot Hy-8 BGll	1580	9.0	2.69	46750	1.65
	G.Cot Hy-6 BGll	1450	-	2.47	40575	1.43

Among different cotton based intercropping systems, maximum seed cotton yield equivalent yield (3312 kg/ha), LER (2.10) and net returns (Rs.109750/ ha) was recorded with sesame intercropped with cotton (1:1) followed by cotton + greengram (1:1) intercropping system (Table 1.7.21).

Table 1.7.21: Seed cotton equivalent yield and economics under cotton based intercropping systems

Intercropping system	Seed cotton equivalent yield (kg/ha)	LER	Net returns (Rs/ha)	B:C ratio
Cotton + groundnut (1:1)	2358 (980)	1.49	69200	3.23
Cotton + sesame (1:1)	3312 (1100)	2.10	109750	4.54
Cotton + greengram (1:1)	3158 (930)	2.00	103215	4.33
Cotton + blackgram (1:1)	2774 (650)	1.59	75950	3.45
Cotton + soybean (1:1)	2123 (1200)	1.34	59225	2.91
Cotton + cowpea (1:1)	2144 (640)	1.43	65220	3.10
Sole cotton	1580	-	38850	2.37

Figure in parentheses indicate intercrop yield

Nutrient management

Green manure crop was sown at sowing in between two rows of cotton. Sunhemp and cowpea was incorporated in the soil at 35 and 50 DAS using power tiller, respectively. Greengram and blackgram stover was incorporated in the soil after two pickings using power tiller. The percent increase in seed cotton yield varied from 5.8 to 23.2% due to green manuring as compared to control. Maximum seed cotton yield

(1910 kg/ha), net returns (Rs.61825/ha), B:C ratio (3.14) and RWUE (3.25 kg/ha-mm) was recorded with sunhemp as green manure in cotton (Table 1.7.22).

Table 1.7.22: Effect of green manuring on yield of cotton

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sunhemp	1910(8125)	23.2	3.25	61825	3.14
Cowpea	1730(16680)	11.6	2.95	53275	2.84
Greengram	1650(6410)	6.5	2.81	49475	2.71
Blackgram	1640 (3640)	5.8	2.79	49000	2.70
Control	1550	-	2.64	45325	2.60

Figures in parentheses indicate fresh weight of manure crop

Foliar spray of micronutrients in groundnut revealed that the increase in pod yield was varied from to11.7 and 17.3% due to foliar spray of ferrous sulphate and zinc sulphate @ 1% compared to control. Among these zinc sulphate @ 1% recorded higher pod yield (1560 kg/ha), net returns (Rs.70370/ha), B:C ratio (3.51) and RWUE (2.66 kg/ha) compared to control (Table 1.7.23).

Table 1.7.23 : Effect of foliar fertilization on yield of groundnut

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Zinc sulphate @ 1%	1560	17.3	2.66	70370	3.51
Ferrous sulphate @ 1%	1485	11.7	2.53	65555	3.34
Control	1330	-	2.26	56090	3.02

In another trial maximum pod yield of groundnut (1475 kg/ha), net returns (Rs. 60800/ha), B:C ratio (3.19) and RWUE (2.51 kg/ha-mm) was recorded due to foliar application of sea weed extract @ 4% compared to control (Table 1.7.24).

Table 1.7.24: Effect of foliar application of sea weed extract on groundnut yield and economics

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sea weed extract @ 4%	1475	10.1	2.51	60800	3.19
Control	1340	-	2.28	52700	2.90

Alternate land use

In agri-horti system involving guava + field crops, maximum fruit yield and intercrop seed yield (4130 kg/ha and 575 kg/ha) with net returns of Rs. 68275/ ha, was recorded under guava + black gram agri-horti system compared to guava + groundnut, and guava alone (Table 1.7.25).

Table 1.7.25: Performance of agri-horti systems

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio
	With intervention	Without intervention		
Guava (sole)	-	4910	43100	7.18
Guava + groundnut GG2 (pod 735 and haulm 1640)	3870	-	62615	3.30
Guava + blackgram T-9 (seed 575)	4130	-	68275	4.55

Figures in parentheses indicate yield of groundnut and blackgram

c. On - farm demonstrations

Village profile

The program is being implemented in Pata meghpar village, Kalavad Taluk, Jamnagar district, Gujarat. The total cultivated area is 2793 ha out of which 1675 ha is rainfed. The mean annual rainfall is 541 mm with seasonal rainfall of 541 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 26th 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 is 32.3 and 25ºC, respectively which has more or less remained similar during past 10 years. The extreme events like unusual and high intensity rainfall in short spans are increasing during 32nd and 35th SMW (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 33-34th SWM of August (mid-season) and 37-38th 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 during 2015-16

During the year 2015, at Pata Meghapar village, a rainfall of 695 mm was received which was excess by 91 mm compared normal of 604 mm (Fig.). During south-west monsoon (June to September), 695 mm rainfall was received which was excess by 140.5 mm (25.3%) over the normal of 555 mm, during *rabi* (October-December) and summer there was no rainfall against the normal of 27.3 mm and 17.7 mm, respectively.

Normal onset of monsoon : 16 June (24th SMW)

Onset of monsoon during 2015-16 : 18 June (25th SMW)

Annual mean rainfall : 604 mm

Annual rainfall during 2015-16 : 695 mm

Mean crop seasonal rainfall during *kharif* : 555 mm

Crop seasonal rainfall during 2015-16 (*kharif*) : 695 mm during *kharif* and there was no rainfall during *rabi*

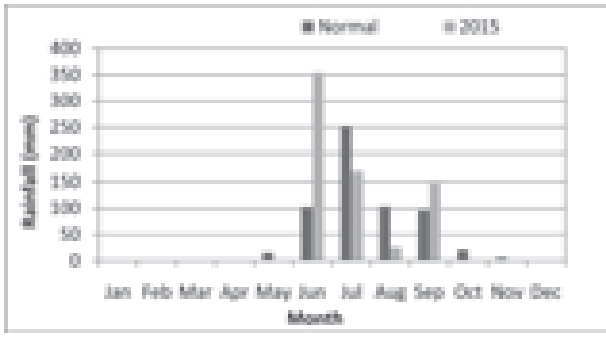


Fig. 1.7.4: Normal and actual (2015) monthly rainfall at Pata Meghapar

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
25	25 June to 20 July	Groundnut	Flowering & pegging
		Cotton, sesame, greengram, blackgram, castor	Vegetative
15	29 July to 12 August	Groundnut	Pegging & pod formation
		Cotton	Square formation
		Sesame	Flowering and capsule formation
		Greengram, blackgram	Flowering &pod development
		Castor	Vegetative
31	18 August to 18 September	Groundnut	Pod development
		Cotton	Boll formation
		Sesame, greengram, blackgram	Maturity
		Castor	Flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTC) implemented
Early season drought	Cotton, castor	Improved varieties/hybrids
	Groundnut	Interculturing and weeding/ *in-situ* moisture conservation
	Cotton	*in-situ* moisture conservation
Mid season drought	Groundnut	Supplemental irrigation/ interculturing and weeding
	Cotton	interculturing and weeding
Terminal drought	Cotton	Supplemental irrigation/ foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During 2015, the monsoon commenced in time with the first effective precipitation of 30.0 mm on 18th June. Dry spell occurred during 25 June to 20 July (26 days).

In-situ moisture conservation in groundnut through *Murrum* application @20 t/ha increased the pod yield of groundnut (1866 kg/ha) by 39.1% compared to farmer practice. The higher net returns (Rs.79172/ha), B:C ratio (4.23) and RWUE (2.68 kg/ha-mm) were also recorded with *murrum* application (Table 1.7.26).

Table 1.7.26: Effect of *murrum* application on yield of groundnut

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With *murrum* 20 t/ha	Without *murrum* application				
GG20 (110)	1866 (3284)	-	39.1	2.68	79172	4.23
	-	1342 (2421)	-	1.93	38406	2.75

Figures in parentheses indicate haulm yield of groundnut

In-situ moisture conservation through furrow opening between two rows in cotton increased seed cotton yield by 11.9% as compared to control. The beneficial effect of this practice was also observed on net returns (Rs.46370/ha), B:C ratio (2.44) and RWUE (2.38 kg/ha-mm) (Table 1.7.27).

Table 1.7.27: Effect of *in-situ* moisture conservation through furrow opening on yield of cotton

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With IP	With FP				
Research variety	1655	-	11.9	2.38	46370	2.44
(160 to 180)	-	1480	-	2.13	38538	2.21

Life saving irrigation of 30 mm was applied at vegetative stage (10 July) of cotton. Seed cotton yield (2280 kg/ha), net returns (Rs.43300/ha), B:C ratio (1.36) and RWUE (2.21 kg/ha-mm) was higher due to supplemental irrigation compared to control (Table 1.7.28).

Table 1.7.28: Effect of supplemental irrigation on yield of cotton

Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With Irigation	Without Irigation				
Res. variety	2280	-	20.7	2.21	43300	1.36
(150 to 180)	-	1330		1.88	33925	1.20

Weeding/interculture in groundnut and cotton during early season drought at gave higher yield of groundnut (1665 kg/ha) and cotton (1680 kg/ha) compared to normal practice. It also recorded higher net returns (Rs. 62852 & 49900/ha), B: C ratio (3.19 & 2.67) and RWUE (2.40 and 2.42 kg/ha-mm), respectively in groundnut and cotton (Table 1.7.29).

Table 1.7.29: Interculturing and weeding on yield of groundnut and Bt cotton (Mean of seven farmers)

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Groundnut	GG 20 (110)	1665 (2770)	-	13.5	2.40	62852	3.19
		-	1467 (2395)	-	2.11	52691	2.90
Bt Cotton	Res. variety	1680	-	9.12	2.42	49900	2.67
	(150 to 180)	-	1568	-	2.26	45580	2.58

Figures in parentheses indicate haulm yield of groundnut

Situation: Mid season drought

During 2015, a dry spell of 15 days occurred during 29 July to 12 August during pegging pod formation stage of groundnut, greengram, sesame and blackgram, square formation stage of cotton and vegetative stage of castor.

Yield of groundnut was almost doubled (2404 kg/ha) due to two supplemental irrigations given at flowering and pod formation. It also recorded higher net returns (Rs.97847/ha), B:C ratio (4.21) and RWUE (3.02 kg/ha-mm) compared to no supplemental irrigation (Table 1.7.30).

Table 1.7.30: Effect of supplemental irrigation on yield of groundnut

Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With Irigation	Without Irigation				
GG 20 (110)	2404 (3365)		97.7	3.02	97847	4.21
	-	1216 (1774)		1.75	37232	2.34

Figures in parenthesis haulm yields

Intercultivation in groundnut and cotton increased groundnut pod yield by 13.5% and that of seed cotton yield by 9.12% due to compared to normal practice. It also recorded higher net returns, B:C ratio and RWUE compared to farmers practice of no intercultivation (Table 1.7.31).

Table 1.7.31: Effect of intercultivation and weeding on yield of groundnut and Bt cotton

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Groundnut	GG 20 (110)	1665(2770)	-	13.5	2.40	62852	3.19
		-	1467(2395)	-	2.11	52691	2.90
Bt Cotton	Res. variety (150 to 180)	1680	-	9.12	2.42	49900	2.67
	-	-	1568.0	-	2.26	45580	2.58

Figures in parentheses are haulm yields

Foliar spray of potassium nitrate @ 1% during dry spells in cotton recorded higher seed cotton yield (1910 kg/ha) by 18.0% compared to normal practice. It also recorded higher net returns (Rs. 60325/ha), B:C ratio (2.98) and RWUE (2.75 kg/ha-mm) (Table 1.7.32).

Table 1.7.32: Effect of foliar spray of potassium nitrate on yield of cotton

Variety (duration)	Seed cotton yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
Res. variety	1910	-	18.0	2.75	60325	2.98
(150 to 180)	-	1620	-	2.33	47550	2.62

Situation: Terminal drought

During 2015, dry spell of 31 days occurred during 18 August to 18 September coinciding with (pod development stage of groundnut, maturity stage in greengram, sesame and blackgram, boll formation stage of cotton and flowering stage of castor).

Supplemental irrigation from harvested rainwater in cotton at vegetative stage boll formation and boll development stages increased seed cotton yield by 13.4% compared to two supplemental irrigations. Similarly, higher net returns (Rs.89435/ha) B:C ratio (3.86) and RWUE (3.01 kg/ha-mm) was also recorded with three supplemental irrigations (Table 1.7.33).

Table 1.7.33: Effect of supplemental irrigation on yield of cotton

Variety (Duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Three irrigations	Two irrigations				
Res. variety	2542	-	13.4	3.01	89435	3.86
(150 to 180)	-	2241	-	2.82	76149	3.51

Preparedness

Cropping systems

The seed cotton yield was increased by 11.9 and 2.7% with cotton hybrids G.Cot. 8 BG II and G.Cot.-6 BGll in compared to different research varieties grown by the farmer, respectively. G.Cot. 8BGII recorded higher net returns (Rs.45300/ha), RWUE (2.59 kg/ha-mm) and B:C ratio (2.54). In castor seed yield with castor hybrid GCH-7 was higher (1482 kg/ha) compared to research varieties (Table 1.7.34).

Table 1.7.34: Performance of cotton and castor hybrids

Crop	Hybrid/variety (duration)	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Bt cotton	G.Cotton-8BGll (140)	1800	11.9	2.59	45300	2.54
	G.cotton-6BGll (180)	1602	2.7	2.31	38685	1.32
	Research variety(180)	1587	-	2.28	36461	2.24
Castor	G. Castor Hy.-7	1482	10.8	2.13	34875	1.68
	Research variety	1338	-	1.93	29475	1.42

Groundnut + castor (3:1) intercropping system recorded higher groundnut pod equivalent yield (2022 kg/ha) compared to sole groundnut crop. Higher net returns (Rs. 62990/ha), B:C ratio (2.33) and RWUE (2.91) was obtained in groundnut + castor intercropping (3:1) with LER of 1.08 (Table 1.7.35).

Table 1.7.35: Performance of cotton based intercropping system

Intercropping system	Seed cotton	LER	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cotton + groundnut (1:1)	1956	1.25	2.81	64903	2.16
Cotton+ sesame (1:1)	1812	1.15	2.61	58370	1.95
Cotton+ forage maize (1:1)	1774	1.13	2.55	56575	1.89
Sole cotton	1570		2.26	46875	1.56

The pod & haulm yield of groundnut increased by 45.4 and 11.1% with narrow row spacing (30cm) as compared to with farmer practice (45cm), respectively. The higher net returns (Rs.88488/ha), B:C ratio (3.14) and RWUE (3.18 kg/ha-mm) were also recorded with narrow row spacing in groundnut.

Nutrient management

Application of castor cake @ 500 kg/ha with RDF recorded higher pod and haulm yields of groundnut by 11.3 and 12.6% compared to normal practice, respectively. Similarly, 9.3% higher seed cotton yield was recorded with application of castor cake. It also recorded higher net returns, B:C ratio and RWUE in both groundnut and cotton (Table 1.7.36).

