राष्ट्रीय जलवायु समुत्थान कृषि में नवप्रवर्तन

National Innovations in Climate Resilient Agriculture

Managing Weather Aberrations
through Real Time Contingency Planning

Annual Report
2017-18

AICRPDA - NICRA

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना

All India Coordinated Research Project for Dryland Agriculture

ICAR-Central Research Institute for Dryland Agriculture

Hyderabad - 500 059

VII QRT of CRIDA-AICRPDA-AICRPAM visits AICRPDA-NICRA village, Tahkapal, Bastar district (Chhattisgarh) on 2nd February, 2018

Field visit

Interaction meeting with farmers

Two-day Technical Workshop of AICRPDA-NICRA ICAR-CRIDA, 26-27 May, 2017

Dr S. Bhaskar, ADG (A,AF&CC) addressing the participants

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Front Cover: Transplanted fingermillet in Chikkamaranahalli, Bengaluru Rural district; Groundnut + castor (3:1) intercropping system in Patameghpar village, Jamnagar district

Back Cover: Interculture in groundnut in Patameghpar village, Jamnagar district; Sowing of pearlmillet with ridger seeder in Nagla Dulhe Khan village, Agra district; Supplemental irrigation through mini sprinklers in groundnut in Patameghpar village, Jamnagar district

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Preface

The agricultural production and productivity in rainfed areas is being more impacted due to climate variability, particularly delayed onset of south-west monsoon and early/midseason/terminal drought. During the first phase (2011-17) of National Innovations in Climate Resilient Agriculture (NICRA), the 23 network centres of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) centres conducted both on-station and on-farm trials/demonstrations to manage weather aberrations through real-time contingency plans (RTCP) and established institutional mechanisms at the village level for implementation of successful adaptation strategies on a sustainable basis.

A critical review of AICRPDA-NICRA programme was done during Fifth Annual Review Workshop of AICRPDA-NICRA at ICAR-CRIDA during 26-27 May, 2017. During second phase (2017-20), NICRA programme at AICRPDA centres was strengthened with a focus on coping measures for midseason drought, expanding the programme to 22 more adjoining villages to the existing 32 villages in 24 districts across 15 states and collaboration with common centres of AICRPAM (All India Coordinated Research Project on Agrometeorology) and AICRPDA for agromet advisories, and technical backstopping by AICRPDA centres to domain NICRA-KVK villages.

During 2017-18, the onset of monsoon was delayed by more than 10 days in NICRA villages of Jamnagar and Banaskantha districts. Further, there were more than 3 dry spells at different stages of crops in NICRA villages of Anantapuramu, Agra, Banaskantha, Solapur, Vijayapura, Akola, Bengaluru Rural, Indore, Parbhani, Kandhamal and Lakhimpur districts. During 2017-18, the interventions to cope with delayed onset of monsoon and seasonal drought (early, mid season and terminal) were demonstrated in more than 1000 farmers' fields in 54 villages representing diverse rainfed agro-ecologies. This helped in coping with weather aberrations and enhancing the crop yields and income. The salient achievements of AICRPDA-NICRA technical programme 2017-18, both on-station and on-farm are documented in this Annual Report 2017-18 of AICRPDA-NICRA.

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.

We are grateful to Dr. T. Mohapatra, Secretary (DARE) & DG, ICAR, New Delhi for his valuable guidance to the project. We also thank Dr. K. Alagusundaram, DDG (NRM) In-charge & DDG (Agril. Engg.), Dr. S. Bhaskar, ADG (A, AF & CC) and Dr. S.K. Chaudhari, ADG (S & WM) for all the guidance and support to AICRPDA from time to time. We also profusely thank the participating farmers from 54 NICRA villages across the country for their participation, contribution and support.

(K. Sammi Reddy)
Director (Acting), ICAR-CRIDA

Contents

कार्यकारी सारांश

अखिल भारतीय समन्वित बारानी अनुसंधान परियोजना (एक्रीपडा) के 23 केंद्र में मौसम प्रतिकूलताओं से जूझने के लिए सही समय की आकस्मिक योजना के कार्यान्वयन एवं तैयारियों पर फोकस करते हुए निक्रा के अंतर्गत केंद्र एवं फार्म पर प्रदर्शनों/जांचों का आयोजन किया गया। राष्ट्रीय जलवायु समुत्थान कृषि पहल के प्रौद्योगिकी प्रदर्शन अवयव के पहले चरण के दौरान, 23 केंद्रों पर एक्रीपडा –निक्रा का कार्य आरंभ किया गया। वर्ष के दौरान, 15 राज्यों के 24 जिलों के वर्तमान 32 गांवों के निकटवर्ती 22 गांवों (कुल 54 गांव) में भी फार्म पर कार्यक्रम को आरंभ किया गया। सही समय की आकस्मिक योजना का कार्यान्वयन दो दृष्टिकोण यानि i) सही समय की आकस्मिक योजनाएं ii) तैयारियां से अपनाया गया। वर्ष 2017-18 के दौरान 1000 से अधिक किसानों के खेतों में मानसून के आरंभ में देरी एवं मौसमी सूखा (आरंभिक, मध्य एवं अंतिम मौसम) से जूझने वाले हस्तक्षेपों का प्रदर्शन किया गया। जामनगर एवं बंसाकांता जिलों के निक्रा के गांवों में मानसून के आने में 10 दिनों की देरी हुई। इसके अलावा, अनंतपुरमम, आग्रा, बंसाकांता, सोलापुर, विजयपुर, अकोला, बेंगलूरू ग्रामीण, इंदौर, परभनी, कंधामल एवं लखिमपुर जिलों के निक्रा के गांवों में फसल के विभिन्न स्तरों पर 3 से अधिक शुष्क दौर आए। विशेष उपलब्धियां नीचे दी जा रही हैं :

I. सही समय की आकस्मिक योजनाएं

मानसून के आरंभ में देरी

वर्ष 2017 के दौरान चिक्कामारहल्ली गांव (बेंगलुरू ग्रामीण जिला, कर्नाटक) में मानसून के आरंभ में 9 दिनों की देरी हुई। उच्च भूमि के दुमट रेतीली मृदाओं में रागी के सूखा सहीष्णु किस्मों का प्रदर्शन किया गया, जिसमें मध्यम अवधि की किस्म जीपीयू-28 (2520 किलोग्राम प्रति हेक्टेयर) एवं लघु अवधि की किस्म जीपीयू-48 (2490 किलोग्राम प्रति हेक्टेयर) की तुलना में लंबी अवधि की किस्म (एमआर-6) ने उन्नत अनाज उत्पादन (2610 किलोग्राम प्रति हेक्टेयर), कुल लाभ (58,989/- रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (3.34) दर्ज किया। इसी प्रकार, रागी की सीधी बोवाई की तुलना में प्रतिरोपित की गई रागी (एमआर-6) ने उन्नत अनाज उत्पादन (2625 किलोग्राम प्रति हेक्टेयर), कुल लाभ (29,866/- रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.12) दर्ज किया।

पटामेघापुर गांव (जामनगर जिला,गुजरात) में, वर्ष 2017 के दौरान, मानसून के आरंभ होने में 24 दिनों की देरी हुई। मध्यम काली मृदाओं में, किस्म जीजी-20 की तुलना में मूंगफली की जीजेजी-9 किस्म ने 16 प्रतिशत अधिक उन्नत फली उत्पादन (2250 किलोग्राम प्रति हेक्टेयर), कुल लाभ (71,200/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.99) एवं वर्षाजल उपयोग क्षमता (4.53 किलोग्राम प्रति हेक्टेयर-मि. मी.) दिया। इसी प्रकार, किसानों द्वारा उगाए गए विभिन्न बीटी कपास अनुसंधान किस्मों की तुलना में बीटी कपास किस्म जी.कॉट 8 बीजीII ने 13.8 प्रतिशत बीज कपास उत्पादन में वृद्धि हुई साथ ही अधिक लाभ (78,550/- रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (3.40) एवं वर्षाजल उपयोग क्षमता (3.54 किलोग्राम प्रति हेक्टेयर-मि.मी.) दिया।