Table 1.7.36: Effect of integrated nutrient management on yield of groundnut and cotton

Crop	INM	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With castor cake	Without castor cake				
Groundnut	GG 20 (110)	1672 (2870)	-	11.3	2.41	46528	2.62
		-	1502 (2550)	-	2.16	39890	2.44
Cotton	Research variety	1710	-	9.3	2.46	50825	1.67
		-	1565	-	2.25	44938	1.53

Figures in parentheses indicate haulm yield of groundnut

Pod and haulm yield of groundnut was increased by 8.8 and 7.3% due to seed inoculation with rhizobium and PSB each of 20 g/kg seed as compared to normal practice, respectively. It also recorded higher net returns (Rs.60238/ha), B:C ratio (3.14) and RWUE (2.34) (Table 1.7.37).

Table 1.7.37: Effect of seed inoculation of rhizobium and PSB on yield of groundnut

Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
GG TAG45 (100)	1632 (2774)	-	8.1	2.35	61386	3.14
	-	1510 (2416)	-	2.17	54730	2.98

Figures in parentheses are haulm yield

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

Experienced weather conditions during 2015-16

During 2015, the onset of monsoon was on 11th June and a rainfall of 756.4 mm was received which was excess by 9.1 mm (1.2%) compared to normal (756.4 mm) (Fig….). Out of total rainfall received, 613 mm was received during *kharif* season which was deficit by 53.3 mm compared to normal of 666.3 mm. During *rabi* (October-December), no rainfall was received compared to normal of 66.8 mm. During summer (March-May), 152.5 mm of rainfall was received which was excess by 129.2 mm compared to normal (23.3 mm).

Normal onset of monsoon : 11-17 June (24th SMW)

Onset of monsoon during 2015-16 : 11 June

Annual mean rainfall : 756.4 mm

Annual mean rainfall during 2015-16 : 765.5 mm

Mean crop seasonal rainfall during *kharif* and *rabi* : 666.3 mm and 66.8 mm respectively

Crop seasonal rainfall during 2015-16 : 613.00 mm in *kharif* and 0 mm in *rabi*

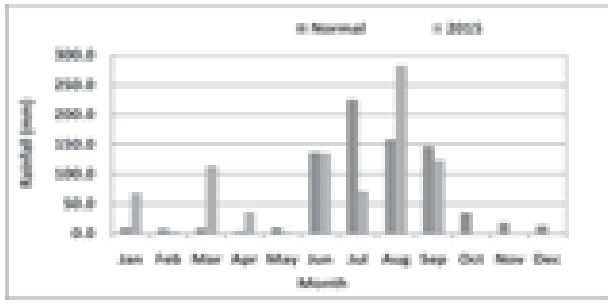


Fig. 1.8.1: Normal and actual (2015) monthly rainfall at Akola

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
24	25 June-18 July	Soybean, cotton, pigeonpea, sorghum and greengram	Vegetative
15	15-29 August	Soybean, sorghum and greengram and pod development	Flowering
		Cotton	Square formation .
		Pigeonpea	Vegetative
1 month and 10 days	20 September – 30 October	Cotton, Pigeonpea	Boll initiation Flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought (25 June-18 July)	Cotton, soybean, sorghum pigeonpea and greengram	Vegetative	
Mid season drought	Cotton	Vegetative	Opening of furrows after
(15-29 August)	Soybean	Flowering	and mulching
	Sorghum	Flag leaf	
Terminal drought	Cotton	Boll development	Foliar spray
(20 September - 30 October)	Pigeonpea	Flowering	Mulching

Salient achievements of on-station experiments

Real time contingency crop planning

Situation: Early season drought

During 2015, the onset of monsoon was normal i.e 17 June the rainfall received during cropping season 644.6 mm in *kharif* & *rabi* which was deficit by 111.9 mm compared to normal rainfall 756.4 mm. The rainfall was excess in June by 1.1% and August by 78.5%, deficit in July by 68.4% and 15.4% in September. There was one dry spell (25 June to 18 July) of 24 days coinciding with vegetative stage of soybean, cotton, pigeonpea, sorghum and greengram. During early season drought, furrow opening and mulching was implemented in the crops such as cotton, soybean, sorghum, maize, and sweet corn.

In a demonstration on soybean variety JS-335 (95-100 days), to facilitate runoff modulation and enhance *in-situ* moisture conservation, introduced mulching and furrow opening at 30-35 DAS in between rows of soybean. This resulted in mitigating the dry spells and gave higher seed yield of soybean (844 kg/ha) as compared to farmers' practice (820 kg/ha). It gave RWUE of 1.30 kg/ha-mm, net returns of Rs. 2133/ha and B:C ratio of 1.07. Similar results were recorded in soybean var. JS9560 (Table 1.8.1).

Table 1.8.1: Effect of *in-situ* moisture conservation in different varieties of soybean

Treatment/ variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase over control
	Seed	Stover					
JS-335							
T_1- Furrow opening	830	965	27274	3156	1.11	1.28	1.2
T_2- Mulching	832	944	28717	1763	1.06	1.29	1.5
T_3- T_1+ T_2	844	906	28735	2133	1.07	1.30	2.9
T_4- Control	820	915	27259	2766	1.10	1.27	
JS-9560							
T_1- Furrow opening	858	980	27316	4123	1.15	1.33	2.1
T_2- Mulching	861	990	28760	2795	1.09	1.33	2.5
T_3- T_1+ T_2	890	1040	28800	3785	1.13	1.38	6.0
T_4- Control	840	1000	27289	3531	1.12	1.30	-

Among different *in-situ* moisture conservation & mulching in sorghum mulching and furrow opening at 30-35 DAS in between rows of sorghum resulted in mitigating the dry spells and gave higher grain yield (4209 kg/ha) with higher net returns (Rs.53561/ha), B:C ratio (2.68), RWUE (6.52 kg/ha-mm) and yield increase was 2.1% as compared to farmers' practice (4106 kg/ha) (Table 1.8.2).

Table 1.8.2: Effect of *in-situ* moisture conservation in sorghum (CSH-9)

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase over control
	Grain	Stalk					
T_1- Furrow opening	4178	4388	30283	54327	2.79	6.48	1.7
T_2- Mulching	4193	4400	31705	53185	2.67	6.50	2.1
T_3- T_1+ T_2	4209	4392	31729	53561	2.68	6.52	2.5
T_4- Control	4106	4300	30175	51945	2.72	6.36	-

Situation: Mid season drought

During 2015, There was one dry spell (15 to 29 August) of 15 days and rainfall was deficit in August 78.5%, and 15.4% in September coinciding with flowering, flag leaf, square formation and pod development stage of soybean, sorghum, greengram and cotton.

To recover the soybean crop from dry spell, protective irrigation was given from the harvested rainwater in farm pond. The highest seed yield of soybean was recorded with two protective irrigations (1055 kg/ha) over no irrigation (802 kg/ha) and yield was 31.5% higher over no irrigation. Similarly, higher RWUE (1.48 kg/ha-mm) was recorded with two protective irrigations over no irrigation (Table 1.8.3).

Table 1.8.3: Effect of protective irrigation on yield of soybean (JS-335)

Protective irrigation	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
One protective irrigation(At pod initiation)	910	13.5	1.72	14642	1.57
Two protective irrigations (At pod initiation and pod development)	1055	31.5	1.48	9364	1.37
Without irrigation (Control)	802	-	1.30	5451	1.21

In cotton (AKH-9916), furrow opening at 30-35 DAS in between rows and foliar spray of 2% urea & DAP at boll development stage resulted in mitigating the dry spells and gave higher seed yield of cotton (1300 kg/ha) as compared to farmers' practice (1166 kg/ha). It gave RWUE of 2.01 kg/ha-mm, net returns of Rs. 36432/ha, B:C ratio of 2.36 and yield increase was 11.49% (Table….). Similar results were recorded in cotton (AKH-081) under HDPS (Table 1.8.4).

Table 1.8.4: Effect of *in-situ* moisture conservation and foliar spray in different varieties of cotton

Treatment/ variety	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase over control
	Seed cotton	Stalk				
AKH-9916						
T_1- Furrow opening	1266	2096	35412	2.35	1.96	8.5
T_2- Mulching	1269	2022	34024	2.23	1.96	8.9
T_3- T_1+ T_2	1297	2024	35202	2.26	2.01	11.2
*T_4- Spray	1300	2088	36432	2.36	2.01	11.5
T_5- Control	1166	1999	31115	2.22	1.74	-
AKH-081						
T_1- Furrow opening	2025	2491	66764	3.14	3.14	6.5
T_2- Mulching	2049	2488	65729	2.98	3.17	7.7
T_3- T_1+ T_2	2074	2500	66791	3.01	3.21	9.1
*T_4- Spray	2082	2566	68008	3.11	3.12	5.8
T_5- Control	1901	2400	60865	2.97	-	-

*Spraying of 2% urea and 2% DAP at boll development stage of cotton

Cotton + sorghum + pigeonpea + sorghum (3:1:1:1) intercropping system with furrow opening and mulching recorded higher CEY (1992 kg/ha), with higher net returns (Rs.78395/ha), B:C ratio (3.30) and RWUE (3.09 kg/ha-mm) compared to control (1867 kg/ha) (Table). Similarly, cotton + soybean + pigeonpea + soybean (3:1:1:1) intercropping system with furrow opening and mulching recorded higher CEY (1758 kg/ha), with higher net returns (Rs.58066/ha), B:C ratio (2.84) and RWUE (2.73 kg/ha-mm) compared to control (1632 kg/ha) (Table 1.8.5).

Table 1.8.5: Performance of intercropping systems (cotton: sorghum: pigeonpea: sorghum) (3:1:1:1)

Treatment	Yield (kg/ha)			CEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Cotton	Intercrop					
		Sorghum	Pigeonpea				
Cotton: sorghum: pigeonpea: sorghum (3:1:1:1) intercropping system							
T_1- Furrow opening	877	1652	284	1920	75410	3.32	2.98
T_2- Mulching	890	1703	295	1970	77143	3.27	3.06
T_3- T_1+ T_2	895	1741	298	1992	78395	3.30	3.09
T_4- Control	841	1688	268	1867	73127	3.26	2.90
Cotton: soybean: pigeonpea: soybean (3:1:1:1) intercropping system							
	Cotton	Soybean	Pigeonpea				
T1- Furrow opening	555	563	389	1687	55807	2.86	2.62
T2- Mulching	571	579	398	1732	56537	2.79	2.69
T3- T1+ T2	588	585	401	1758	58066	2.84	2.73
T4- Control	538	558	370	1632	51807	2.66	2.53

c. On-farm demonstrations

Village profile

The program is being implemented 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, 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 numbers 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 rains contributes 3% and summer rains contributes 4%. The historical rainfall data (last 30 years) indicated that the variability in rainfall during south-west monsoon was deficit (-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 upto 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 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 2015-16

The onset of monsoon was on 11th June. The normal rainfall (Barshitakli station, nearest rain gauge station i.e. 12 km from Warkhed watershed) rainfall data of Akola centre is taken for the analysis of weather conditions during the year 2014 at Barshitakli village. A rainfall of 760.1 mm was received which was deficit by 32.7 mm compared to normal (792.8 mm) (Fig.1.8.2). During *kharif* season (June to September), 644.6 mm of rainfall was received which was deficit by 43.4 mm as compared to normal (688 mm). During *rabi* season (October - December), 19 mm rainfall was received which was deficit by 63 mm compared to normal (82 mm). During summer, 96.5 mm of rainfall was received which was excess by 73.7 mm as compared to normal (22.8 mm).

Normal onset of monsoon	:	11-17 June
Onset of monsoon during 2015 -16	:	11 June
Annual mean rainfall	:	792.8 mm
Annual mean rainfall during 2015-16	:	760.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	*Kharif* 688 mm and *rabi* 82 mm
Crop seasonal rainfall during 2015-16	:	*Kharif* 645 mm and *rabi* 19 mm

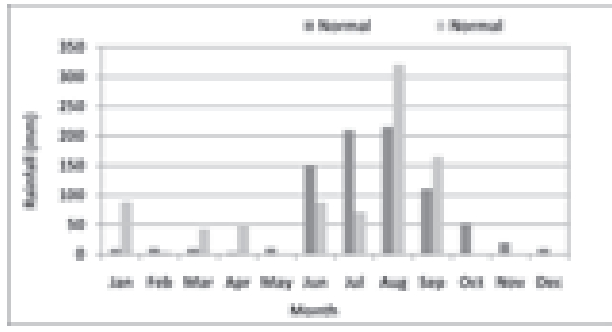


Fig. 1.8.2: Normal and actual (2015) monthly rainfall at Barshitakli

Dry spells during crop growing season (2015)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
27	23 June to 18 July	Soybean, cotton, pigeonpeaand greengram	Vegetative
06	29 July to 03 August	Soybean and greengram	Flowering
		Cotton and pigeonpea	Vegetative
13	16 August to 28 August	Soybean	Flowering
		Greengram	Pod initiation
		Cotton	Square formation
		Pigeonpea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Soybean, cotton, greengram and pigeonpea	Vegetative	Opening of furrow after each row at 30-40 DAS
Terminal drought	Cotton	Boll development	Spraying of 2% urea at flowering and 2% DAP at boll development stage in cotton
	Pigeonpea	Pod initiation	Mulching

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Midseason drought

At Warkhed, during 2015, the onset of monsoon was normal i.e. 11th June. The rainfall was deficit in June (41.9%) and July (65.5%), but excess by 48.2% in August and 47.9% September. There were three dry spells, during 23 June to 18 July (27 days) coinciding with vegetative stage of soybean, cotton, pigeonpea and greengram, 29 July to 3 August (6 days) coinciding with vegetative in cotton and pigeonpea, flowering stage in soybean and greengram, and 16 to 28 August (13 days) coinciding with vegetative, flowering, pod initiation and square formation in pigeonpea, soybean, greengram and cotton.

In-situ moisture conservation in soybean variety JS-335, was demonstrated on fields of 51 farmers and furrows were opened after each row at 30-40 DAS. It was observed that those farmers who followed the furrow opening practice recorded higher average yield of 1055 kg/ha, with net returns of Rs. 17168/ha, B:C ratio of 1.71 and RWUE of 1.79 kg/ha as compared to farmers' practice (831 kg/ha) (Table 1.8.6).

Table 1.8.6: Effect of opening of furrow on performance of soybean

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Without furrow opening	831	-	1.16	10246	1.14
With furrow opening	1055	8.9	1.79	17168	1.71

In-situ moisture conservation in cotton (Mallika) was demonstrated on farmers' fields and furrows were opened 30-40 DAS. Furrow opening practice after each row gave higher yield of 1555 kg/ha, with net returns of Rs. 37854/ha, B:C ratio of 2.02 and RWUE of 2.41 kg/ha as compared to farmers' practice (1425 kg/ha) (Table 1.8.7).

Table 1.8.7: Effect of opening of furrow on performance of cotton

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation	With normal practice				
Cotton	Mallika	1555	-	9.1	2.41	37854	2.02
		-	1425	-	2.21	32238	1.88

One protective irrigation from harvested rainwater in farm pond was provided during the pod initiation stage. The yield increased by 12.5% due to protective irrigation (1093 kg/ha), with higher net returns of Rs.15110/ha, B:C ratio of 1.59 and RWUE of 1.68 kg/ha-mm (Table 1.8.8).

Table 1.8.8: Effect of protective irrigation from harvested rainwater in farm pond

Name of farmer	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With irrigation	Without irrigation				
Godavari Mahalle	Soybean (JS-335)	1030	920	11.95	1.59	13052	1.51
Namdev Jadhav	Soybean (JS-335)	1093	968	12.91	1.68	15110	1.59

Foliar spray of 2% urea at the time of flowering along with 2% DAP at boll development stage in cotton were demonstrated. On average, the CEY increased by 5.6% (1233 kg/ha), with higher net returns of Rs.23933/ha, B:C ratio of 1.67 and RWUE of 1.91 kg/ha-mm due to foliar application as compared to farmers' practice (1167 kg/ha) (Table 1.8.9).

Table 1.8.9: Effect of foliar spray of urea and DAP

Treatment	CEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cotton + greengram (1:1) with foliar spray	1233	5.6	1.91	23933	1.67
Cotton + greengram (1:1) without foliar spray	1167		1.81	21103	1.60

Preparedness

Croping systems

In varietal demonstrations, early maturing varieties of soybean varieties JS-335 (maturity 95-100 days), JS-93-05 (maturity 90-95 days) & JS-95-60 (Maturity 90-95 days) were demonstrated on fields of eight farmers. Among these three varieties, JS-9560 gave highest average yield of 1039 kg/ha with average B:C ratio of 1.68 over other two varieties *viz*, JS-335 (923 kg/ha) and JS-93-05 (987 kg/ha) (Table 1.8.10).

Table 1.8.10: Performance of improved varieties of soybean

Variety	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
JS-335	923	-	1.50	12229	1.48
JS-9305	987	7.0	1.60	14740	1.57
JS-95-60	1039	12.5	1.68	16763	1.65

Soybean + pigeonpea (4:2) intercropping was demonstrated on 16 farmers' fields. The yield increased by 21.3% with soybean + pigeonpea system (4:2) (2164 kg/ha), with higher net returns (Rs.60792/ ha), B:C ratio (3.09) and RWUE (3.36 kg/ha) as compared to farmers' practice of soybean + pigeonpea (6:1) (1785 kg/ha) (Table 1.8.11).

Table 1.8.11: Performance of soybean + pigeonpea (4:2) intercropping system

Intercropping system	Variety	SEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Soybean + pigeonpea (4:2)	JS-335 and ICPL-8863	2164	21.3	3.36	60792	3.09
Soybean + pigeonpea (6:1)		1785	-	2.78	43087	2.29

SEY: Soybean equivalent yield

Cotton + greengram (1:1) intercropping was demonstrated on 7 farmers' fields. The increase in yield was 27.25% with cotton + greengram (1:1) (1885 kg/ha), with net higher returns (Rs.22896/ha), B:C ratio (1.04) and RWUE (1.28 kg/ha-mm) as compared to farmers' practice (sole cotton) (1485 kg/ha) (Table 1.8.12).

Table 1.8.12: Performance of cotton + greengram (1:1) intercropping system

Treatment	SEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cotton (Mallika Bt) +greengram (Utkarsh) (1:1)	1885	1.28	22896.44	1.04
Sole cotton	1485	1.01	15194.88	0.85

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

Experienced weather conditions during 2015-16

During 2015, a rainfall of 988.9 mm was received which was excess by 266.3 mm (36.8%) compared to normal 722.6 mm. During *kharif* (June to September), 218.6 mm rainfall was received which was excess by 68.4 mm than normal of 150.2 mm; in *rabi* season (October – December), 475.8 mm rainfall was received which was excess by 84.9 mm than normal of 391 mm and during summer (March to May), 294.2 mm rainfall was received which was also excess by 153.3 mm than normal of 140.9 mm (Fig. 1.8.3)

Normal onset of monsoon	:	1 June (South-west monsoon) 20 October (North-east monsoon)
Onset of monsoon during 2015-16	:	5 June (South-west monsoon) 28 October (North-east monsoon)
Annual mean rainfall	:	722.6 mm
Annual rainfall during 2015-16	:	988.9 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	150.2 and 391 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*)	:	218.6 and 475.8 mm, respectively

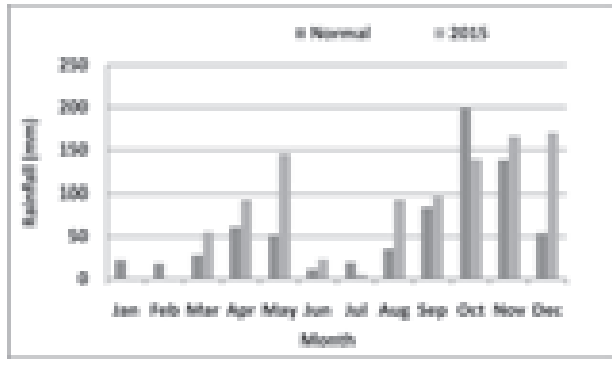


Fig.: Normal and actual (2015) monthly rainfall at Kovilpatti

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
7	1-7 October	Greengram, cotton, sorghum	Seedling
14	15- 28 October	Maize, greengram, cotton, sorghum, pearlmillet, pearlmillet	Vegetative
7	5- 11 November	Maize, cotton, sorghum, pearlmillet	Vegetative
		Greengram	Flowering
20	26 November to 15 December	Maize, sorghum Greengram	Flowering Pod maturity
		Cotton	Squaring to flowering

Salient achievements of on-station experiments

Real time contingency planning : Nil

Preparedness

Rainwater management

The higher maize grain yield (4060 kg/ha), net returns (Rs.19640/ha), B:C ratio (1.53) and RWUE (8.53 kg/ha-mm) were recorded with broad bed furrow using tractor drawn implement over ridge and furrow method. Similarly, *in-situ* moisture conservation thorough broad bed furrow in greengram recorded higher seed yield (750 kg/ha) over flat sowing (630 kg/ha). In sorghum, higher grain yield (2520 kg/ha) was recorded with *in-situ* moisture conservation thorough broad bed furrow compared to flat sowing (2130 kg/ha). Adoption of *in-situ* moisture conservation technology (broad bed and furrows) resulted in 11, 16 and 15% higher yield than conventional sowing of maize, greengram and sorghum, respectively (Table 1.8.13).

Table 1.8.13: Effect of of *In-situ* moisture conservation on yield and economics of in different crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Broad bed furrows	Flat sowing				
Maize	CO (H) M6	4060	3630*	10.6	8.53	19640	1.53
Greengram	CO8	750	630	16.0	1.58	14200	1.61
Sorghum	K8	2520	2130	15.5	5.29	7860	1.32

*****Ridges and furrow sowing*

Cropping systems

During 2015 onset of South-west monsoon was on 5th June (Delay by 4 days) and onset of North-east monsoon on October 28 (delayed by 8 days). Wet spell was observed in 39th, 41st, 44th, 46th and 47th standard meteorological weeks (SMW). Dry spell was observed during 45th and 48th SMW. Greengram was in flowering stage during the dry spell in 45th SMW and maize, pearlmillet, cotton and sorghum were in flowering stage during the dryspell in 48th SMW (Table….). During the growth period of cotton in 2015-16, a total of 556 mm rainfall was received while, the rainfall received during vegetative stage was normal (244 mm). The rainfall received during squaring to blooming was 142 mm (87% excess), blooming to boll opening was 170 mm (142% excess) and no rainfall was received during ripening and maturity.

Among different cotton varieties, KC 3 recorded higher seed cotton yield (1350 kg/ha) with B:C ratio of 2.11 followed by SVPR 4 (1410 kg/ha). However, *desi* cotton variety K 11 recorded lowest seed cotton yield (860 kg/ha) with B:C ratio of 1.82. Among different maize hybrids, COH (M) 6 recorded higher grain yield (4925 kg/ha) with B:C ratio of 2.43 followed by COH (M) 7 with grain yield of 3950 kg/ha with B:C ratio of 1.95.

Among three short duration varieties of greengram (CO8, VBN2 and Local), higher seed yield was recorded by CO8 (960 kg/ha) with B:C ratio of 2.35 followed by VBN 2 (780 kg/ha) compared to local variety (540 kg/ha). The variety Co 8 gave 39% higher seed yield over local. Among minor millets (barnyard millet, kodo millet and foxtail millet), barnyard millet recorded higher grain yield (1590 kg/ha) with B:C ratio of 2.67 followed by foxtail millet (1250 kg/ha). Kodo millet recorded lowest yield (1105 kg/ha) (Table 1.8.14).

In cotton based intercropping systems, greengram, clusterbean, groundnut and gingelly were sown as intercrops in cotton (KC-3). Cotton with clusterbean system recorded higher cotton equivalent yield (1447 kg/ha) as compared to other intercropping systems with higher RWUE (8.09 kg/ha-mm) and B:C ratio (1.48) and net returns of Rs. 19760/ha (Table 1.8.15).

Table 1.8.14: Performance of drought tolerant varieties of different crops

Crop	Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cotton	KC 3	1350	2.84	29800	2.11
	K 11	860	1.81	16320	1.82
	SVPR 2	1320	2.77	23340	1.73
	SVPR 4	1410	2.96	27120	1.84
Maize	COH (M) 6	4925	8.93	40550	2.43
	DKC 9117 (C)	3810	8.00	24940	1.88
	COH (M) 7	3950	8.30	26900	1.95
Greengram	CO8	960	2.02	33100	2.35
	VBN2	780	1.64	25400	2.19
	Local variety (C)	540	1.13	12000	1.59
Barnyard millet	CO(KV)-2	1590	2.84	20890	2.67
Kodo millet	CO-3	1105	2.71	8495	1.68
Foxtail millet	CO(TC)-7	1250	2.63	10000	1.80

Table 1.8.15: Performance of different intercropping systems

Treatment	Yield (kg/ha)		CEY (Rs/ha)	LER	MAI	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop						
Cotton sole	940	-	-	-	-	8980	1.29	1.97
Cotton + greengram (2:2)	580	395	1050	1.08	998	13210	1.43	0.83
Cotton + clusterbean (2:2)	530	3850	1447	1.33	4946	19760	1.48	8.09
Cotton + groundnut (2:2)	575	460	958	1.05	462	9750	1.32	0.97
Cotton + sesame (2:2)	525	410	1111	1.04	526	13400	1.40	0.86

LER: Land equivalent ratio; CEY: Crop equivalent yield; MAI: Monetary advantage index

Alternate land use

In aonla based agri-horti system, pearlmillet, sorghum and sesame were grown as an intercrop. Among these aonla with sesame system recorded higher intercrop yield (910 kg/ha) compared to other systems with higher B:C ratio (1.50) and net returns of Rs. 12250/ha. Aonla + sorghum system recorded lower net returns (Rs. 4110/ha) and B:C ratio (1.19).

In custard apple based agri-horti system, custard apple + sesame system recorded higher net returns (Rs.14300/ha), B:C ratio (1.60) and RWUE of (1.33 kg/ha-mm) followed by custard apple with pearlmillet system.

In sapota based agri-horti system, sapota + recorded higher intercrop yield (1840 kg/ha) with higher net returns (Rs.9000/ha), B:C ratio (1.48) and RWUE (3.87 kg/ha-mm) over other sapota based agri-horti systems (Table 1.8.16).

Table 1.8.16: Performance of aonla based agri-horti systems

Treatment	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop*	Inter crop	Stover/ stalk yield			
Aonla based agri-horti systems						
Aonla + pearlmillet	-	1890	4725	8550	1.43	3.97
Aonla + sorghum	-	1970	5910	4110	1.19	4.14
Aonla + sesame	-	610	2440	12250	1.50	1.28
Custard apple based agri-horti systems						
Custard apple + pearlmillet	-	1920	4800	8100	1.39	4.03
Custard apple + sorghum	-	2050	6150	6450	1.32	4.31
Custard apple + sesame	-	635	2540	14300	1.60	1.33
Sapota based agri-horti systems						
Sapota + pearlmillet	-	1840	4600	9000	1.48	3.87
Sapota + sesame	-	470	1880	3900	1.16	0.99
Sapota + greengram	-	610	1400	6700	1.28	1.28

***** Main crops have not yet reached fruiting stage

c. On-farm demonstrations

Village profile

The program is being implemented in Muthukrishnapuram, Thoppurediapatti and Vadakkupatti revenue villages, 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 (normal) is 970.4 mm with seasonal rainfall of 150.2 mm during *kharif*, 390.9 mm during *rabi* (October-December) and 140.9 mm during summer (March-May). The major soil types are medium deep to deep black 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 in general

The climate in this agro-climatic zone is semi-arid and north-east monsoon season is the main cropping season under rainfed conditions. Out of the total annual average rainfall of 970.4 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 was 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^{0}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.

Experienced weather conditions during 2015-16

During 2015, in Muthukrishnapuram village, onset of South-west monsoon was delayed by 4 days during 1st week of June (5th June) and by 8 days (28th October) during North-east monsoon. A rainfall of 12.4 mm was received which was deficit by 137.8 mm compared to normal (150.2 mm) during South-west monsoon; 392.2 mm rainfall was received during North-east monsoon (October-December) which was excess by 1.3 mm compared to normal rainfall of 390.9 mm. During summer, (March to May 2015), 96.6 mm of rainfall was received which was deficit by 44.3 mm compared to normal of 140.9 mm (Fig. 1.8.4).

Normal onset of monsoon	:	1 June (South-west monsoon) 20 October (North-east monsoon)
Onset of monsoon during 2015-16	:	5 June (South-west monsoon) 28 October (North-east monsoon)
Annual mean rainfall	:	772.6 mm
Annual mean rainfall during 2015-16	:	501.2 mm
Mean crop seasonal rainfall	:	*Kharif* 150.2 mm and *rabi* 391.0 mm
Crop seasonal rainfall during 2015-16	:	*Kharif* 12.4 mm and *rabi* 392.2 mm

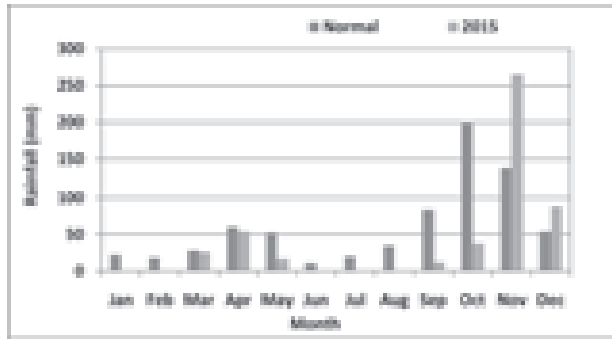


Fig. 1.8.4: Normal and actual (2015) monthly rainfall at Muthukrishnapuram village

Dry spells during crop growing season (2015-16): Nil

Salient achievements of on-farm demonstrations

Real time contingency planning: Nil

Preparedness

Rainwater management

Adoption of broad bed and furrow method for *in-situ* moisture conservation resulted in 12.2, 13.4 and 16.5% higher yield in maize, greengram and sorghum, respectively. Higher B:C ratio (1.72) was recorded with maize sown on broad bed and furrows followed by greengram (1.52) (Table 1.8.17)

Table 1.8.17: Effect of broad bed and furrow for soil moisture conservation on crop yield and economics

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation	With flat bed				
Maize	CO(H)M6	4360	3830	12.16	11.12	25640	1.72
Greengram	CO8	710	615	13.38	1.81	12100	1.52
Sorghum	K8	2640	2205	16.48	6.73	9720	1.40

Cropping systems

Four entries of cotton *viz.*, three upland varieties (KC 3, SVPR2 and SVPR4) and one *desi* variety (K 11) were demonstrated in farmers' fields Among the entries, the SVPR 4 cotton variety has recorded significantly superior seed cotton yield of 1305 kg/

ha which gave the B:C ratio of 1.79 followed by KC3 (1210 kg/ha). Even though the *desi* cotton variety K 11 recorded lowest yield of 905 kg/ha it gave B:C ratio of 1.70 due to low cost of cultivation. Among the maize hybrids, COH (M) 6 recorded significantly higher grain yield of 4300 kg/ha with B:C ratio of 2.05 followed by COH (M) 7 (4150 kg/ha). Among the greengram variety CO8 recorded significantly higher seed yield of 980 kg/ha with B:C ratio of 2.06 followed by VBN 2 (820 kg/ha). Among the sorghum varieties, recently released variety K12 recorded significant higher grain yield of 2350 kg/ha with B:C ratio of 1.36 followed by K8 (2108 kg/ha) (Table 1.8.18).