आरंभिक मौसमी सूखा

वन्नेदोड्डी गांव(अनंतपुरमम जिला, आंध्र प्रदेश) के, वर्षा आधारित एल्फीसोल्स में, वर्षा आधारित फसलों की तुलना में, कृषि तालाब में संचित वर्षाजल से अतिरिक्त सिंचाई (10 मि.मी. गहराई) करने से मूंगफली (1672 किलोग्राम प्रति हेक्टेयर) में 13.3 प्रतिशत फली उत्पादन में वृद्धि हुई। इसी प्रकार अरंड किस्म हरिता (692 किलोग्राम प्रति हेक्टेयर) एवं पीसीएच (634 किलोग्राम प्रति हेक्टेयर) के उत्पादन में क्रमश: 13.8 एवं 12.9 प्रतिशत की वृद्धि हुई।

चिक्कामारहल्ली गांव (बेंगलुरू ग्रामीण जिला, कर्नाटक) में, उच्चभूमियों के दुमट रेतीली मृदाओं में स्व-स्थाने नमी

संरक्षण सहित रागी (एमआर-6) + अरहर (बीआरजी-2) अंतर सस्ययन में अरहर की जोड़ी पंक्तियों के बीच संरक्षण नालों की खुदाई से रागी + अक्काडी सस्ययन उगाने के किसानों की प्रक्रिया की तुलना में 20.9 प्रतिशत अधिक रागी समतुल्य उत्पादन (2483 किलोग्राम प्रति हेक्टेयर), कुल लाभ (52,678/- रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.89) दर्ज किया गया।

पतामेघापुर गांव (जामनगर जिला, गुजरात) के, मध्यम काली मृदाओं में, बिना निकौनी/निराई-गुडाई (1718 किलोग्राम प्रति हेक्टेयर) की तुलना में निकौनी एवं निराई-गुडाई के कारण 70,666/- रुपए प्रति हेक्टेयर के कुल लाभ एवं 4.1 का बी:सी अनुपात सहित मूंगफली के फली उत्पादन में करीब 25.4 प्रतिशत (2149 किलोग्राम प्रतिहेक्टेयर) की वृद्धि हुई।

मध्य मौसमी सूखा

वारखेड़ गांव (अकोला जिला, महाराष्ट्र) के, मध्यम काली मृदाओं में, बिना संरक्षण सिंचाई(1104 किलोग्राम प्रति हेक्टेयर) की तुलना में सोयाबीन में फली के विकास स्तर पर कृषि तालाब में संचित जल से एक संरक्षण सिंचाई देने से अधिक लाभ (16202 प्रतिहेक्टेयर), बी:सी अनुपात (1.68) एवं जल उपयोग क्षमता (3.03 किलोग्राम प्रति हेक्टेयर-मि. मी.) सहित 1381 किलोग्राम प्रति हेक्टेयर का उन्नत बीज उत्पादन हुआ।

कवालागी गांव (विजयपुर जिला, कर्नाटक) के, मध्यम काली मृदाओं में, किसानों की प्रक्रिया की तुलना में अरहर, चना एवं ज्वार में 0.5 प्रतिशत की दर से KNO_3 के पर्ण छिडकाव से क्रमश: 25.4, 25.6 एवं 19.8 प्रतिशत उन्नत उत्पादन हुआ। किसानों की प्रक्रिया की तुलना में उन्नत प्रक्रिया ने अधिक लाभ (40,713/- रुपए, 28,843/- रुपए एवं 17,424/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.5, 34 एवं 2.8) एवं वर्षाजल उपयोग क्षमता(2.22, 5.43 एवं 5.90 किलोग्राम प्रति हेक्टेयर-मि.मी.) भी दर्ज किया।

नरोतेवाडी गांव (सोलापुर जिला, महाराष्ट्र) के, मध्यम काली मृदाओं में, बिना सिंचाई(780 किलोग्राम प्रति हेक्टेयर) की तुलना में कृषि तालाब में संचित वर्षाजल से दो अतिरिक्त सिंचाई, पहली सिंचाई ध्वज पर्ण स्तर (5 सेंटीमीटर की गहराई) पर एवं दूसरी सिंचाई अनाज भराव स्तर पर देने से ज्वार के अनाज उत्पादन(1050 किलोग्राम प्रति हेक्टेयर) में 35 प्रतिशत तक की वृद्धि हुई। इसके अलावा अधिक लाभ (11,450/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.77) एवं जल उपयोग क्षमता (28.4 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया।

कडेसारा कलान गांव (ललितपुर जिला, उत्तर प्रदेश) के, मध्यम काली मृदाओं में, बिना अतिरिक्त सिंचाई (345 किलोग्राम प्रति हेक्टेयर) की तुलना में संचित वर्षाजल से अतिरिक्त सिंचाई (40 मि.मी.) देने से अधिक लाभ (6,702/- रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात(1.44) सहित उड़द के बीज उत्पादन में 42.4 प्रतिशत (491 किलोग्राम प्रति हेक्टेयर) की वृद्धि हुई।

अंतिम सूखा

लपसिया गांव (राजसमंद जिला, राजस्थान) के, गहरी काली मृदाओं में, बिना अतिरिक्त सिंचाई (1737 किलोग्राम प्रति हेक्टेयर) की तुलना में कृषि तालाब में संचित वर्षाजल से मक्का में एक अतिरिक्त सिंचाई + उड़द (2:2) के अंतरसस्ययन प्रणाली ने अधिक लाभ (17,303/- रुपए प्रति हेक्टेयर), बी:सी अनुपात(2.03) एवं जल उपयोग क्षमता (5.79 किलोग्राम प्रति हेक्टेयर-मि.मी.) सहित 26 प्रतिशत अधिक मक्का समतुल्य उत्पादन (2192 किलाग्राम प्रतिहेक्टेयर) दिया।

पतामेघापुर गांव (जामनगर जिला, गुजरात) के, मध्यम काली मृदाओं में, बिना अतिरिक्त सिंचाई (2012 किलोग्राम प्रति हेक्टेयर) की तुलना में कपास के वर्ग निर्माण (square formation) एवं गलर विकास स्तर पर वैकल्पिक पंक्तियों में 30 मि.मी. की दो अतिरिक्त सिंचाइयों से अधिक लाभ (99,150/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.07) एवं जल उपयोग क्षमता(3.88 किलोग्राम प्रति हेक्टेयर-मि.मी.) सहित बीज कपास उत्पादन में 31 प्रतिशत (2628 किलोग्राम प्रतिहेक्टेयर) तक की वृद्धि हुई। इसी प्रकार, मूंगफली में बिना अतिरिक्त सिंचाई (2021 किलोग्राम प्रति हेक्टेयर) की तुलना में फली निर्माण स्तर पर अतिरिक्त सिंचाई से मूंगफली के

उत्पादन में 22 प्रतिशत तक की वृद्धि हुई। इसके अलावा अधिक लाभ (86,174/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (4.47) एवं जल उपयोग क्षमता (3.64 किलोग्राम प्रति हेक्टेयर-मि.मी.) दिया।

कालीमाटी गांव (बंसाकांता जिला, गुजरात) के, गहरी दुमट मृदाओं में, बिना अतिरिक्त सिंचाई (1395 किलोग्राम प्रति हेक्टेयर) की तुलना में अरंड में पुष्पण से कैप्सूल विकास स्तर पर सूक्ष्म सिंचाई द्वारा कृषि तालाब में संचित वर्षाजल से दो अतिरिक्त सिंचाई (30 मि.मी.) देने से अधिक लाभ (65,414/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (4.53) एवं वर्षाजल उपयोग क्षमता (2.27 किलोग्राम प्रति हेक्टेयर-मि.मी.) सहित 39 प्रतिशत उन्नत बीज उत्पादन (1943 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

बबुलगांव गांव (परभनी जिला, महाराष्ट्र) के, मध्यम काली मृदाओं में, किसानों की प्रक्रिया (1560 किलोग्राम प्रति हेक्टेयर) की तुलना में कपास (अजित-155) में अतिरिक्त सिंचाई (5 सेंटीमीटर) देने से अधिकतम बीज कपास उत्पादन (1950 किलोग्राम प्रति हेक्टेयर), कुल लाभ (49,273/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.69) एवं जल उपयोग क्षमता (3.0 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया।