Table 1.8.18: Performance of varieties/hybrids of different crops

Crop	Variety	yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cotton	KC 3	1210	3.09	20220	1.66
	K 11	905	2.31	15660	1.70
	SVPR 2	1190	3.04	19380	1.63
	SVPR 4	1305	3.33	24210	1.79
Maize	COH (M) 6	4300	10.97	30800	2.05
	DKC 9117 (C)	3960	10.10	26040	1.89
	COH (M) 7	4150	10.59	28700	1.98
Greengram	CO8	980	2.50	30300	2.06
	VBN2	820	2.09	20700	1.73
	Local variety (C)	560	1.43	5100	1.18
Sorghum	K8	2108	5.38	4904	1.22
	K12	2350	5.99	8050	1.36
	Local variety (C)	1890	4.82	2070	1.09

Among cotton based intercropping systems, cotton + clusterbean system (2:2) recorded higher seed cotton equivalent yield (1563 kg/ha) compared to other intercropping systems and also recorded higher B:C ratio of 1.53 followed by cotton + greengram with B:C ratio of 1.49. Higher net returns (Rs.22730/ha) was also recorded with cotton + clusterbean system (2:@) due to higher yield of clusterbean (Table 1.8.19).

Table 1.8.19: Intercropping systems

Treatment	Yield (kg/ha)		MCEY	LER	MAI	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop							
Cotton (sole)	980	-	-	-	-	32500	8660	1.27	2.50
Cotton + greengram (2:2)	645	440	1169	1.18	2406	33000	16090	1.49	1.12
Cotton + clusterbean (2:2)	615	3980	1563	1.42	6763	42900	22730	1.53	10.15
Cotton + groundnut (2:2)	595	460	978	1.05	471	30200	10890	1.36	1.17
Cotton + sesame (2:2)	585	395	1149	1.06	820	34150	14120	1.41	1.01

LER: Land equivalent ratio; MCEY: Main crop equivalent yield; MAI: Monetary advantage index

Alternate land use

In aonla intercropping system, aonla with pearlmillet system recorded higher intercrop yield as compared to other intercropping systems and also recorded higher B:C ratio of 1.50 followed by aonla with sesame. Although sorghum recorded higher yield, the cost of harvesting and less price resulted in lower B:C ratio (Table 1.8.20).

Table 1.8.20: Performance of aonla based agri-horti systems

Treatment	Yield (kg/ha)			Cost of cultivation (Rs./ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop*	Inter crop	Stover/ stalk yield				
Aonla	-	-	-	-	-	-	-
Aonla + pearlmillet	-	1955	4887	19500	9825	1.50	4.99
Aonla + sorghum	-	2110	6330	21400	6030	1.28	5.38
Aonla + sesame	-	590	2360	26500	8900	1.34	1.51

In sapota based intercropping systems, sapota with pearlmillet system recorded higher yield (1680 kg/ha) as compared to other intercropping systems but higher B:C ratio of 1.61 was recorded by sapota + greengram system followed by sapota + pearlmillet (Table 1.8.21).

Table 1.8.21: Performance of sapota based agri-horti systems

Treatment	Yield (kg/ha)			Cost of cultivation (Rs./ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop*	Inter crop	Stover/ stalk yield				
Sapoto	-	-	-	-	-	-	-
Sapoto + pearlmillet	-	1680	4200	7300	7900	1.46	4.29
Sapoto + gingelly	-	510	2040	22900	7700	1.34	1.30
Sapoto +greengram	-	640	1500	19850	12150	1.61	1.63

In acid lime based intercropping system, acid lime with sorghum system recorded higher yield (1980 kg/ha) as compared to other intercropping systems, but the cost of harvesting and less price resulted in lower B:C. ratio (Table 1.8.22).

Table 1.8.22: Performance of acid lime based agri-horti systems

Treatment	Yield (kg/ha)			Cost of cultivation (Rs./ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop*	Inter crop	Stover/ stalk yield				
Acid lime	-	-	-	-	-	-	-
Acid lime+ pearlmillet	-	1740	4350	18400	7700	1.42	4.44
Acid lime+ sorghum	-	1980	5940	19200	6540	1.34	5.05
Acid lime+ sesame	-	535	2140	24500	7600	1.31	1.36

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

Experienced weather condition during 2015-16

During 2015, the onset of monsoon was early by 11 days (9th June). A rainfall of 574.8 mm was received which was deficit by 388.2 mm (40.3%) compared to normal of 963 mm (Fig. 1.8.5). During *kharif* season, 406.3 mm rainfall was recorded which was deficit by 394.2 mm (49.2%) than normal rainfall of 800.5 mm; *rabi* season received 1.8 mm rainfall and was deficit by 108.7 mm (98.4%) than normal of 110.5 mm and summer season received 157.5 mm which was excess by 121 mm (331.5%) as against normal of 36.5 mm.

Normal onset of monsoon	:	20 June
Onset of monsoon during 2015	:	9 June
Annual mean rainfall	:	764.0 mm
Annual mean rainfall during 2015	:	565.6 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	639.1 mm in *kharif* & 109 mm in *rabi*
Crop seasonal rainfall during 2015-16	:	408.1mm & 1.8mm respectively in *kharif* & *rabi*

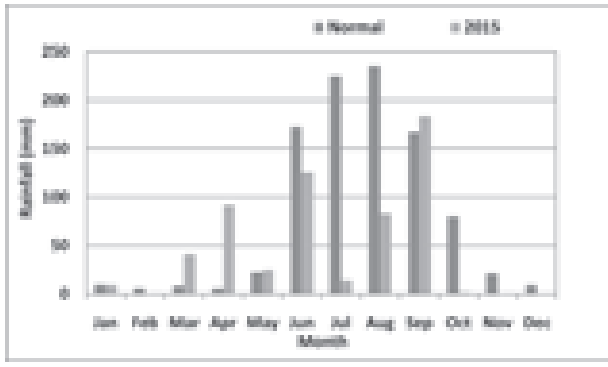


Fig. 1.8.5 : Normal and actual (2015) monthly rainfall at Parbhani

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (Days)	Dates & months		
46	20 June to 4 August	Soybean, pigeonpea, cotton, sorghum, greengram, blackgram	Seedling and flowering
43	19 September to 31 October	Soybean, pigeonpea, cotton, sorghum	Pod formation, grain filling, boll development/ maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Soybean, cotton & pigeonpea	Seedling	Dust and straw mulching
	Blackgram & greengram		Dust mulching
Mid season drought	Soybean & cotton	Vegetative/ growing stage	Foliar spray of KNO_3, water sprays, kaoline
Terminal drought	Cotton	Square formation	Protective irrigation
	Pigeonpea	Branching	

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

During 2015, the onset of monsoon was early by 11 days (9th June). A rainfall of 574.8 mm was received which was deficit by 388.2 mm (40.3%) compared to normal of 963 mm, deficit in June 27.1% and in July by 94%. Dry spell of 46 days was occurred (20 June to 4 August) at seedling and flowering stage of *kharif* crops. To overcome the early season drought, dust and straw mulching was done to prevent soil moisture evaporation.

Among different crops, soybean variety MAUS-71 gave higher yield (522 kg/ha) with *in-situ* moisture conservation through mulching over without mulching. Similarly, in cotton (Ajit 155), higher seed cotton yield was recorded (704 kg/ha) with mulching compared to without mulching (647 kg/ha), and pigeonpea (BDN- 711) recorded higher yield (520 kg/ha), net returns (Rs.18942/ha), B:C ratio (2.08) and RWUE (1.82 kg/ha-mm) (Table 1.8.23).

Table 1.8.23: Effect of mulching on *kharif* crop yields under early season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Mulching	Without Mulching				
Soybean	MAUS-71	522	485	7.6	1.83	6630	1.52
	MAUS-158	497	464	7.1	1.74	5705	1.45
Cotton *Bt*	Ajit 155	704	647	8.8	2.47	7228	1.30
Greengram	BM2003-2	272	254	7.1	0.95	4845	1.42
Blackgram	TAU-1	316	292	8.2	1.10	6485	1.51
Pigeonpea	BDN- 711	520	483	7.7	1.82	18942	2.08

To overcome the early season drought the first weeding followed by hoeing or interculture was carried out at 21 to 30 days after sowing. Among different soybean varieties MAUS-71 gave higher yield (545 kg/ha) with weeding/interculture over without weeding/interculture. Similarly, in cotton (Ajit 155), higher seed cotton yield was recorded (782 kg/ha) with weeding/interculture compared to without weeding/interculture (668 kg/ha). Similarly pigeonpea (BDN- 711) recorded higher seed yield (539 kg/ha) with net returns (Rs.20272/ha), B:C ratio (2.16) and RWUE (1.89 kg/ha-mm) with weeding/interculture (Table 1.8.24).

Table 1.8.24: Effect of weeding/interculture on *kharif* crop yields under early season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture (1 hoeing and 1 weeding)	Without weeding/ interculture (1 hoeing)				
Soybean	MAUS-71	545	464	17.5	1.91	7481	1.60
	MAUS-158	528	453	16.6	1.85	6852	1.54
Cotton	Ajit 155	782	668	17.1	2.55	9441	1.37
Pigeonpea	BDN- 711	539	470	14.7	1.89	20272	2.16
	BSMR- 853	502	439	14.4	1.76	17682	2.01

Situation: Mid season drought

The rainfall was deficit in August by 35.5% but excess in September by 25.1%. There were dry spells of 43 days from 19th September to 31st October which coincided with vegetative stage/ pod formation, flowering and grain filling stages *kharif* crops.

Among different soybean varieties MAUS-71 gave higher yield (575 kg/ha) with weeding/ interculture over without weeding/interculture. In cotton (Ajit 155), higher seed cotton yield was recorded (807 kg/ha) with weeding/interculture compared to without weeding/interculture (668 kg/ha). Similarly pigeonpea (BDN- 711) recorded higher seed yield (562 kg/ha) with net returns (Rs. 21882/ha), B:C ratio (2.25) and RWUE (1.97 kg/ha-mm) with weeding/interculture (Table 1.8.25).

Table 1.8.25: Effect of intercultural operations on *kharif* crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding				
Soybean	MAUS-71	575	476	20.8	2.01	8591	1.67
	MAUS-158	546	461	18.4	1.91	7518	1.60
Cotton	Ajit 155	807	674	19.7	2.83	10566	1.47
Pigeonpea	BDN- 711	562	477	17.8	1.97	21882	2.25
	BSMR- 853	518	444	16.7	1.81	18802	2.07

To overcome the stress due to midseason drought, foliar sprays of KNO_3 (2%), water sprays and kaoline (7%) were undertaken in soybean at 35 DAS (grand growth) and 60 DAS (flowering. The foliar spray of KNO_3 recorded higher yield (582 kg/ha), net returns (Rs.8534/ha), B:C ratio (1.65) and RWUE (2.04 kg/ha) over control (515 kg/ha) (Table 1.8.26).

Table 1.8.26: Effect of foliar sprays on soybean (MAUS-162) yield

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
KNO_3	582	515	13.0	2.04	8534	1.65
Water spray	567	515	10.1	1.98	8179	1.63
Kaoline	544	515	5.6	1.90	7028	1.53

Foliar sprays of KNO_3 (2%), water sprays and kaoline (7%) were undertaken in cotton at 35 DAS (vegetative) and 60 DAS (square formation). The foliar spray of KNO_3 recorded higher yield (820 kg/ha), net returns (Rs.11400/ha), B:C ratio (1.45) and RWUE (2.87 kg/ha) over control (724 kg/ha) (Table 1.8.27).

Table 1.8.27: Effect of foliar sprays on cotton (Ajit-155) yield

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
KNO_3	820	724	13.3	2.87	11400	1.45
Kaoline	745	724	3.0	2.81	7525	1.30
Water spray	767	724	6.0	2.69	8254	1.31

Situation: Terminal drought

A dry spell of 43 days from 19th September to 31st October and no rainfall in November occurred coinciding with flowering and maturing stage of *kharif* crops. Supplemental irrigation was given pigeonpea at flowering and also in cotton at square formation stage (depth of irrigation 5 cm) with sprinklers from harvested rainwater & open well. The increase in yield was 72.0 & 77.8%, respectively with supplemental irrigation over no irrigation. The higher seed yield (748 kg/ha), net returns were Rs. 30706/ha with B:C ratio of 2.41 and RWUE (2.64 kg/ha-mm) were recorded due to supplemental irrigation. Similarly, seed cotton yield (1124 kg/ha), net returns (Rs.25318/ha), B:C ratio (2.00) and RWUE (3.94 kg/ha-mm) were higher with supplemental irrigation (Table 1.8.28).

Table 1.8.28: Effect of protective irrigation on pigeonpea and cotton crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With irrigation	Without irrigation				
Pigeonpea	BDN- 711	748	435	72.0	2.62	30706	2.41
Cotton	Ajit 155	1124	632	77.8	3.94	25318	2.00

Preparedness

Rainwater management

In-situ rainwater management in soybean (MAUS-71) crop with broad bed and furrows (BBF) gave higher seed yield (648 kg/ha), net returns (Rs.10616/ha), B:C ratio (1.80) and RWUE (2.27 kg/ha-mm) compared to flat bed (471 kg/ha) and opening of furrow (603 kg/ha) (Table 1.8.29).

Table 1.8.29: Effect of *in-situ* rainwater management on soybean (MAUS-71) yield and economics

Treatment	Yield (kg/ha)			Cost of cultivation (Rs./ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed yield in (2015)	Mean seed yield (2 years)	Stover/ stalk yield				
Opening of furrow	603	717	753	9211	1.70	2.11	22.81
BBF	648	752	810	10616	1.80	2.27	32.04
Flat bed	471	579	592	5522	1.43	1.72	-

In cotton, *in-situ* rainwater management in cotton with broad bed and furrows gave higher seed cotton yield (786 kg/ha), net returns (Rs. 9496/ha), B:C ratio (1.36) and RWUE (2.75 kg/ha-mm) compared to flat bed (622 kg/ha) and opening of furrow (741 kg/ha) (Table 1.8.30).

Table 1.8.30: Effect of *in-situ* rainwater management on cotton (Ajit-155) yield and economics

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% increase yield
	Seed (2015)	Mean seed (2 years)	Stalk					
Ridge and furrow	741	906	2646	24983	8362	1.33	2.60	19.13
BBF	786	974	2952	25874	9496	1.36	2.75	26.36
Flat bed	622	692	2278	24283	3707	1.15	2.18	-

Cropping systems

Improved short duration varieties of soybean, pigeonpea, greengram, blackgram, cotton and sorghum were evaluated for yield and economics sown under conditions of delayed onset of monsoon. Short duration variety of soybean MAUS 71 recorded higher yield (527 kg/ha) over local variety (445 kg/ha). Drought tolerant variety (BDN 711) of pigeonpea recorded seed yield of 548 kg/ha compared to local variety (459 kg/ha). BM-4 variety of greengram gave higher yield (272 kg/ha) compared to local variety (254 kg/ha). Blackgram variety TAU-1 recorded higher yield (316 kg/ha) compared to local variety (294 kg/ha). PKV-801 variety of sorghum gave higher yield (1457 kg/ha) compared to local variety (1325 kg/ha) and Bt cotton (Ajit 155) (684 kg/ha) as compared to local variety (591 kg/ha) (Table 1.8.31).

Table 1.8.31: Yield and economics of improved varieties of various crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved variety	With local variety				
Soybean	MAUS- 71 (Short duration)	527	445	18.4	1.85	6899	1.55
	MAUS- 162	483	421	14.7	1.69	5271	1.41
	MAUS-158 (Short duration)	474	433	9.5	1.66	4938	1.39
	MAUS-81 (Short duration)	456	412	10.6	1.60	4272	1.33
Pigeonpea	BDN- 711 (drought tolerant)	548	459	19.4	1.92	20605	2.16
	BSMR- 853	485	390	19.6	1.70	16195	1.91
	BDN- 708	442	376	17.5	1.55	13185	1.74
Greengram	BM2003-2	272	254	7.1	0.95	4845	1.42
Blackgram	TAU-1	316	294	7.5	1.10	6485	1.51
Cotton Bt	Ajit 155	684	591	15.7	2.4	6655	1.30
Sorghum	PVK- 801	1457	1325	10.0	5.11	6502	1.42

Among intercropping systems soybean + pigeonpea (4:2) resulted in higher crop equivalent yield of 1835 kg/ha, with net returns of Rs.27253/ha, B:C ratio of 3.40 and RWUE of 3.40 kg/ha-mm compared to cotton+ greengram (1:1) (1482 kg/ha) (Table 1.8.32).

Table 1.8.32: Performance of intercropping systems

Treatment	Yield (kg/ha)		CEY	LER	MAI	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop						
Soybean + pigeonpea (4:2)	478	492	1835	2.10	14276	27253	2.09	3.40
Cotton + greengram (1:1)	697	246	1482	1.89	6544	13898	1.40	3.30

LER: Land equivalent ratio; CEY: Crop equivalent yield; MAI: Monetary advantage index

Nutrient management

The foliar sprays of 19:19:19 (0.5%) and micronutrients mixture (0.5%) comprised of Fe-2.5%, Mn-1%, Zn- 3%, Cu- 1%, Mo-0.10%, B- 0.5% were undertaken in soybean at 35 and 60 DAS. The foliar spray of 19:19:19 (0.5%) recorded higher yield (573 kg/ha), with net returns of Rs.7726/ha, B:C ratio of 1.57 and RWUE of 2.01 kg/ha-mm compared to micronutrients mixture (0.5% each) (569 kg/ha) (Table 1.8.33).

Table 1.8.33: Effect of foliar sprays on soybean yield and economics

Treatment	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% increase in yield
	Seed	No foliar spray	Stover				
19:19:19	573	515	745	7726	1.57	2.01	11.3
Micronutrients mixture	569	515	738	7553	1.56	2.00	10.5

Similar foliar sprays were undertaken in cotton at 35 DAS and 65 DAS. The foliar spray of 19:19:19 (0.5%) recorded higher yield (788 kg/ha), with net returns of Rs. 8007/ha, B:C ratio of 1.29 and RWUE of 2.76 kg/ha compared to micronutrients mixture (0.5% each) (776 kg/ha) (Table 1.8.34).

Table 1.8.34: Effect of foliar sprays on cotton yield and economics

Treatment	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% increase in yield
	Seed (2015)	No foliar spray	Stover/ Stalk				
19:19:19	788	724	2947	8007	1.29	2.76	8.84
Micronutrients mixture	776	724	2761	8420	1.31	2.72	7.18

In another experiments, the integrated nutrient management (RDF + FYM @ 5 t/ha) in soybean was recorded higher yield (559 kg/ha), with net returns of Rs.7558/ha, B:C ratio of 1.57 and RWUE of 1.96 kg/ha compared to RDF (548 kg/ha). In another trial, site specific nutrient management (SSNM) in during soil application of RDF and ferrous sulphate @ 25 kg/ha and zinc sulphate @ 20 kg/ha in soybean and it gave 16.1% more yield than normal practice (548 kg/ha), with higher net returns of Rs.7592/ha, B:C ratio of 1.60 and RWUE of 1.92 kg/ha compared to without SSNM farmer practices (472 kg/ha).

Tillage with tractor drawn implements and sowing with BBF was done in soybean. The seed yield of soybean was higher (597 kg/ha) with higher net returns (Rs.8637/ha), B:C ratio (1.81) and RWUE (2.09 kg/ha-mm) (Table). In another trial, tractor drawn tillage recorded higher field efficiency (4.5 hr/ha) with energy output (23020 MJ/ha) and energy use efficiency (2.28) compared to animal drawn tillage (18 hr/ha) with lower energy output (20380 MJ/ha) and energy use efficiency (2.16) (Table 1.8.35).

Table 1.8.35 : Energy use efficiency of different implements

Treatment	Field efficiency (hr/ha)	Energy (MJ/ha)		Energy use efficiency/ ER
		Input	Output	
Tractor drawn tillage + sowing	4.5	10105	23020	2.28
Animal drawn tillage + sowing	18	9449	20380	2.16

c. On-farm demonstrations

Village profile

The program is being implemented in Babulgaon 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 is 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 temperatures during crop season are 41 and 21^{0}C, respectively. The extreme events like unusual and high intensity rainfall in short span are 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.

Experienced weather conditions during 2015-16

The rainfall data of Parbhani centre was taken. During 2015, the onset of monsoon was early by 11 days (9th June). A rainfall of 574.8 mm was received which was deficit by 388.2 mm (40.3%) compared to normal of 963 mm (Fig…..). During *kharif* season, 406.3 mm rainfall was recorded which was deficit by 394.2 mm (49.2%) than normal rainfall of 800.5 mm; *rabi* season received 1.8 mm rainfall and was deficit by 108.7 mm (98.4%) than normal of 110.5 mm and summer season received 157.5 mm which was excess by 121 mm (331.5%) as against normal of 36.5 mm.

Dry spells during crop growing season (2015-16)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
46	20 June to 4 August	Soybean, pigeonpea, cotton, sorghum, greengram, blackgram	Seedling and vegetative
43	19 Sep to 31 October	Soybean, Pigeonpea, cotton, sorghum, greengram, blackgram	Pod formation and grain filling

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented	No. of farmers	Area (ha)
Early season drought	Soybean	Dust mulching and straw mulching	32	12.8
	Cotton	Dust mulching and straw mulching	2	0.8
Mid season drought	Soybean	Foliar sprays of KNO_3 and water sprays	27	10.8
	Cotton	Foliar sprays of KNO_3 and water sprays	2	0.8
Terminal drought	Cotton	Protective irrigation	2	0.8
	Pigeonpea	Protective irrigation	4	1.6

Situation: Mid season drought

There were dry spells 43 days from 19th September to 31st October which coincided with vegetative stage, pod formation, flowering and grain filling stages of *kharif* crop. To overcome the stress due to midseason drought, foliar sprays of KNO_3 (1 and 2%), water sprays and kaoline (7 %) were undertaken in soybean at 35 DAS (grand growth) and 60 DAS (flowering). The foliar spray of KNO_3 recorded higher yield (484 kg/ha), net returns (Rs.5544/ha), B:C ratio (1.44), RWUE (1.69 kg/ha) and the increase in yield was 11.26% over control (471 kg/ha). Similarly in cotton, foliar spray of KNO_3 gave higher seed cotton yield (804 kg/ha) as compared to control (762 kg/ha) and the increase in yield was 12.12% (Table 1.8.36).

Table 1.8.36: Effect of foliar sprays on different crops yield and economics

Crop	Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray				
Soybean	KNO_3	484	435	11.3	1.69	5544	1.44
	Water spray	471	435	8.3	1.65	4627	1.36
Cotton	KNO_3	804	712	12.1	2.82	11168	1.44
	Water spray	762	712	7.0	2.67	8008	1.31

Situation: Terminal drought

During 2015, in *kharif* season 406.3 mm rainfall was recorded which was deficit by 394.2 mm (49.2%) than normal rainfall of 800.5 mm, deficit in July 94%, August 64.7%, October 97.8% and in November and December 100%. Supplemental irrigation (5 cm) was given to pigeonpea crop at flowering and also in cotton at square boll development stage in the month of September with sprinklers from harvested rainwater in open well to overcome the terminal drought situation. The increase in yield was 77.8 and 70.3%, respectively with supplemental irrigation over no irrigation. The higher seed yield of pigeonpea (494 kg/ha), net returns were Rs. 17016/ha with B:C ratio of 1.97 and RWUE of 1.73 (kg/ha-mm) was recorded due to supplemental irrigation. Similarly, higher seed cotton yield (1124 kg/ha), net returns (Rs.25318/ha), B:C ratio (2.00) and RWUE (3.94 kg/ha-mm) was recorded with supplemental irrigation (Table 1.8.37).

Table 1.8.37: Effect of protective irrigation on cotton and pigeonpea yields and economics

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With irrigation	Without irrigation				
Cotton	Ajit 155	1124	632	77.8	3.94	25318	2.00
Pigeonpea	BDN- 711	494	290	70.3	1.73	17016	1.97

Preparedness

Rainwater management

In-situ rainwater management with BBF in soybean (MAUS-71) gave higher seed yield (632 kg/ha), net returns (Rs.9024/ha), B:C ratio (1.61) and RWUE (2.21 kg/ha-mm) compared to flat bed method (487 kg/ha) (Table 1.8.38).

Table 1.8.38: Effect of *in-situ* rainwater management on soybean (MAUS-71)

Treatment	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% increase in yield
	Seed (2015)	Mean (2 years)	Stover				
BBF	632	694	866	9024	1.61	2.21	29.77
Farmer's practice (Flat bed)	487	543	574	5374	1.42	1.70	-

Cropping systems

The intercropping system of soybean + pigeonpea (4:2) resulted in higher main crop equivalent yield of 1731 kg/ha, with higher net returns of Rs.19840/ha, B:C ratio of 1.62 and RWUE of 3.36 (kg/ha-mm) compared to cotton + greengram (1:1) with yield of 1466 kg/ha (Table 1.8.39).

Table 1.8.39: Effect of intercropping systems on crop yields and economics

Treatment	Yield (kg/ha)		MCEY	LER	MAI	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop						
Cotton + greengram (1:1)	697	246	1466	1.88	6505	13898	1.40	3.30
Farmer's practice (Sole cotton)	754	-	-	-	8181	1.31	2.64	
Soybean + pigeonpea (4:2)	472	488	1731	2.08	10391	19840	1.62	3.36
Sole soybean	463	-	-	-	3549	1.26	1.62	

Nutrient management

Foliar sprays of 19:19:19 (0.5%) were undertaken in pigeonpea at 35 and 60 DAS. The foliar spray of 19:19:19 (0.5%) recorded higher yield (484 kg/ha), net returns of Rs.16422/ha, B:C ratio of 1.94, RWUE of 1.70 kg/ha, and yield increase was 11.09% compared to farmer's practice of no foliar spray (0.5%) (436 kg/ha).

The foliar sprays of micronutrients mixture (0.5%) comprised of Fe- 2.5%, Mn-1%, Zn- 3%, Cu- 1%, Mo-0.10% and B- 0.5% were undertaken in cotton at 35 and 60 DAS. The foliar spray of micronutrients mixture recorded higher yield (781 kg/ha), with higher net returns of Rs.8645/ha, B:C ratio of 1.33 and RWUE of 2.74 kg/ha compared to farmer's practice (712 kg/ha).

Integrated nutrient management (RDF + FYM @ 5 t/ha) in soybean recorded higher yield (472 kg/ha), with higher net returns of Rs.4249/ha, B: C ratio of 1.67, RWUE of 1.96 kg/ha-mm and yield increase was 1.94% compared to farmer practices (RDF) (548 kg/ha).

During *kharif* 2015, tractor drawn tillage + sowing and animal drawn tillage + sowing were demonstrated. Among these, tractor drawn method recorded higher field efficiency (4.5 hr/ha) with higher energy output (26071 MJ/ha) and energy use efficiency (2.35) compared to animal drawn implements (18 hr/ha) with energy output (27258 MJ/ha) and energy use efficiency (2.60) (Table 1.8.40).