खनेर गांव (सांबा जिला,जम्मु एवं कशमीर) में, बिना अतिरिक्त सिंचाई (2260 किलोग्राम प्रति हेक्टेयर) की तुलना में कृषि तालाब में संचित वर्षाजल से मक्का को एक अतिरिक्त सिंचाई देने से 29,167/- रुपए का कुल लाभ, 2.39 का बी:सी अनुपात एवं 4.89 किलोग्राम प्रति हेक्टेयर-मि.मी. का जल उपयोग क्षमता सहित 11.3 प्रतिशत का उन्नत अनाज उत्पादन दिया।

II. तैयारियां

वर्षाजल प्रबंधन

अचलपुर गांव (होशियारपुर जिला, पंजाब) में, किसानों की सपाट बोवाई (3263 किलोग्राम प्रति हेक्टेयर) की तुलना में मेढ़ों पर मक्का की बोवाई से 11.7 प्रतिशत उन्नत अनाज उत्पादन (3646 किलोग्राम प्रति हेक्टेयर), कुल लाभ (28,971/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.88) एवं वर्षाजल उपयोग क्षमता (9.4 किलोग्राम प्रति हेक्टेयर-मि.मी.) हुआ।

वन्नेदोड्डी गांव (अनंतपुरम जिला, आंध्र प्रदेश) के, वर्षा आधारित एल्फीसोल्स मृदाओं में, किसानों की बिना गहरी जुताई (1371 किलोग्राम प्रति हेक्टेयर) की प्रक्रिया की तुलना में मानसून पूर्व वर्षा के बाद चिसिल हल से गहरी जुताई से मूंगफली में उन्नत फली उत्पादन (1611 किलोग्राम प्रति हेक्टेयर), कुल लाभ (43,567/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.39) एवं 3.16 किलोग्राम प्रति हेक्टेयर-मि.मी. का वर्षाजल उपयोग क्षमता दर्ज किया गया।

नगला दुल्हे खान गांव (आग्रा जिला, उत्तर प्रदेश) में, पारंपरिक कर्षण + बीजों के छिडकाव (1729 किलोग्राम प्रति हेक्टेयर) की तुलना में एमबी हल द्वारा ग्रीष्मकालीन जुताई से स्व-स्थाने नमी संरक्षण एवं बाजरा में रिडजर सीडर द्वारा बोवाई से अधिक लाभ (22,036/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.40) एवं वर्षाजल उपयोग क्षमता (6.65 किलोग्राम प्रतिहेक्टेयर-मि.मी.) सहित 33 प्रतिशत उन्नत अनाज उत्पादन (2302 किलोग्राम प्रति हेक्टेयर) हुआ।

कालीमाटी गांव (बंसाकांता जिला, गुजरात) में, बिना उप-खंडीय मेढ़ (1083 किलोग्राम प्रति हेक्टेयर) की तुलना में उप-खंडीय मेढ़ द्वारा स्व-स्थाने नमी संरक्षण से अधिक लाभ (18,768/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.92) एवं वर्षाजल उपयोग क्षमता (0.90 किलोग्राम प्रतिहेक्टेयर-मि.मी.) सहित उन्नत बाजरा अनाज उत्पादन (1239 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

बबुलगांव गांव (परभनी जिला, महाराष्ट्र) में, सपाट क्यारी (1400 किलोग्राम प्रति हेक्टेयर) की तुलना में चौडी क्यारी एवं कूंड से सोयाबीन में स्व-स्थाने नमी संरक्षण से उन्नत बीज उत्पादन (1610 किलोग्राम प्रति हेक्टेयर), कुल लाभ (27385 प्रति हेक्टेयर), बी:सी अनुपात (1.26) एवं 2.53 किलोग्राम प्रति हेक्टेयर-मि.मी. का वर्षाजल उपयोग क्षमता प्राप्त हुआ।

सस्ययन प्रणालियां

लपसिया गांव (राजसमंद जिला, राजस्थान) में, मक्का एवं उड़द (1764 किलोग्राम प्रति हेक्टेयर) के मिश्रित सस्ययन की तुलना में मक्का + उड़द के अंतरसस्ययन प्रणाली ने अधिक लाभ (19,211/- रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.22) सहित 25.4 प्रतिशत उन्नत मक्का समतुल्य उत्पादन (2212 किलोग्राम प्रति हेक्टेयर) दिया।

चिक्कामारहल्ली गांव (बेंगलुरू ग्रामीण जिला, कर्नाटक) में, उच्चभूमियों के दुमट रेतीली मृदाओं में, एकल अरहर (523 किलोग्राम प्रति हेक्टेयर) की तुलना में अरहर (बीआरजी-1) + लोबिया (1:1) ने उन्नत अरहर समतुल्य उत्पादन (1221 किलोग्राम प्रति हेक्टेयर), कुल लाभ (11,151/- रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.29) दर्ज किया गया।

नगला दुल्हे खान गांव (आग्रा जिला, उत्तर प्रदेश) में, एकल बाजरा (1621 किलोग्राम प्रति हेक्टेयर) की तुलना में बाजरा + तिल पट्टीदार सस्ययन प्रणाली (4:4) ने 2996 किलोग्राम प्रति हेक्टेयर का बाजरा समतुल्य उत्पादन, 24,441/- रुपए प्रति हेक्टेयर का कुल लाभ एवं 2.79 का बी:सी अनुपात दिया।

बलवास गांव (हिसार जिला, हरियाणा) में, चना की लंबी अवधि किस्म सी-235 की तुलना में चना की लघु अवधि की किस्म एचसी-1 ने नमी दबाव परिस्थितियों के अंतर्गत अच्छा निष्पादन दिया एवं 10.1 प्रतिशत उन्नत बीज उत्पादन (815 किलोग्राम प्रति हेक्टेयर), कुल लाभ (17,360/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.94) एवं वर्षाजल उपयोग क्षमता (29.3 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया।

वारखेड़ गांव (अकोला जिला, महाराष्ट्र) में, एकल कपास (1212 किलोग्राम प्रति हेक्टेयर) की तुलना में मध्यम काली मृदाओं में प्रदर्शित कपास आधारित अंतरसस्ययन प्रणालियों में, कपास + मूंग (1:1), कपास + लोबिया (1:1) एवं कपास + ग्वार (1:1) से कपास समतुल्य उत्पादन 20, 55 एवं 28 प्रतिशत (1452,1882 एवं 1555 किलोग्राम प्रति हेक्टेयर) था। अन्य सस्ययन प्रणालियों की तुलना में कपास + लोबिया (1:1) अंतरसस्ययन प्रणाली ने अधिक लाभ (32,527/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.58) दिया।

पोषक प्रबंधन

चिक्कामारहल्ली गांव (बेंगलुरू ग्रामीण जिला, कर्नाटक) में, उच्चभूमियों के दुमट रेतीली मृदाओं में, केवल 100 प्रतिशत सिफारिश किए गए उर्वरक (2749 किलोग्राम प्रति हेक्टेयर) के प्रयोग की तुलना में रागी (एमआर-6) + अरहर (बीआरजी-2) (8:2) अंतरसस्ययन प्रणाली में 100 प्रतिशत सिफारिश किए गए उर्वरक + 12.5 किलोग्राम प्रति हेक्टेयर का $ZnSO_4$ के प्रयोग से उन्नत रागी समतुल्य उत्पादन (3016 किलोग्राम प्रति हेक्टेयर), कुल लाभ (34,844/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.16) दर्ज किया गया।

सफल ऊर्जा प्रबंधन

वन्नेदोड्डी गांव (अनंतपुरम जिला, आंध्र प्रदेश) के, वर्षा आधारित एल्फीसोल्स मृदाओं में, बैलों द्वारा चालित स्थानीय बीज ड्रिल (1535 किलोग्राम प्रति हेक्टेयर) की तुलना में, बैलों द्वारा चालित अनंता प्लांटर से मूंगफली की बोवाई ने उन्नत फली उत्पादन (1667 किलोग्राम प्रति हेक्टेयर), कुल लाभ (48,793/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.74) एवं वर्षाजल उपयोग क्षमता (3.39 किलोग्राम प्रतिहेक्टेयर-मि.मी.) दर्ज किया गया।

नरोतेवाडी गांव (सोलापुर जिला, महाराष्ट्र) के, मध्यम काली मृदाओं में, किसानों की स्थानीय बीज ड्रिल (820 किलोग्राम प्रति हेक्टेयर) की तुलना में टू- बाउल फर्टीलाइज़र सीड ड्रिल से रबी ज्वार की बोवाई से अनाज उत्पादन(1010 किलोग्राम प्रति हेक्टेयर), कुल लाभ (19,260/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.4) एवं वर्षाजल उपयोग क्षमता (12.78 किलोग्राम प्रति हेक्टेयर-मि.मी.) में वृद्धि हुई।

खनेर गांव (सांबा जिला, जम्मु एवं कशमीर) की, मध्यम काली मृदाओं में, किसानों की प्रक्रिया की तुलना में मेइज प्लांटर से मक्का की बोवाई से 24,278/- रुपए प्रति हेक्टेयर का कुल लाभ एवं 2.31 का बी:सी अनुपात सहित 27 प्रतिशत उन्नत अनाज उत्पादन दिया। इसमें ऊर्जा का निवेश 6893

एमजे प्रति हेक्टेयर एवं ऊर्जा से उत्पादन 89903 एमजे प्रति हेक्टेयर था।

वैकल्पिक भूमि उपयोग/समेकित कृषि प्रणाली

खनेर गांव (सांबा जिला,जम्मु एवं कशमीर) की, उथली मृदाओं में, आंवला + मिश्रित चारा प्रणाली के अंतर्गत मिश्रित चारा के उत्पादन मे 23000 से 24800 किलोग्राम प्रति हेक्टेयर हुई। इसके साथ ही 47.5 किलोग्राम प्रति हेक्टेयर-मि. मी. का वर्षाजल उपयोग क्षमता, 17,794/-रुपए प्रति हेक्टेयर का कुल लाभ एवं 2.49 का बी:सी अनुपात सहित औसतम उत्पादन 23900 किलोग्राम प्रति हेक्टेयर हो गया।

तेराहा सराया गांव (मिर्जापुर जिला,उत्तर प्रदेश) के, मध्यम जलोढ़ मृदा में, चावल की खेती एवं पशु पालन (3 भैंस + 2 भैंस के बछडे) सम्मिलित समेकित कृषि प्रणाली ने 1,51,677/- रुपए प्रति हेक्टेयर का कुल लाभ, 2.2 का बी:सी अनुपात एवं 160 मानव दिवस प्रति हेक्टेयर प्रति वर्ष का रोज़गार प्रदान किया, जबकि कृषि-बागवानी प्रणाली ने 27,460/- रुपए प्रति हेक्टेयर का कुल लाभ दिया।

निक्रा – अनुकूल अनुसंधान

जैविक, अजैविक एवं समेकित उत्पादन प्रणालियों के अंतर्गत विभिन्न फसलों के निष्पादन के मूल्यांकन ने स्पष्ट किया कि सूरजमुखी का बीज उत्पादन क्रमश: जैविक एवं अजैविक के अंतर्गत की तुलना में समेकित प्रबंधन (1374 किलोग्राम प्रति हेक्टेयर) अंतर्गत प्लॉटों में 14 एवं 7 प्रतिशत अधिक थी। जबकि, समेकित एवं जैविक प्रबंधन दोनों समान दर्ज किए गए। लेकिन अजैविक प्रबंधन की तुलना में मूंग (673-706 किलोग्राम प्रतिहेक्टेयर) एवं अरहर (898-911 किलोग्राम प्रति हेक्टेयर) का अधिक उत्पादन दर्ज किया। विभिन्न उत्पादन प्रणालियों पर मृदा pH, उपलब्ध नाइट्रोजन एवं मैगनिशियम (Mn) का कोई महत्वपूर्ण प्रभाव नही था। जबकि, अजैविक एवं समेकित उत्पादन प्रणालियों की तुलना में जैविक प्रबंधन के अंतर्गत वाले खेतों में महत्वपूर्ण रूप से उन्नत मृदा जैविक कार्बन (C) (0.67 प्रतिशत) दर्ज किया गया। अजैविक उत्पादन प्रणाली की तुलना में समेकित प्रणालियों के समान जैविक प्रबंधन के अंतर्गत वाले खेतों में भी महत्वपूर्ण रूप से उन्नत उपलब्ध पोटाश (263.1 किलोग्राम प्रति हेक्टेयर), Cu (2.54 पीपीएम), Fe (7.92 पीपीएम) एवं Zn (0.57 पीपीएम) दर्ज किया गया।

गांव की जलवायु जोखिम प्रबंधन समिति (वीसीआरएमसी)

निक्रा द्वारा अपनाए गए हर गांव में स्थापित की गई गांव की जलवायु जोखिम प्रबंधन समिति आकस्मिक फसल योजना, मृदा एवं फसल आधारित हस्तक्षेपों एवं पारंपरिक किराए केंद्रों आदि जैसे विभिन्न जलवायु जोखिम समुत्थान हस्तक्षेपों के कार्यान्वयन में गांव स्तरीय संस्था के रूप काफी प्रभावी सिद्ध हुई।

पारंपरिक किराए केंद्र (सीएचसी)

वर्ष 2017-18 के दौरान, केंद्रों द्वारा अपनाए गए नए गावों के किसानों को भी पारंपरिक किराए केंद्र की सुविधाएं उपलबध कराई गई। पारंपरिक किराए केंद्रों ने संसाधनहीन गरीब किसानों को सस्ते दामों में आवश्यकता आधारित उपकरणों/यंत्रों को किराए पर देने में सहायता की ताकि वे भूमि तैयारी, कम समय में बड़े क्षेत्र में सही समय एवं सही तरीके से बोवाई एवं अधिक ऊर्जा क्षमता सहित अन्य कृषि कार्य कर सके। वर्ष 2011 से, पारंपरिक किराए प्रबंधन समिति ने किराए द्वारा प्राप्त आय को हर निक्रा गांवों में पारंपरिक किराए केंद्रों की गतिविधियों एवं उपकरणों के रख-रखाव में खर्च किया गया। पारंपरिक किराए केंद्रों ने अधिकतम मांग की अवधि के दौरान श्रमिकों की कमी को दूर करने में महत्वपूर्ण योगदान दिया।

गांव का बीज बैंक

सही समय की आकस्मिक योजना के कार्यान्वयन के दौरान बीज एक प्रमुख निवेश है। निक्रा के गांवों में विभिन्न फसलों के अल्पावधि के बीज एवं सूखा सहीष्णु किस्मों के उत्पादन द्वारा बीजों की अनुपलब्धता की समस्या के समाधान के लिए वर्षा आधारित वैकल्कि फसलों एवं किस्मों को प्रदान करने का प्रयास जारी है। वर्ष के दौरान, विभिन्न निक्रा के गांवों में विभिन्न वर्षा आधारित फसलों के करीब 330 टन बीजों का उत्पादन/रख-रखाव किया गया।

चारा बैंक

किसानों के खेतों, सामुदायिक भूमियों एवं खेत के मेढ़ों पर चारा उत्पादन (हरा एवं सूखा दोनों) को बढ़ाने का प्रयास किया गया। होशियारपुर जिले के नैवाल एवं अचलपुर के निक्रा के गांवों में हरे चारे की उपलब्धता को पूरा करने के लिए बाजरा (एफबीसी-16) के उन्नत किस्मों को प्रदान किया गया एवं किसानों के खेतों के मेढ़ों पर संकर नेपियर कर्तनों को रोपा गया। बेंगलुरू ग्रामीण जिला, चिक्कामारनहल्ली गांव में, किसानों को वार्षिक चारा स्रोत की स्थापना करने एवं मेढ़ों को स्थिरता प्रदान करने के लिए स्टाइलोसेंथेसिस हामाटा के बीजों की आपूर्ति की गई। बस्तर जिला, तहकपाल गांव में, किसानों ने स्टाइलोसेंथेसिस (62.7 किलोग्राम), संकर नेपियर बाजरा (22.4 किलोग्राम), बेरसीम (53.75 किलोग्राम) एवं चारा ज्वार (95.2 किलोग्राम) के बीजों का उत्पादन किया।