Table 1.8.40: Effect of treatments on energy use efficiency

Treatment	Field efficiency (hr/ha)	Energy (MJ/ha)		Energy use efficiency
		Input	Output	
Tractor drawn tillage + sowing	4.5	11116	26071	2.35
Animal drawn tillage + sowing	18	10480	27258	2.60

Real time contingency plan implementation



Drought tolerant high yielding varieties/ hybrids of maize (Kanchan), sorghum (CSV 20) and blackgram (Birsa Urd-1) for delayed onset of monsoon in Kumbhi & Bankheta, Garhwa district


Short duration castor hybrid (GCH 7) and greengram variety (GM 4) for delayed onset of monsoon at SK Nagar, Gujarat


In-situ **moisture conservation by opening of conservation furrows in castor (left) and Setaria (var. Suryanandi) for delayed onset of monsoon at Vannedoddipally village, Anantapuramu district**

Four storey nursery technique as RTCP to cope with delayed onset of monsoon in Tahkapal village, Bastar district

Furrow opening in direct seeded paddy to cope with early season drought in Tahkapal village, Bastar district

Mid field ditches for saving crop from early season drought in Tahkapal village, Bastar district


Mulching with crop residues in soybean (left) and Intercultivation in cotton (right) to cope with early- and mid-season drought in Babhulgaon village, Parbhani district

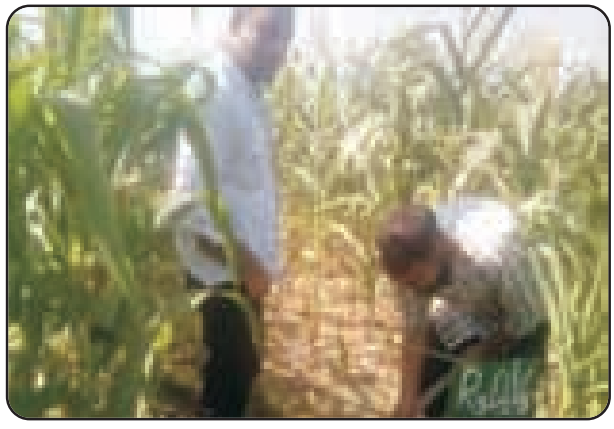

In-situ **moisture conservation intervention by furrow opening in cotton to cope with early season drought in Pata Meghpar village, Jamnagar district**


DSR with life saving irrigation (left) compared to without intervention (right) in Terha Saraya village, Mirzapur district


Removal of lower leaves in maize and and their use as mulch/fodder to cope with mid season drought in Khaner village, Samba district


Supplemental irrigation (drip) in castor (left) to cope with terminal drought at Kalimati/ Dholiya village, Banaskantha District (right: crop without irrigation)

Preparedness

Rainwater harvesting in farm pond for supplemental irrigation to maize at Rakh Dhiansar, Jammu & Kashmir

Ridge planted maize (left) and flat bed sown maize (right) at Ballowal Saunkhri, Punjab

***Rabi* sorghum under ridges and furrow method (left) and farmers' practice (right) at Narotewadi village, Solapur district**

Compartmental bunding

Farmers' practice (no compartmental bunding)

Performance of pearlmillet under compartmental bunding at Agra, Uttar Pradesh


Improved groundnut variety Kadiri-6 (left) compared to local variety TMV-2 (right) at Vannedoddipally village, Ananthapuramu district


Castor + greengram intercropping system (1:1) compared to sole castor at SK Nagar, Gujarat



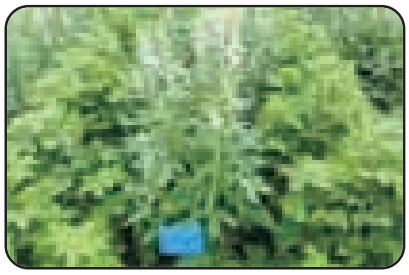
Pigeonpea (BRG 2) + field bean (1:1)

Pigeonpea (BRG-2) + soybean (1:1)

Pigeonpea (BRG 1) + cowpea (1:1)

Evaluation of different intercropping systems at Bengaluru, Karnataka

Cotton + groundnut (1:1)



Cotton + sesame (1:1)

Cotton + greengram (1:1)

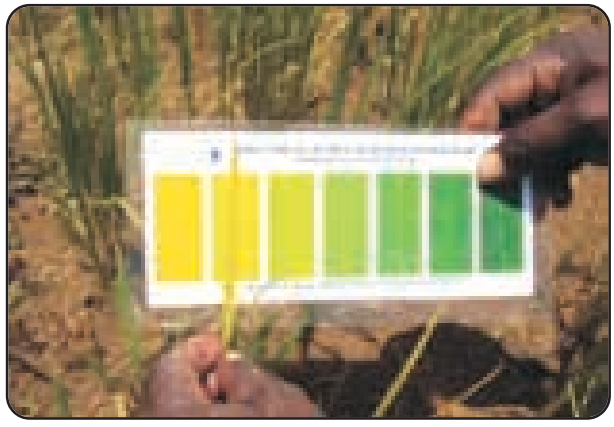
Cotton +blackgram (1:1)

Cotton + soybean (1:1)

Cotton + cowpea (1:1)

Field view of different intercropping systems at Rajkot, Gujarat

Promotion of ash gourd cultivation as alternate crop to maize in Achalpur and Nainwan villages, Hoshiarpur district



Use of leaf colour chart for nitrogen management in rainfed rice at Tahkapal village, Bastar district

Sowing of greengram with zero till drill (left) at SK Nagar, Gujarat, and maize with maize planter at Rakh Dhiansar, Jammu & Kashmir

Alternate land use and utilization of inter-row space for intercrops of cowpea, colocasia and elephant foot yam at Jaddalpur, Chhattisgarh

2. NICRA – Strategic Research

Adaptation strategies through cropping systems at selected soil benchmark sites

Risk coping production systems resilient to climate, land and water modifications require diversified structures in space and time such as cropping systems. Inter-annual and intra-annual seasonal climate variability is one of the major factors influencing biophysical systems. Further, the spatial variability of soils in turn affects the ability of the crops to cope with drought and finally yields. The present study was undertaken at Varkhed watershed (77p 7' 00'' to 77p 10' 00'' E; 20p 32' 20'' to 20p 35' 00'' N), Barishtakali Tehsil, Akola district, Maharashtra, to assess the climate risks and to identify cropping systems as an adaptation strategy at selected soil sites.

At Varkhed watershed, during 2015, onset of monsoon was normal (11 June). A seasonal rainfall (June-September) of 613 mm was received which was deficit by 77.2 mm compared to normal (690.2 mm) (Fig). The dry spell during 25th to 29th SMW coincided with vegetative stage of soybean, greengram, cotton and pigeonpea whereas the second dry spell during 33rd to 34th SMW coincided with the flowering stage of soybean and greengram, and vegetative stage of cotton and pigeonpea. The dry spell during 38th to 44th SMW affected flowering of soybean, pod initiation of greengram, square formation of cotton and vegetative growth of pigeonpea.

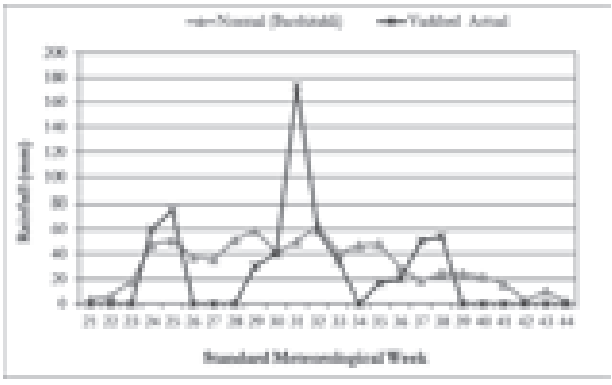


Fig. Normal and actual (2014) weekly rainfall in Barshitakli village, Varkhed watershed

In general, crop yields were low in the village. *In-situ* moisture conservation through opening of conservation furrow at 30-35 DAS in soybean (JS-335) resulted in 9% higher seed yield compared to farmers' practice of no conservation furrow. Higher seed yield (980 kg/ha) of soybean was recorded with opening of conservation furrow in very fine smectitic, calcareous Vertic Ustochrepts soil followed by Typic Haplusterts (820 kg/ha), Typic Ustochrepts (798 kg/ha) and Typic Ustorthents (753 kg/ha) (Fig). Higher seed yield (764 kg/ha) of greengram (Utkarsh) and rainwater use efficiency (1.62 kg/ha-mm) was recorded under deep to very deep soils (very fine smectitic, calcareous, Typic Haplusterts) followed by yields under medium to deep soils (667 kg/ha), medium soils (577 kg/ha) and shallow soils (520 kg/ha).

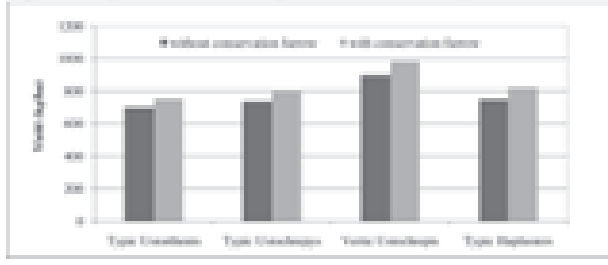


Fig. Performance of soybean under *in-situ* moisture conservation in various soil types

Similarly, in soybean + pigeonpea intercropping system (4:2) higher soybean equivalent yield (SEY) was recorded under Vertic Haplusterts soil (1953 kg/ha), while it was 1635 and 1594 kg/ha under Typic Haplusterts and Typic Ustochrepts, respectively (Fig).

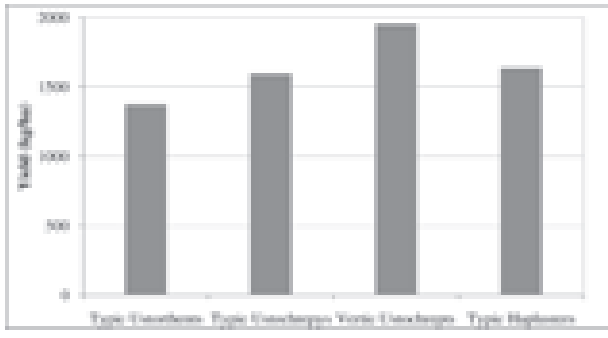


Fig . Performance of soybean + pigeonpea intercropping system in different soils

Potential of organic crop production as a climate change adaptation and mitigation strategy in rainfed agriculture

Organic agriculture is one of the fastest growing sectors of agricultural production, and is reported to have both climate change adaptation and mitigation potential particularly in rainfed agriculture. A field experiment was conducted during *kharif* 2015 at GRF of the institute to evaluate the performance of sunflower, green gram and pigeonpea under organic, inorganic and integrated crop management systems. The experiment was laid out in a strip-plot design with three production systems and three crops. In the plots under organic management, farmyard manure was applied on the N equivalent basis to all the three crops and the P requirement was supplemented through rock phosphate. In the plots under integrated management, 25% of equivalent recommended N was applied through farmyard manure. The remaining 75% N and 100% P and K was applied through chemical fertilizers. The plots under inorganic management received recommended dose of chemical fertilizers.

In general, the seed yield of all three crops was poor across different treatments due to poor rainfall distribution during crop season with 3 dry spells of more than 12 days. The seed yield of sunflower was 15 and 18% higher in the plots under INM (625 kg/ha) than that under inorganic organic management, respectively. However, both INM and organic management recorded similar seed yield of greengram (547-566 kg/ha) while the yield was lowest (515 kg/ha) under inorganic management. Pigeonpea yield was highest in the plots under organic management (417 kg/ha) which was higher by 8 and 19% compared to integrated and inorganic treatments, respectively (Fig). In general, pigeonpea yield was low due to less rainfall during October (23 mm) and no rainfall after 11 October till crop harvest in December.

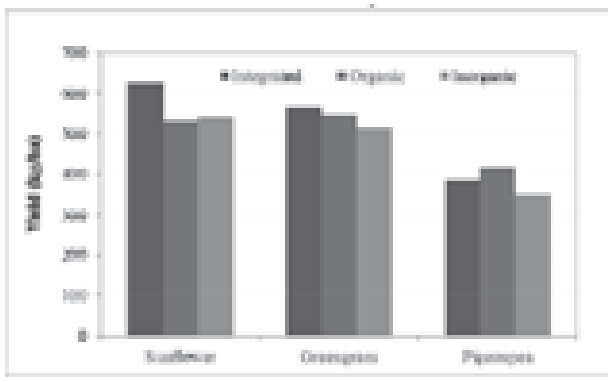


Fig . Performance of crops under different production systems

Among different production systems, plots under organic management had lower bulk density (1.30 Mg/m^3) than other treatments. However, soil pH (6.6-6.7) and organic C (0.45-0.49%) were similar under all three production systems. The plots under integrated management had higher content of available N (262 kg/ha), P (25.6 kg/ha) and K (241.1 kg/ha) compared to other treatments. The soil moisture content in different plots ranged between 4.7-13.8% depending on the amount of rainfall received prior to soil sampling. On average, the soil moisture content was 0.35-0.5% higher in the plots under organic management during the crop season (Fig) compared to integrated and inorganic treatments. Similarly, the soil temperature was lower under organic management by 0.7^0C compared to other treatments.

3. NICRA - Other Activities

3.1. Village Institutions

3.1.1. Village Climate Risk Management Committee (VCRMC)

VCRMCs have been established in each NICRA village and actively involved in various activities of project. During 2015-16 in NICRA villages, the VCRMCs participated in implementation of various climate risk resilient interventions such as contingency crop planning, soil and crop based interventions, and efficient functioning of custom hiring centers etc.

NICRA Village	VCRMC meeting	Outcome of VCRMC meetings
Chikkamaranahalli village, Bengaluru Rural district, Karnataka (Bengalure)	08.07.2015	Gap filling in pigeonpea and groundnut in groundnut + pigeonpea cropping system
	27.08.2015	Weeding and intercultivation in finger millet
		Opening of moisture conservation furrow between paired row of pigeonpea
	30.09.2015 10.10.2015	Advised farmers to take up plant protection measures in pigeonpea
Kalimati/Dholia, Chandanki villages, Banaskantha/ Mehasana districts, Gujarat (SK Nagar)	26.05.2015	Planning of interventions for different crops
	24.07.2015 17.08.2015	Nutrients applied as soil application in pearlmillet crop
Kavalagi village, Vijayapura district, Karnataka (Vijayapura)	09.06.2015	Seed treatment in pigeonpea and greengram
	21.07.2015	Short duration crops were sown as contingency plan
	28.07.2015	Moisture conservation practices like repeated intercultivation
	04.08.2015	In fallow land, compartment bunding was done
	18.08.2015	KNO_3 @ 0.5% spray for all Kharif crops
	25.08.2015	Pearlmillet was harvested for fodder purpose
	08.09.2015	In this period,60 mm rainfall was received. Urea 2% spray has been taken for all the Kharif crops
	18.09.2015	In this period, 110 mm rainfall was received Rabi crops were sown with improved varieties
Babhulgoan village, Parbhani district, Maharashtra (Parbhani)	02.07.2015	Hoeing and weeding operations were taken up. Opening of furrow after every 4 rows in soybean and 2 rows in pigeonpea and cotton. (30 days after sowing)
	13.10.2015	Protective irrigation to soybean and cotton crop harvested rain water from bore / open wells

NICRA Village	VCRMC meeting	Outcome of VCRMC meetings
Naiwan & Achalpur villages Hoshiarpur district, Punjab (Ballowal Saunkhri)	19.06.2015	Revise the rate of custom hiring centre
	15.11.2015	Pre-sowing irrigation from the harvested rainwater in village pond at village Nainwan
Warkhed village, Akola district, Maharashtra (Akola)	12.08.2015	Opening of furrows in soybean and cotton for moisture conservation
	11.09.2015	Foliar spray @ 2% urea and 2% DAPS at the time of flowering and boll development stage in cotton
Vannedoddipally village, Anantapur amu district, Andhra Pradesh (Ananthapuramu)	11.09.2015	Conservation furrows in groundnut, castor, pigeonpea and cotton
	11.09.2015	Carbendazim and mancozeb spayed against leaf spot in groundnut
	13.10.2015	Spaying of carbendizm against botrytis in castor
	02.12.2015	Pheromone traps for pink bollworm
Tahakapal, Tandapal and Gumiyapal villages, Bastar district, Chattishgarh (Jagdalpur)	31.08.2015	Sowing of mid season upland crops with seed drill
	29.09.2015	Mid season drought review with farmers
	18.10.2015	Supplemental irrigation in paddy
Raura and Patuna villages, Rewa district, Madhya Pradesh (Rewa)	30.08.2015	Water management in kharif crops
	06.09.2015	In- situ moisture conservation under drought condition
	16.11.2015	Post harvest operations in kharif and pre-sowing operations for rabi
	20.01.2016	Plant protection for chickpea from chickpea pod borer
Chamua village, Lakhimpur district, Assam (Biswanath Chariali)	12.03.2015	Establishment of fodder seed bank in the village
	06.04.2015	Vaccination of cattle of NICRA village against FMD disease
	03.06.2015	Foundation seed of different paddy varieties were collected and distributed among farmers
	09.07.2015	Seeds of peanut were distributed for cultivation of peanut on experimental basis in the village
	02.11.2015	A temporary storage structure was developed for storage of fertilizers at the village
	11.11.2015	Distributed seeds of rapeseed and potato and fertilizers among farmers
	25.11.2015	Agromet advisories were displayed for management of late blight disease of potato

3.1.2. Custom Hiring Centre (CHC)

Custom Hiring Centre (CHC) was established in each NICRA village and need based implements were made available for farmers for hiring as per the rates approved by custom hiring management committee (CHMC). The money incurred from CHC

is maintained and used for repair of the implements. Implements availability for various agricultural operations on custom hiring during 2015-16 in adopted NICRA villages, are given below.