कृषि-सलाह/कृषिमौसम सलाह

सही समय की आकस्मिक उपायों को मौसम सूचना एवं कृषि सलाहों को ब्लैक बोर्डों पर, मोबाइलों द्वारा एसएमएस सेवा एवं रेडियो के माध्यम से सभी गांवों में आकस्मिक उपायों के कार्यान्वयन के लिए सलाह दी गई। वर्ष 2017-18 के दौरान, अकोला, अनंतपुरमम, बेंगलुरू ग्रामीण, परभनी, सोलापुर एवं विजयपुर जिलों के निक्रा द्वारा अपनाए गए गांवों में अखिल भारतीय कृषिमौसम विज्ञान अनुसंधान परियोजना के केंद्रों के सहयोग से समय पर कृषिमौसम सलाह दिए गए।

मृदा स्वास्थ्य कार्ड

वर्ष 2017-18 के दौरान, कोविलपट्टी (23 किसान), अकोला (108 किसान), अरजिया (40 किसान), जगदलपुर (5 किसान), फुलबानी (38 किसान), राजकोट (25 किसान) एवं एसके नगर (47 किसान) के अपनाए गए गांवों में मृदा स्वास्थ्य कार्ड प्रदान किए गए।

प्रशिक्षण/क्षेत्र दौरा/क्षेत्र दिवस

वर्ष के दौरान, केंद्रों द्वारा 61 प्रशिक्षण एवं 22 क्षेत्र दिवस/प्रदर्शन दौरे आयोजित किए गए जिससे किसानों सहित 11611 पणधारियों को लाभ हुआ। इन प्रशिक्षण/प्रसार गतिविधियों से कृषि एवं संबंधित क्षेत्रों पर जलवायु विविधता एवं कृषि, संबंधित क्षेत्र एवं कृषि सलाहों पर इसके प्रभाव, उन्नत वर्षा आधारित प्रौद्योगिकियों/श्रेष्ठ प्रक्रियाओं पर मौसम पूर्व एवं मौसम में प्रशिक्षण, प्रतिकूल मौसम के दौरान विषयपरक हस्तक्षेपों के निष्पादन पर किसानों एवं अन्य पणधारियों को जानकारी प्रदान करने के लिए क्षेत्रीय दौरे/क्षेत्रीय दिवसों का आयोजन किया गया।

जिला कृषि आकस्मिक योजनाओं के कार्यान्वयन हेतु संपर्क

वर्ष 2017-18 के दौरान, जिला स्तरीय फसल आकस्मिक योजनाओं के अद्यतन में केंद्रों के वैज्ञानिकों को सक्रिय रूप से शामिल किया गया। इस कार्य में कृषि विज्ञान केंद्रों एवं संबंधित राज्यों के संबंधित विभागों के वैज्ञानिकों एवं अधिकारियों को शामिल किया गया। इसके अलावा, जिला कृषि आकस्मिक योजनाओं के कार्यान्वयन के लिए 5 राज्यों (कर्नाटक, आंध्र प्रदेश, तेलंगाना, महाराष्ट्र एवं राजस्थान) में राज्य स्तरीय बैठकों का आयोजन किया गया जिसमें केंद्रों के वैज्ञानिकों ने भी भाग लिया एवं कार्य योजनाओं के विकास में योगदान दिया।

अकोला, अनंतपुरमम, बेंगलुरू, विजयपुर, परभनी एवं सोलापुर जैसे एक्रीपडा एवं एक्रीपॉम के समान केंद्रों के एक्रीपडा-निक्रा गांवों में कृषिमौसम सलाह एक्रीपॉम केंद्रों द्वारा दिया गया। एक्रीपडा-निक्रा गांवों की सफल सही समय की आकस्मिक योजनाओं उन्नयन एक्रीपॉम द्वारा एक्रीपॉम-निक्रा के गांवों में किया जाएगा। इसी प्रकार, एक्रीपडा केंद्रों (अकोला, अनंतपुरमम, बेंगलुरू, बिस्वनाथ चरिअलि, चियान्की, हिसार, इंदौर, जगदलपुर, झांसी, कोविलपट्टी, परभनी, राजकोट, राख धैंसर, एसके नगर, सोलापुर, वारणासी एवं विजयपुर) के मुख्य केंद्रों में निक्रा-कृषि विज्ञान केंद्रों को सही समय की आकस्मिक योजना एवं अपनाने योग्य प्रौद्योगिकियों पर तकनीकी जानकारी दी गई।

Executive Summary

The 23 Centers of AICRPDA are conducting on-station and on-farm demonstrations/trials under NICRA with the focus on real time contingency plan (RTCP) implementation and preparedness to cope with weather aberrations. During the first phase of the Technology Demonstration Component of National Initiative on Climate Resilient Agriculture (NICRA), the AICRPDA-NICRA was undertaken at 23 centres. During the year, the on-farm programme was extended to 22 more adjoining villages to the existing 32 villages (total 54 villages) in 24 districts across 15 states. The RTCPs implementation was in a two-pronged approach i.e. i) Real-time contingency measures and ii) Preparedness. The interventions to cope with delayed onset of monsoon and seasonal drought (early, mid season and terminal) were demonstrated in more than 1000 farmers' fields during 2017-18. The onset of monsoon was delayed by more than 10 days in NICRA villages of Jamnagar and Banaskantha districts. Further, there were more than 3 dry spells at different stages of crops in NICRA villages of Anantapuramu, Agra, Banaskantha, Solapur, Vijayapura, Akola, Bengaluru Rural, Indore, Parbhani, Kandhamal and Lakhimpur districts. The salient achievements are summarized below.

I. Real-time contingency measures

Delayed onset of monsoon

At Chikkamaranahalli village (Bengaluru rural district, Karnataka), during 2017, onset of monsoon was delayed by 9 days. Among the drought tolerant varieties of fingermillet demonstrated in loamy sand soils of uplands, long duration variety (MR-6) recorded higher grain yield (2610 kg/ha), net returns (Rs.58989/ha) and B:C ratio (3.34) compared to medium duration var. GPU-28 (2520 kg/ha) and short duration var. GPU-48 (2490 kg/ha). Similarly, transplanted fingermillet (MR-6) recorded higher grain yield (2625 kg/ha), net returns **(**Rs**.** 29866/ ha) and B:C ratio (2.12) as compared to direct sown fingermillet.

At Patameghpar village (Jamnagar district, Gujarat), during 2017, the onset of monsoon was delayed by 24 days. In medium black soils, short duration groundnut var. GJG-9 gave 16% higher pod yield (2250 kg/ha), net returns (Rs. 71200/ ha), B:C ratio (3.99) and RWUE (4.53 kg/ha-mm) as compared to var. GG-20. Similarly, seed cotton yield was increased by 13.8% with Bt. cotton variety G.Cot. 8 BGII compared to different Bt cotton research varieties grown by the farmer, with higher net returns (Rs. 78550/ha), B:C ratio (3.40) and RWUE (3.54 kg/ha-mm).

Early season drought

At Vannedoddi village (Ananthapuramu district, Andhra Pradesh), in rainfed Alfisols, supplemental irrigation (10 mm depth) from harvested rainwater in farm pond increased the pod yield by 13.3% in groundnut (1672 kg/ha) and 13.8 & 12.9% in castor varieties Haritha (692 kg/ha) and PCH-111 (634 kg/ ha), respectively compared to rainfed crops.

At Chikkamaranahalli village (Bengaluru rural district, Karnataka), *in-situ* moisture conservation in loamy sand soils of uplands with opening of conservation furrow between paired rows of pigeonpea in fingermillet (MR-6) + pigeonpea (BRG-2) intercropping (8:2) recorded 20.9% higher fingermillet equivalent yield (2483 kg/ha), net returns (Rs.52678/ha) and B:C ratio (2.89) compared to farmers practice of growing finger millet + *Akkadi* cropping.

At Patameghpar village (Jamnagar district, Gujarat), in medium black soils, the pod yield of

groundnut was increased by 25.4% (2149 kg/ha) with net returns of Rs 70666/ha and B:C ratio of 4.1 due to weeding and interculture as compared to no weeding/interculture (1718 kg/ha).

Mid season drought

At Varkhed village (Akola district, Maharashtra), in medium black soils, one protective irrigation from harvested water in farm pond at pod development stage in soybean gave higher seed yield of 1381 kg/ha with higher net returns (Rs. 16202/ha), B:C ratio (1.68) and WUE (3.03 kg/ha-mm) over no protective irrigation (1104 kg/ha).

At Kavalagi village (Vijayapura district, Karnataka), in medium black soils, foliar spray of KNO_3 @ 0.5% gave 25.4, 25.6 and 19.8% higher yields in pigeonpea, chickpea and sorghum, respectively over farmers' practice. The improved practice also recorded higher net returns (Rs.40713, 28843 and 17424/ha), B:C ratio (3.5., 3.4 and 2.8) and RWUE (2.22, 5.43 and 5.90 kg/ha-mm) compared to farmers' practice.

At Narotewadi village (Solapur district, Maharashtra), in medium black soils, two supplemental irrigations from harvested rainwater in farm pond, 1st irrigation (5 cm depth) at flag leaf stage and 2nd irrigation at grain filling stage increased grain yield of sorghum (1050 kg/ha) by 35% over without irrigation (780 kg/ha), and gave higher net returns (11450/ha), B:C ratio (1.77) and WUE (28.4 kg/ha-mm).

At Kadesara Kalan village (Lalitpur district, Uttar Pradesh), in medium black soils, supplemental irrigation (40 mm) from harvested rainwater increased the seed yield of blackgram by 42.4% (491 kg/ha) with higher net returns (Rs.6702/ha) and B:C ratio (1.44) compared to without supplemental irrigation (345 kg/ha).

Terminal drought

At Lapsiya village (Rajsamand district, Rajasthan), in deep black soils, one supplemental irrigation in maize + blackgram (2:2) intercropping system from harvested rainwater in farm pond gave 26% higher maize equivalent yield (2192 kg/ha) over farmers' practice of no supplemental irrigation (1737 kg/ha) with higher net returns (Rs 17303/ha), B:C ratio (2.03) and WUE (5.79 kg/ha-mm).

At Patameghpar village (Jamnagar district, Gujarat), in medium black soils, two supplemental irrigations each of 30 mm in alternate rows applied at square formation and boll development stage of cotton increased seed cotton yield by 31% (2628 kg/ha) with higher net returns (Rs.99150/ha), B:C ratio (3.07) and WUE (3.88 kg/ha-mm) compared to without supplemental irrigation (2012 kg/ha). Similarly, yield of groundnut was increased by 22% with supplementary irrigation at pod formation stage and gave higher net returns (Rs.86174/ha), B:C ratio (4.47) and WUE (3.64 kg/ha-mm) compared to without supplemental irrigation (2021 kg/ha).

At Kalimati village (Banaskantha district, Gujarat), in deep loamy soils, supplemental irrigation (30 mm) from harvested rainwater in farm pond given twice through micro-irrigation during flowering to capsule development in castor recorded 39% higher seed yield (1943 kg/ha) with higher net returns (Rs. 65414/ha), B:C ratio (4.53) and RWUE (2.27 kg/ha-mm) compared to no supplemental irrigation (1395 kg/ha).

At Babulgaon village (Parbhani district, Maharashtra), in medium black soils, supplemental irrigation (5 cm) in cotton (Ajit 155) gave highest seed cotton yield (1950 kg/ha), net returns (Rs.49273/ha), B:C ratio (1.69) and WUE (3.0 kg/ha-mm) compared to farmers' practice (1560 kg/ha).

At Khaner village (Samba district, Jammu & Kashmir), one supplemental irrigation to maize from the harvested water in farm pond gave 11.3% higher grain yield (2516 kg/ha) with net returns of Rs 29167/ha, B:C ratio of 2.39 and WUE of 4.89 kg/ha-mm compared to without supplemental irrigation (2260 kg/ha).

II. Preparedness

Rainwater management

At Achalpur village (Hoshiarpur district, Punjab), sowing of maize on ridges produced 11.7% higher grain yield (3646 kg/ha), net returns (Rs. 28971/ha), B:C ratio (1.88), and RWUE (9.4 kg/ha-mm) followed by bed sowing (3482 kg/ha) compared to farmers' practice of flat sowing (3263 kg/ha).

At Vannedoddi village (Ananthapuramu district, Andhra Pradesh), in rainfed Alfisols, deep ploughing with chisel plough after receiving pre-monsoon showers recorded higher pod yield of groundnut (1611 kg/ha), net returns (Rs.43567/ha), B:C ratio (2.39) and RWUE of 3.16 kg/ha-mm compared to the farmers' practice of no deep ploughing (1371 kg/ha).

At Nagla Dulhe Khan village (Agra district, Uttar Pradesh), *in-situ* moisture conservation with summer ploughing by MB plough and sowing by ridger seeder in pearlmillet produced 33% higher grain yield (2302 kg/ha) with higher net returns (Rs.22036/ha), B:C ratio (2.40) and RWUE (6.65 kg/ha-mm) as compared to conventional tillage + broadcasting (1729 kg/ha).

At Kalimati village (Banaskantha district, Gujarat), *in-situ* moisture conservation with compartmental bunding recorded higher grain yield of pearlmillet (1239 kg/ha) with higher net returns (Rs. 18768/ha), B:C ratio (1.92) and RWUE (0.90 kg/ha-mm) compared to no compartmental bunding (1083 kg/ha).

At Babulgaon village (Parbhani district, Maharashtra), *In-situ* moisture conservation in soybean (MAUS-71) with broad bed and furrow (BBF) method resulted in higher seed yield (1610 kg/ha), net returns (Rs. 27385/ha), B:C ratio (1.26) and RWUE of 2.53 kg/ha-mm compared to flat bed method (1400 kg/ha).

Cropping systems

At Lapsiya village (Rajsamand district, Rajasthan), maize + blackgram (2:2) intercropping system gave 25.4% higher maize equivalent yield (2212 kg/ha) compared to mixed cropping of maize and blackgram (1764 kg/ha), with higher net returns (Rs. 19211/ha) and B:C ratio (2.22)

At Chikkamaranahalli village (Bengaluru rural district, Karnataka), in loamy sand soils of uplands, pigeonpea (BRG-1) + cowpea (1:1) recorded higher pigeonpea equivalent yield (1221 kg/ha), net returns (Rs.11151/ha) and B:C ratio (1.29) compared to sole pigeonpea (523 kg/ha).

At Nagla Dulhe Khan village (Agra district, Uttar Pradesh), pearlmillet + sesame strip cropping system (4:4) gave higher pearlmillet equivalent yield (PEY) of 2996 kg/ha, net returns of Rs 24441/ha and B:C ratio of 2.79 compared to sole pearlmillet (1621 kg/ha)

At Balawas village (Hisar district, Haryana), chickpea cv. HC-1 a short duration variety, performed well under moisture stress conditions and recorded 10.1% higher seed yield (815 kg/ha), net returns (Rs.17360/ha), B:C ratio (1.94) and RWUE (29.3 kg/ha-mm) compared to cv. C-235 a long duration variety.

At Varkhed village (Akola district, Maharashtra), among cotton based intercropping systems demonstrated in medium black soils, the increase in cotton equivalent yield was 20, 55 and 28% (1452, 1882 and 1555 kg/ha) with cotton + greengram (1:1), cotton + cowpea (1:1) and cotton + clusterbean (1:1) intercropping systems as compared to sole cotton (1212 kg/ha). Cotton + cowpea (1:1) intercropping system gave higher net returns (Rs 32527/ha) and B:C ratio (1.58) compared to other cropping systems.

Nutrient management

At Chikkamaranahalli village (Bengaluru rural district, Karnataka), in loamy sand soils of

uplands, application of 100% RDF + 12.5 kg/ha of $ZnSO_4$ in fingermillet (MR-6) + pigeonpea (BRG-2) (8:2) intercropping system recorded higher finger millet equivalent yield (3016 kg/ha), net returns (Rs. 34844/ha) and B:C ratio (2.16) compared to application of only 100% RDF (2749 kg/ha).