NICRA village	Implement used	Farm operation	Usage / unit (days)	Area covered (ha)	Labour saving (hr/ha)	Cost saving (Rs/ha)
Chikkamaranahalli village, Bengaluru Rural district, Karnataka (Bengalure)	Improved sickles	Harvesting	16	6.3	64.0	1320
	Hand weeders earthing up	Weeding and	2	12.8	260.0	290
	Modified seed drill	Sowing finger millet	6	20.0	8.0	160
	Spike tooth harrow	Secondary tillage	5	20.2	12.5	330
Pata meghapar village, Jamnagar district, Gujarat (Rajkot)	Cultivator	Primary tillage	15	22.0	2.0	216
	Reversible plough	Deep ploughing	10	14.0	1.5	486
	Mobile slicer	Incorporation of cotton stalks	17	28.0	3.0	972
	Rotavator	Ploughing	13	20.0	3.0	648
Kalimati/Dholia, Chandanki villages, Banaskantha/ Mehasana districts, Gujarat (SK Nagar)	Disc harrow	Ploughing	16	10.0	2.0	400
	Rotavator	Seedbed preparation	40	26.0	2.5	600
	Roto till drill	Sowing	12	8.0	3.5	1500
	Multi crop seed cum fertilizer drill	Sowing	22	25.0	5.0	1200
	Power weeder	Weeding	30	15.0	6.0	1200
	Improved sickle	Harvesting	60	20.0	3.0	250
	Castor decorticator	Decarticating of castor	20	15.0	5.0	750
	Maize sheller	Threshing	10	3.0	4.0	400
Kavalagi village, Vijayapura district, Karnataka (Vijayapura)	Bund former	Compartmental bunding	5	6.0	10.0	800
	Knapsack sprayer	Plant protection	2	4.0	4.0	100
	Power sprayer	Plant protection	3	8.0	2.0	100
	Cycle operated fertilizer drill	Fertilizer application		1.0	2.0	400
	Cycle weeder	Weeding	1	1.0	4.0	650
Babhulgoan village, Parbhani district, Maharashtra (Parbhani)	Seed cum ferti drill	Sowing		4.0	50%	400
	Stubble collector	Collection of stubbles		8.0	70%	600
	Ridger	Opening of conservation furrow		8.0	50 %	-

NICRA village	Implement used	Farm operation	Usage / unit (days)	Area covered (ha)	Labour saving (hr/ha)	Cost saving (Rs/ha)
Narotewadi village, Solapur district, Maharashtra (Solapur)	Tractor operated four blade baliram plough	Ploughing	50	160.0	30 %	40%
	Cultivator 9 teeth and 5 teeth	Clod crushing				
	Two way M.B plough	Ploughing				
	Cycle hoe	Hoeing				
	Laxmi sickle	Cutting				
	Crida-9 row tractor drawn seed cum ferti drill	Sowing				
Budhadani village, Kandhamal district, Odisha (Phulbani)	Power tiller	Land preparation	10	2.5	25%	15%
	Reaper	Harvesting	12	2.0	60%	35%
	Winnower	Threshing	12	2.0	60%	40%
	Water pump	Irrigation	6	1.0	40%	30%
	Sprayer	Plant protection	5	1.5	60%	40%
Warkhed village, Akola district, Maharashtra (Akola)	Multipurpose	Threshing	47	2.4	11.0	1170.00
	Rotavator	Land preparation	04	3.6	5.0	900.00
Vannedoddepally village, Anantapuramu district, Andhra Pradesh (Ananthapuramu)	Duck foot 5 row cultivator	Preparatory cultivation	2	5.0	2.0	-
	Castor shell mill	Threshing	5	5.0	4.0	-
Tahakapal, Tandapal and Gumiyapal villages, Bastar district, Chattishgarh (Jagdalpur)	Cultivator	Ploughing	05		3.0	300.00
	Seed cum fertilizer drill	Sowing	03		1.0	250.00
	Rotavator	land preparation	04		2.0	300.00
	Trolley	Transport of inputs & farm produce	03		3.0	200.00
Khaner village, Samba district, Jammu & Kashmir (Rakh Dhiansar)	Maize Planter	Sowing of maize	12	1.3	-	-
	Maize Sheller	Shelling of Maize cobs	27	2.0	-	-

NICRA village	Implement used	Farm operation	Usage / unit (days)	Area covered (ha)	Labour saving (hr/ha)	Cost saving (Rs/ha)
Nagla Duleh khan village, Agra district, Uttar Pradesh (Agra)	Seed cum ferti drill	sowing	20	-	-	400.00/ha
	Rotavatr	Seedbed preparation	10			600.00
Muthukrishnapuram and V adakkupatti villages, Thoothukkuri district, Tamil Nadu (Kovilpatti)	Ferti seed drill	Sowing	4	3.0	2.0	1000
	Rotavator	In situ mulching	3	3.0	3.0	2100
Raura and Patuna villages, Rewa district, Madhya Pradesh (Rewa)	Raised bed planter Harrow Rotavator Seed drill Cultivator	Sowing Field preparation Field preparation Sowing Land preparation	15 20 10 25 20	8.0 20.0 10.0 50.0 30.0	-	-
Chamua village, Lakhimpur district, Assam (Biswanath Chariali)	WLP Power tiller Cultivator Rotavator Paddy thresher	Nursery bed preparation of Sali paddy Ploughing Ploughing Ploughing Threshing of paddy	80 75 120 80	53.3 20.0 56.0 45.0	20.6 41.2 43.1 94.5 -	750 750 375 2250 -

3.1.3. Village Seed Bank

Efforts were made to provide the sources of alternative crop seed and varieties to address the problem of seed unavailability. In Chikkamaranahalli village, Bengaluru Rural district, farmers have stored the seed material of improved varieties of fingermillet and pigeonpea for sowing in the next season. The farmers of Budhadani village, Kandhamal district, maintained seed of Vandana, Sahabhagi and ODR 1-2 of rice. In Raura and Patuna villages, Rewa district, farmers maintained, the seed material from their own seed harvested from *kharif* and *Rabi* crops and supplied within the village.

Seed availability in NICRA villages

NICRA village	Crop	Variety/hybrid	Quantity (kg)
Kalimati and Chandanki villages (SK Nagar)	Pearlmillet	GHB 558	80
	Maize	GM 2	320
	Greengram	GM 4	300
	Blackgram	GU 1	180
	Cluster bean	GG 2	160
	Sorghum (Fodder)	CSV 21	2500

NICRA village	Crop	Variety/hybrid	Quantity (kg)
Babhulgoan village (Parbhani)	Soybean	MAUS 71 MAUS 162	3640
	Pigeonpea	BDN 711	130
Tedha village (Varanasi)	Rice	NDR-97, NDR-105, Susak Samrat	6000
		Sweta	3500
	Sesame	JT-1	800
	Greengram	HUM-16	1200
Hardoiya village (Faizabad)	Pigeonpea	NDA-2	50
		NDA-1	50
	Maize	Naveen	50
	Chickpea	PUSA-362	200
		Udai	100
	Lentil	HUL-57	30
	Mustard	NDA1	10
		Varuna	20
	Linseed	Garima	10
Tahakapal village (Jagdalpur)	Paddy	MTU1010	596
	Black gram	Pant Urdu	149
	Pigeon pea	Asha	68
	Sorghum	Local variety	125
	Finger millet	GPO 28	366
	Kodo millet	JK48	417
	Horsegram	Bastar kulti1	89
	Little millet	JK8	134
	Niger	T9i	30
Nignoti and Bishkhedi villages (Indore)	Soybean	RVS201-04	4000
	Wheat	HD-2987	10000
		MPO-1215	6000
Chamua, Lakhimpur and Sonitpur villages (Biswanath Chariali)	Rice	Luit100	260
		Dishang 110	140
		TTB – 404	172
	Rapeseed	TS-38	50
		TS-36	20
		Total	**41946**

3.1.4 Fodder Bank

Farmers were supplied with seeds of *Stylosanthes hamata* for sowing on the bunds to establish perennial fodder source and to stabilize bunds in NICRA village, Bengaluru and the fodder was used for feeding small ruminants. Dry fodder of sorghum and bajra was stored and used for own cattle. Haulm of groundnut and straw of wheat was also stored for own cattle by the farmers of NICRA village, Rajkot during drought condition. Farmers in NICRA village, Parbhani maintained their own fodder by growing sorghum and bajra. The live fodder bank maintained more than 2000 q fodder in NICRA village, Jhansi. Paddy straw, wheat straw, chickpea and Lentil straw stoves was stored as fodder bank and use as feed purpose for milch animals as well as for draught animals in NICRA villages, Rewa. A 'fodder seed bank' was established at the NICRA village Chamua, Biswanath Chariali. Population of jersey cattle in the village has increased from 15 to 40 at the end of March, 2015. Presently 12 small farmers of the village are maintaining scientific dairy farming and hybrid Napier is cultivated in more than one ha of land in the village. In NICRA village of Ballowal Saunkhri, the fodder bank of *hybrid napier* has been planted to strengthen the avavilability of green fodder. In NICRA villages adopted by Jagdalpur centre, stylosantheis, napier, berseem and sorghum based fodder systems were developed in 5 farmers' fields.

3.2. Training / Field days etc., organized

3.2.1. Trainings

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
Ananthapuramu	Importance of micronutrients in rainfed crops	25	20.06.2015
	Importance of seed treatment in rainfed crops	20	15.07.2015
	Importance of deep ploughing in groundnut + pigeonpea system and castor + pigeonpea intercropping systems	23	15.07.2015
	Package of practices for contingent crops	22	12.08.2015
	Importance of conservation furrows in castor	15	11.09.2015
	Management botrytis in castor	32	13.10.2015
	Soil test based fertilizer application for rabi crops	30	07.11.2015
	Management of cotton pink boll worm in cotton	25	02.12.2015
Arjia	Organic farming	20	21.08.2015
Bengaluru	*Kharif* planning	47	22.05.2015
	NICRA farmers to ORP demonstration site at Baichenahalli	28	21.10.2015
Rajkot	Contingency crop planning	52	03.06.2015
	Importance of microirrigation system in crop production	77	20.08.2015
	Nutrient management in *kharif* crops	32	23.09.2015
	Pest management in rabi crops	23	21.11.2015
SK Nagar	Sowing methods in different rainfed crops	259	20.06.2015
	Foliar and soil application of fertilizers in different crops at village Dholiya	318	25.08.2015
Vijayapura	*In-siotu* moisture conservation and contingency crop planning	100	07.08.2015

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
Parbhani	Management of kharif crops	75	19.06.2015
	Improved crop management practices	64	16.07.2015
	Management of rabi crops	32	30.09.2015
Solapur	Pre-seasonal training in management of kharif crops	60	20.06.2015
	Rabi pre-season training	45	09.09.2015
	Management of rabi crops	75	09.10.2015
	Soil testing and rabi crop planning	126	05.12.2015
	Potash management in dryland crops	90	21.12.2015
Ballowal Saunkhri	Seed production	22	22.01.2015
Kovilpatti	Vermi-composting	25	05.06.2015
Akola	Improved cultivation techniques for soybean and cotton	41	13.08.2015
Jagdalpur	Kharif crop planning & sowing methods	52	25.07.2015
	Integrated pest management in kharif crops	45	31.08.2015
	Integrated pest management & water management	52	30.09.2015
	Vegetable crop planning and production technology in Badi situation	46	28.11.2015
	Post harvest technology & preparation for rabi crops	48	10.12.2015
Rakh Dhiansar	Pre-season training in *kharif* crops	30	30.06.2015
	Pre-season training in management of rabi crops	30	13.11.2015
Jhansi	Weed control in *kharif* crops	20	21.08.2015
	Seed treatment in rabi crops	27	03.11.2015
	Moisture conservation	17	29.01.2016
Indore	*Kharif* crop planning ,varieties selection and input arrangement	46	12.052015
	Animal health care during rainy season Training on Production technology of rabi crops	16 42	18.06.2015 18.11.2015
	Spot guidance to farmers and monitoring of the trails	38	02.01.2016
	Improvement in water productivity and cropping intercity	41	03.02.2016
	Two days training on Integrated farming system	48	04-05.12. 2015
Rewa	Post harvest operation of field crops	25	16.11.2015
	Rabi crops and cropping systems suitable for the region	30	20.11.2015
	Importance of plant protection in field crops	20	06.01.2016
	Total number of beneficiaries		**2501**

3.2.2. Field days

AICRPDA centre	Intervention	NICRA village	Date	Beneficia-ries (No.)
Anantapuramu	Conservation furrows	Vannedoddipally	11.09.2015	10
	Pigeonpea PRG-158		02.12.2015	23
	Cotton pheromone traps		02.12.2015	12
Arjia	Community pasture land	Bagatpura	14.09.2015	97
	Maize+blackgram (2:2) intercropping system	Kochariya	28.09.2015	93
	World soil day		05.12.2015	283
Bengaluru	Sustainable dryland practices under NICRA	Chikaputtaya-napalya,	15.09.2015	87
Vijayapura	Chickpea variety (JG-11) and intercropping systems viz sorghum + chickpea (2:4) and safflower + chickpea (2:4)	Kavalagi	17.12.2015	120
Parbhani	Drought mitigation with opening of conservation furrow in soybean	Bobhulgaon	16.08.2015	108
	Mulching for in-situ moisture conservation		02.09.2015	72
	Rabi crop planning		04.10.2015	45
	Rabi crop management techniques-advice		20.11.2015	32
Hisar	Timely sowing of *Kharif* crops	Budhshelly and	30.06.2015	20
	Weed management	Balawas	22.07.2015	15
Varanasi	Soils water conservation measures	R.C.Nagar Padri Mirzapur	14.06.2015	35
Jagdalpur	Krishi Panchayat	Jhartarai & Bastar	13.01.2016	65
	Water conservation and efficient utilization for crop production	Tahkapal & Tokapal	05.08.2015	26
Jhansi	Fodder production	Kadesara Kalan	29.10.2015	82
Rewa	Processing and storage of kharif crops for seed purpose	Patauna	24.11.2015	35
	Water management in rabi crops	Raura	12.12.2015	28
			Total number of beneficiaries	**1288**