Efficient energy management

At Vannedoddi village (Ananthapuramu district, Andhra Pradesh), in rainfed Alfisols, sowing of groundnut with bullock drawn Ananta planter recorded higher pod yield (1667 kg/ha), net returns (Rs.48793/ha), B:C ratio (2.74) and RWUE (3.39 kg/ha-mm) when compared to bullock drawn local seed drill (1535 kg/ha).

At Narotewadi village (Solapur district, Maharashtra), in medium black soils, sowing of *rabi* sorghum with two bowl fertilizer seed drill increased grain yield (1010 kg/ha), net returns (19260/ha), B:C ratio (2.4) and RWUE (12.78 kg/ha-mm) compared to farmers' practice of local seed drill (820 kg/ha).

At Khaner village (Samba district, Jammu & Kashmir), in medium black soils, sowing of maize with maize planter gave 27% higher grain yield over farmers' practice with net returns of Rs 24278/ha and B:C ratio of 2.31. The energy input was 6893 MJ/ha and energy output was 89903 MJ/ha.

Alternate land use/integrated farming system

At Khaner village (Samba district, Jammu & Kashmir), in shallow soils, the yield of mixed fodder under aonla + mixed fodder system ranged from 23000 to 24800 kg/ha with mean yield of 23900 kg/ha, RWUE of 47.5 kg/ha-mm, net returns of Rs 17794/ha and B:C ratio of 2.49.

At Terha Saraya village (Mirzapur District, Uttar Pradesh), in medium alluvial soil, integrated farming system (IFS) involving rice cultivation and livestock (3 buffalo + 2 buffalo calf) gave net returns of Rs. 151677/ha, B:C ratio of 2.2 and employment generation of 160 man day/ha/yr whereas agri-horti system gave net returns of Rs. 27460/ha.

NICRA-Strategic Research

Evaluation of the performance of different crops under organic, inorganic and integrated production systems showed that the seed yield of sunflower was 14 and 7% higher in the plots under integrated management (1374 kg/ha) than that under inorganic and organic management, respectively. However, both integrated and organic management recorded similar but higher seed yields of greengram (673-706 kg/ha) and pigeonpea (898-911 kg/ha) compared to inorganic management. Different production systems had no significant on soil pH, available N and Mn. However, plots under organic management recorded significantly higher soil organic C (0.67%), compared to inorganic and integrated production systems. Plots under organic management being on par with integrated production systems also recorded significantly higher available K (263.1 kg/ha), Cu (2.54 ppm), Fe (7.92 ppm) and Zn (0.57 ppm) compared to inorganic production system.

Collabration

During 2017-18, strengthened collabration with AICRPAM centers for dissemination of agromet advisories and with NICRA-KVKs for technical back stopping.

Village Climate Risk Management Committee (VCRMC)

VCRMCs established in each NICRA village proved to be an effective village level institution 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.

Custom Hiring Centre (CHC)

During 2017-18, the CHC facilities were also extended to farmers of new villages adopted by the centres. 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. Since 2011, 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 is the vital input during RTCP implementation. Efforts were made to provide the seed of alternative crops and varieties of the rainfed crops to address the problem of seed unavailability, through seed production of short duration and drought tolerant varieties of different field crops in NICRA villages. During the year, about 330 tons seed of different rainfed crops was produced/ maintained in different NICRA villages.

Fodder Bank

Efforts were made to increase fodder production (both green and dry) on farmers' fields, community lands and field bunds. To strengthen the availability of the green fodder in the NICRA villages of Naiwan and Achalpur, Hoshiarpur district seed of improved variety of pearlmillet (FBC 16) was provided and hybrid Napier cuttings were planted on the field bunds of the farmers. At Chikkamaranahalli village, Bengaluru Rural district, farmers were supplied with seeds of *Stylosanthes hamata* for sowing on the bunds to establish perennial fodder source and to stabilize bunds. At Tahakpal village, Bastar district farmers produced seed of *Stylosanthes* (62.7 kg), hybrid Napier bajra (22.4 kg), berseem (53.75 kg) and fodder sorghum (95.2 kg).

Agro-advisories/Agromet 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 2017-18, timely agromet advisories were given in collaboration with AICRPAM centres in adopted villages of Akola, Anantapuramu, Bengaluru Rural, Parbhani, Solapur and Vijayapura districts.

Soil Health Cards

During 2017-18, soil health cards were provided in the adopted villages of Kovilpatti (23 farmers), Akola (108 farmers), Arjia (40 farmers), Jagdalpur (5 farmers), Phulbani (38 farmers), Rajot (25 farmers) and SK Nagar (47 farmers).

Trainings/Field Visits/Field Days

During the year, 61 trainings and 22 field days/exposure visits were organized by the centres which benefitted 11611 stakeholders including farmers. These trainings/other extension activities focused on sensitization 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.

Linkages for Operationalizing District Agriculture Contingency Plans

During 2017-18, the scientists of the centres were actively involved in 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 5 states (Karnataka, Andhra Pradesh, Telangana, Maharashtra and Rajasthan) for operationalization of district agriculture contingency plans and contributed in developing action plans.

Agromet advisories from common centres of AICRPDA-AICRPAM viz. Akola, Anantapuramu, Bengaluru, Vijayapura, Parbhani and Solapur were issued by AICRPAM centres in AICRPDA NICRA villages. Successful RTCPs from AICRPDA-NICRA villages will be up-scaled in AICRPAM-NICRA villages by the AICRPAM. Similarly, NICRA-KVKs in the domain districts of AICRPDA centres (Akola, Anantapuramu, Bengaluru, Biswanath Chariali, Chianki, Hisar, Indore, Jagdalpur, Jhansi, Kovilpatti, Parbhani, Rajkot, Rakh Dhiansar, SK Nagar, Solapur, Varanasi and Vijayapura) were given technical inputs on real time contingency planning and doable technologies.

Introduction

Climate change/variability impacts are more pronounced in rainfed agriculture. The productivity of rainfed crops are most affected due to delayed onset of monsoon and in-season drought. The projected impacts are likely to further aggravate yield fluctuations of many crops with impact on food security and prices. In the XI Five Year Plan, ICAR launched the National Initiative on Climate Resilient Agriculture (NICRA) with Technology Demonstration as one of the major components. The location-specific climate risk resilient technologies are being demonstrated in farmers' fields in a participatory mode in 151 vulnerable districts spread across the country. In XII Plan, NICRA is being implemented as National Innovations in Climate Resilient Agriculture.

AICRPDA-NICRA Programme

AICRPDA, a natural resource management project, has the network of 19 main centres, 3 sub centres, 5 voluntary centres, 8 Operational Research Projects and 3 voluntary centres at CAZRI, IGFRI and IISWC (Fig.1) which represent diverse rainfed agro-ecologies and are located in 17 states (Table.1). Over a period of 4 decades, AICRPDA network centres generated agroecology-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, and farm mechanization 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: AICRPDA Network Centres - Agro-ecological Setting

Name of the Centres	SAU / ICAR Inst/other (Hqrs)	Agro-Climatic Zone (NARP)/ Agro–eco Sub Region(AESR)	Climate**	MARF (mm)	Dominant Soil Type	MRPS
Main Centres						
Akola	PDKV, Akola	Western Vidarbha Zone in Maharashtra (6.3)	Semiarid (Hot moist)	824	Vertisols	Cotton
Anantapur	ANGRAU, Hyderabad	Scarce rainfall zone (Rayalaseema) in A.P. (3.0)	Arid (Hot)	544	Alfisols	Groundnut
Arjia	MPUAT, Udaipur	Southern zone in Rajasthan (4.2)	Semiarid (Hot dry)	656	Vertisols	Maize