3.3. Agro-advisories

Centre	Agro-Advisories	
	Mode	Frequency
Ananthapuramu	Mobile -SMS Black Board in NICRA village	Every Tuesday & Friday
Agra	SMS through farmer portal (in collaboration with IAAS)	Twice in a week
Faizabad	Weather bulletins, Kisan call, center, All India Radio	Daily
Bengaluru	Crop weather bulletins (in collaboration with AICRPAM and IMD) Display board in NICRA villages	Twice in a week (Tuesday & Friday)
Kovilpatti	SMS, All India radio	Weekly
Rajkot	SMS through farmer's portal	Twice in a week
Indore	Weather forecasting from IMD Pune	Every Tuesday & Friday
Biswanath Chariali	Mini weather station, agromet services	Daily

3.4. Soil Heath Cards

Distribution of soil health cards in NICRA villages across the centres

Centre	NICRA village	Soil health cards issued (No. of farmers)
Arjia	Kochariya and Lapsiya	40
Ananthapuramu	Vannedoddipally	49
Akola	Warkhed	108
SK Nagar	Kalimati and Chandanki	93
Faizabad	Hardoya	15
Jhansi	Kadesara Kala	60
Kovilpatti	Muthukrishnapuram & Vadakkupatti	23
Vijayapura	Kavalagi	46
Phulbani	Budhadani	40
Jagdalpur	Tahakapal	86
Agra	Nagla Duleh khan	40
Varanasi	Tedha	30
Rewa	Raura and Patuna	65
Biswanath Chariali	Chamua	14

Other activities

VCRMC meetings


VCRMC meeting at village Tahkapal, Bastar district, Chittisgarh and Chamua, Lakhimpur district

Custom hiring centre (CHC) activities



Demonstration of operation of potato planter at Jinjia village, Biswanath Chariali (left) and paddy thresher at Tahkapal village, Bastar district

Seed bank


Seed production of chickpea and fenugreek at Pata meghapar village, Jamnagar district

Impact of village seed bank of Chamua was realized in nearby villages (horizontal expansion of the climate resilient technology)

Fodder bank

Different types fodder cultivated in Chamua village, Lakhimpur district

Trainings/field days organized

Training on seed production at Nainwan & Achalpur villages, Hoshiarpur district

Pre -*kharif* training at Khaner village, Samba district

Farmers' trainings organized at Pata Meghpar village, Jamnagar district

Glimpses of harvest festival and farmers' fair at Chamua village, Lakhimpur district

Animal health camps organized at Pata Meghpar village, Jamnagar district

Soil profile (left) and distribution of soil health cards (right) in vannedoddi village, Anthapuramu district

3.5 Publications

a) Research papers

- Annu Priya, Adlul Islam Nema AK, and Sikka AK. 2015. Assessing sensitivity of reference evapotranspiration to changes in climatic variables: A case study of Akola, India. Mausam 66(4): 777-784.
- Kushal Sarmah, Prasanta Neog, Rajbansh R and Sarmah A. 2015. Verification and usability of medium range weather forecast for north bank plain zone of Assam. Mausam, 66(3): 585-594.
- Srinivasarao Ch and Gopinath KA. 2016. Resilient rainfed technologies for drought mitigation and sustainable food security. Mausam 67(1): 169-182.
- Srinivasarao Ch, Ravindra Chary G, Rani N and Baviskar VS. 2016. Real time implementation of agricultural contingency plans to cope with weather aberrations in Indian agriculture. Mausam 67(1): 183-194.

b) Popular articles

- Vora VD, Patel JT, Sutaria GS, Vekaria PD and Akbari KN. 2015. *Jalvayu Parivartan thi pak utapadan par thati asato ane Upayo*. Divadandi :pp.16, August-2015.
- Jadhav JD, Pawar PB, More and Vijay Amrutsagar. 2014. *Apatkalin paristhititil pik niyojan*. Agrowon – Sakal: pp. 011, 2014.
- Jadhav JD, Pawar PB and Amrutsagar VM. 2014. Kay *Mhanta September Madhye Kharif ani March , Madhye Rabi*. Adhunik Kisan: pp. 027-030, 2014.
- Thorve SB, Upadhye SK, Jadhav JD and Amrutsagar VM. 2014. *Gahu Pikachi Lagwad*. Adhunik Kisan : pp. 03, 2014.
- Jadhav JD, Pawar PB and Amrutsagar VM. 2015. *Tapman Wadhiche sankat*. Daily Lokmat: pp. 03, 2015.

c) Research / Extension Bulletins

- Akashe VB, Najan BR, Amrutsagar VM and Kharbade. 2015. Recent trends of insect–pests under climate change scenario in dryland crops of scarcity zone. Zonal Agricul. Research Station, Solapur (MS).
- Aasevar B, Aamnd Gore, Madan P, Modha S, Ganesh G and Sarika N. 2015. *Koradvah kheti shashvath utpadan tantragnan*, Parbani.
- Bhagvan A, Madan P, Anand G, Suryavanshi M and Gaikwad G. 2015. *Koradwayu khetiche sudharith tantrgnayan*, Parbhani.
- Dutta S, Sarma PK, Prasanta Neog, Karmakar RM, Baruah S and Borah P. 2015. Soils of NICRA villages Survey and land use planning: (AAU/RD(BL)/08/2015-16).
- Gabhane V, NagdeveM and Damre P. 2015. *Jamineechya shashwath supiktesati giripushpache mahatv*, Akola.
- Gadge S, Amrutsagar V, Shende V and Patil S. 2015. *Shashwath Koradwah Khetisaati Sudharith Ekatmik Kheti Padhath*. Solapur.
- Jain MP, and Thakur HS. 2015. Contingent crop production practices for Malawa agroclimatic zone of M.P (Hindi). RVSKVV bulletin. 20p.
- Kothari AK, Sharma RK, Sharma SK, Chary GR and SrinivasaRao Ch. 2015. Success stories towards agriculture in southern Rajasthan-A participatory approach. Dry land Farming Research Station, Arjia Bhilwara (Rajasthan) :37p.
- More N, Amrutsagar V, Shende V and Deshmukh V. 2015. *Koradwayu turichha pikasati maleekhataddhare ekatmik spuradh vyavasthapan*, Solapur.
- Pendke M, Asevar B, Samindre M, Gore A, Pavar S and Suryavanshi M. 2015. *Viheer va Krupanlika punarbharan tantrgyan*. Parbhani.

- Prasanta Neog, Sarma PK, Dutta S, Gogoi U, Rajbansghi R, Sarmah K, Baruah S, Borah P, Sarmah D, Sarma MK, Chary GR, Srinivas Rao Ch and Hazarika GN. 2015. Resilient Agriculture for flash flood affected areas of North bank Plains zone of Assam: RB No. Dr/ 15 (BU)/ 87/2015-16.

- Ramachandrappa BK, Shankar MA, Sathish A, Thimmegowda MN, Devaraja K, Srinivasa Rao Ch, Jagadeesh BN, Anitha M, Savitha MS, Dinesh Kumar SP and Srikanth Babu PN. 2015. Dryland Agriculture Technology Park - A Tool for Dryland Technologies and Contingency plan. Technical Bulletin/ 01/2015. All India Co-ordinated Research Project for Dryland Agriculture, University of Agricultural Sciences, Bengaluru, Karnataka, India. pp. 61.

- Sahadeva Reddy B, Bargavi K, Reddy MVS, Radhika P, Babu MVS, Reddy KM, Kumari CR, Malleswari SN, Swamy GN, Shanthi P, Reddy AM, Nataraj KC, Reddy YPK and Sudheer KVS. 2015. Promising Technologies for dry land Agriculture. ANGRAU, AICRPDA, Agricultural research station, Anantapuramu.

3.6. Linkages Developed

The AICRPDA, centers are developed linkages with ICAR institutes, Central government schemes/ State Government programmes for implementation of NICRA programmes, state line department, KVKs, ATMA, NGOs, State and capacity building of various stake holders.

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Acronyms

AAU	Assam Agricultural University	LER	Land Equivalent Ratio
AEY	Amla Equivalent Yield	MAI	Monetary Advantage Index
AICRPAM	All India Coordinated Research Project on Agrometeorology	MCEY	Main Crop Equivalent yield
AICRPDA	All India Coordinated Research Project for Dryland Agriculture	MEY	Maize Equivalent Yield
ANGRAU	Acharya NG Ranga Agricultural University	MJ	Mega Joules
ARS	Agricultural Research Station	mm	Millimeter
ATMA	Agricultural Technology	MOP	Murate of Potash Management Agency
BBF	Broad Bed Furrows	MPUA&T	Maharana Pratap University of Agriculture & Technology
BC ratio	Benefit Cost ratio	NDUAT	Narendra Dev University of Agriculture & Technology
BHU	Banaras Hindu University	NMR	Net Monetary Returns
CCSHAU	Chaudhury Charan Singh Haryana Agricultural University	NRM	Natural Resource Management
CCTs	Continuous Contour Trenches	ORP	Operational Research Project
CD	Critical Difference	OUAT	Odisha University of Agriculture & Technology
CEY	Castor Equivalent Yield	PAU	Punjab Agricultural University
CHC	Custom Hiring Centre	PC Unit	Project Coordination Unit
CHMC	Custom Hiring Management Committee	PDKV	Dr. Panjabrao Deshmukh Krishi Vidyapeeth
CRIDA	Central Research Institute for Dryland Agriculture	PEY	Pigeonpea Equivalent Yield
DAS	Days After Sowing	PPB	Parts Per Billion
DAT	Days After Transplanting	PPM	Parts Per Million
DOS	Date of Sowing	RDF	Recommended Dose of Fertilizer
DOT	Date of Transplanting	RDN	Recommended Dose of Nitrogen
FBEY	Field Bean Equivalent Yield	REY	Rice Equivalent yield
FEY	Fingermillet Equivalent Yield	RP	Ridge Planting
FP	Farmers' Practice	RRS	Regional Research Station
FP	Flat Planting	Rs	Rupees
FYM	Farm Yard Manure	RTCP	Real Time Contingency Practices
GEY	Grain Equivalent Yield	RWUE	Rain Water Use Efficiency
Ha	Hectare	SAU	State Agricultural University
HW	Hand Weeding	SEY	Soybean Equivalent Yield
IGFRI	Indian Grassland and Fodder Research Institute	SKDAU	Sardar Krishinagar Dantiwada Agriculture University
IGKV	Indira Gandhi Krishi Vidyapeeth	SKUAS&TJ	Sher-e-Kashmir University of Agricultural Science & Technology, Jammu
IMD	Indian Meteorological Department	SMW	Standard Metrological Week
INM	Integrated Nutrient Management	SSNM	Site Specific Nutrient Managmenent
IP	Improved Practice	SWM	South West Monsoon
JAU	Junagadh Agricultural University	TNAU	Tamil Nadu Agricultural University
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya	UASB	University of Agricultural Sciences, Bengaluru
KCl	Potassium Chloride	UASD	University of Agricultural Sciences, Dharwad
Kg	Kilogram	VCRMC	Village Climate Risk Management Committee
KNO_3	Potassium Nitrate	VNMKV	Vasantarao Naik Marathwada Krishi Vidyapeeth
LCC	Leaf Colour Chart	WUE	Water Use Efficiency

Leaf Colour Chart: decision tool for N application

***In-situ* moisture conservation with Scooping in between rows**

Real Time Contingency Plan Implementation: Alternate Crops / Varieties

Sesame cv. Shekar, Chianki

Clusterbean (GG-2), SK Nagar

Greengram (GM-4), SK Nagar

Rapeseed (JT-90-1), B. Chariali

Sesame (G. Til-2), Rajkot

Phule Vasudha, Solapur

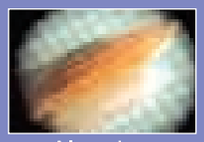
Foxtail millet

Little millet

Fodder bajra

Grain Amaranthus KBGA-1 (Red)

Bengaluru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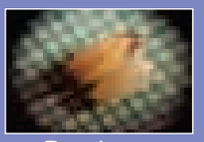
Amti minjo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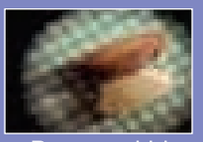
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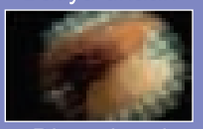
Batiya dhaan


Bhawar gedi


Bhawar Rodi


Bodi Dhaan


Dhagarda kaja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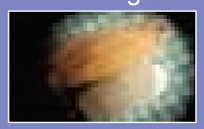
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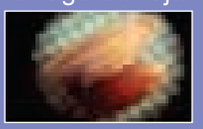
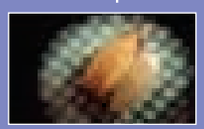
Fataki guda


Ghoda chaur


Godandi


Godawari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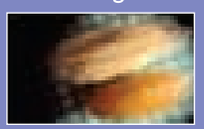
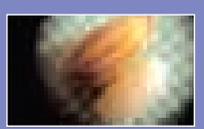

Hardi gathi


Hardi gathi


Hathi panjara


Jeera phool


Karela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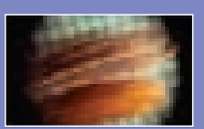
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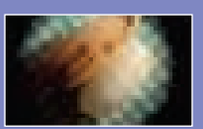
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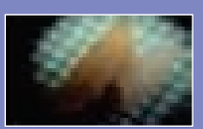
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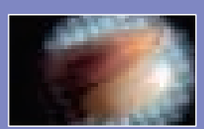
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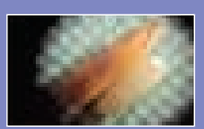
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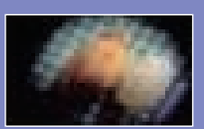
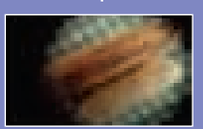

Kosawari


Kuriya kuji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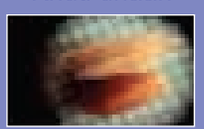
Lal bacho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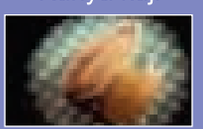
Leem dhaan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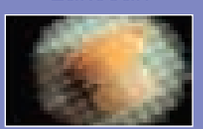
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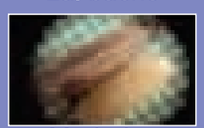
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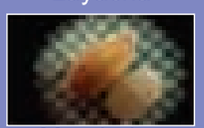
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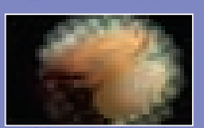
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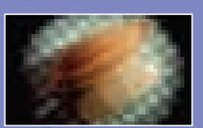
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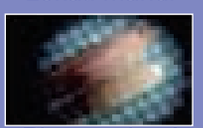
Pharsa phool

Ramijeera

Sendur singar

Surmatiya

Tamakoni

Umari chudi

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