Name of the Centres	SAU / ICAR Inst/other (Hqrs)	Agro-Climatic Zone (NARP)/ Agro–eco Sub Region(AESR)	Climate**	MARF (mm)	Dominant Soil Type	MRPS
B. Saunkhri	PAU, Ludhiana	Kandi region in Punjab (9.1)	Sub-humid (Hot dry)	1011	Inceptisols	Maize
Bangalore	UAS_B, Bangalore	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermil-let
Bijapur	UAS_D, Dharwad	Northern dry zone in Karnataka (6.1)	Semiarid (Hot dry)	595	Vertisols	Rabi Sorghum
Biswanath Chariali	AAU, Jorhat	North Bank plain zone in Assam (15.2)	Humid (Hot)	1990	Alfisols	Rice
Chianki	BAU, Ranchi	Western plateau zone of Jharkhand(11.0)	Subhumid (Hot moist)	1179	Inceptisols	Rice
Hisar	CCSHAU, Hisar	South-western dry zone in Haryana(2.3)	Arid (Hyper)	412	Inceptisols	Pearlmillet
Indore	RVSKVV, Gwalior	Malwa plateau in Madhya Pradesh (5.2)	Semiarid (Hot moist)	958	Vertisols	Soybean
Jagadalpur	IGAU, Raipur	Basthar Plateau zone in Chattisgarh (12.1)	Subhumid (Hot moist)	1297	Inceptisols	Rice
Kovilpatti	TNAU, Coimbatore	Southern zone of Tamil Nadu (8.1)	Semiarid (Hot dry)	723	Vertisols	Cotton
Parbhani	MAU, Parbhani	Central Maharashtra Plateau Zone in Maharashtra (6.2)	Semiarid (Hot moist)	901	Vertisols	Cotton
Phulbani	OUAT, Bhubaneswar	Eastern Ghat Zone in Orissa (12.1)	Subhumid Hot moist)	1580	Oxisols	Rice
Rajkot	JAU, Junagarh	North Saurashtra zones in Gujarat (5.1)	Semiarid (Hot dry)	590	Vertisols	Groundnut
Rewa	JNKVV, Jabalpur	Keymore plateau and Satpura Hill zone in Madhya Pradesh (10.3)	Subhumid (Hot dry)	1088	Vertisols	Soybean
S.K. Nagar	SDAU, Dantewada	Northern Gujarat in Gujarat (2.3)	Semiarid/ Arid (Hot dry)	670	Entisols	Pearlmillet
Solapur	MPKV, Rahuri	Scarcity zone in Maharashtra (6.1)	Semiarid (Hot dry)	732	Vertisols	Rabi Sorghum
Varanasi	BHU, Varanasi	Eastern Plain and Vindhyan Zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	1049	Inceptisols	Rice
Sub Centres						
Agra	RBSC, Agra	South–western semiarid zone in Uttar Pradesh (4.1)	Semiarid (Hot dry)	665	Inceptisols	Pearlmillet
Faizabad	NDUAT, Faizabad	Eastern plain zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	1051	Inceptisols	Rice
Rakh Dhiansar	SKUAS_T, Jammu	Low altitude subtropical zone in Jammu and Kashmir (14.2)	Semiarid (Moist dry)	860	Inceptisols	Maize

Name of the Centres	SAU / ICAR Inst/other (Hqrs)	Agro-Climatic Zone (NARP)/ Agro–eco Sub Region(AESR)	Climate**	MARF (mm)	Dominant Soil Type	MRPS
Operational Research Project (ORP)						
Anantapur	ANGRAU, Hyderabad	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh (3.0)	Arid (Hot)	544	Alfisols	Groundnut
Arjia	MPUAT, Udaipur	Southern zone in Rajasthan (4.2)	Semiarid (Hot dry)	656	Vertisols	Maize
Ballowal Saunkhri	PAU, Ludhiana	Kandi region in Punjab (9.1)	Subhumid) (Hot dry)	1011	Inceptisols	Maize
Bangalore	UAS_B, Bangalore	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermil-let
Chianki	BAU, Ranchi	Western plateau zone of Jharkhand (11.0)	Subhumid (Hot moist)	1179	Inceptisols	Rice
Hisar	CCSHAU, Hisar	South-western dry zone in Haryana (2.3)	Arid (Hyper)	412	Inceptisols	Pearlmillet
Indore	RVSKVV, Gwalior	Malwa plateau in Madhya Pradesh (5.2)	Semiarid (Hot moist)	958	Vertisols	Soybean
Solapur	MPKV, Rahuri	Scarcity zone in Maharashtra (6.1)	Semiarid (Hot dry)	732	Vertisols	Rabi Sorghum
Voluntary Centres						
Darsi	ANGRAU, Hyderabad	Krishna-Godavari zone of Andhra Pradesh (7.3)	Semiarid	871	Alfisols/ Vertisols/	Pigeonpea
Munger	BAU, Sabour	South Bihar Alluvial plain zone of Bihar (13.1)	Submumid	1143	Inceptisols	Maize
Raichur	UAS, Raichur	North-eastern dry zone of Karnataka (6.2)	Semiarid	621	Vertisols/ Alfisols	Rabi sorghum
Imphal	CAU, Imphal	Sub-tropical zone of Manipur (17.2)	Perhumid	1372	Inceptisols	Rice
Aklera	Agriculture Univ, Kota	South eastern plain zone of Rajasthan (5.2)	Semiarid	844	Vertic Inceptisols	Soybean
Bellary (VC)	CSWCRTI, Dehradun	Northern dry zone in Karnataka (3.0)	Arid (Hot)	502	Vertisols	Rabi Sorghum
Jhansi	IGFRI, Jhansi	Bundhelkhand zone in Uttar Pradesh (4.4)	Semiarid (Hot moist)	870	Inceptisols	kharif Sorghum
Jodhpur	CAZRI, Jodhpur	Arid Western zone of Rajasthan (2.1)	Arid (Hyper)	331	Aridisols	Pearlmillet

**Climate details as per AESR details given by NBSSLUP (ICAR); MARF-Mean Annual Rainfall; MRPS- Major Rained Production system

During the first phase (2011-17) of the Technology Demonstration Component of NICRA, the AICRPDA-NICRA programme was undertaken at 23 centres. The focus of the programme during the period was 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. 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, intercropping 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.

Real Time Contingency Plan Implementation (RTCP) - Concept

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 RTCP at AICRPDA centres was implemented with two pronged approach i.e. preparedness and real-time contingency measures, with major emphasis 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; and iii) enhance performance, improve productivity and income.

RTCP Measures in Rainfed Agriculture

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

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. 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.

AICRPDA-NICRA: Phase-II

To strengthen AICRPDA-NICRA during second phase, critical review was done during the Fifth Annual Review Workshop of AICRPDA-NICRA held at ICAR-CRIDA during 26-27 May, 2017 and the following recommendations were made to develop the technical programme for 2017-18.

Dr. S. Bhaskar, ADG (A, AF & CC) addressing the participants

Recommendations

a. On-station

- Two common experiments would be taken up across 23 AICRPDA centres: a) Studies on foliar sprays to cope with midseason drought, and b) Evaluation of crops/varieties under delayed onset of monsoon.

b. On-farm

- To implement real-time contingency plans to cope with delayed onset of monsoon and midseason drought and preparedness for coping with drought/excess rainfall events/floods
- In addition to existing NICRA villages, the program would be expanded to adjoining villages with focus on demonstration of low cost rainfed technologies
- The farmers of new villages would also be made members of existing Custom Hiring Centres (CHCs) for sharing/hiring of farm implements

c. Convergence with AICRPAM-NICRA

Agromet advisories from common centres of AICRPDA- AICRPAM viz. Akola, Anantapuramu, Bengaluru, Vijayapura, Parbhani and Solapur will be issued by AICRPAM centres in AICRPDA NICRA villages. The verification of the impact of agromet advisories will be done by AICRPAM staff. Successful RTCPs from AICRPDA-NICRA villages will be up-scaled in AICRPAM-NICRA villages by the AICRPAM.

d. Convergence with NICRA-TDC-KVKs

All NICRA-KVKs in the domain districts of AICRPDA to consult for technical inputs on real time contingency planning and doable technologies. The details of AICRPDA centres and domain NICRA KVKs are given below.

AICRPDA centre	Domain NICRA KVK (s)	State
Akola	Amravati, Buldana	Maharashtra
Ananthapuramu	Ananthapuramu, Kurnool	Andhra Pradesh
Bengaluru	Tumkur, Kolar	Karnataka
Biswanath Chariali	Dibrugarh, Sonitpur, Kabri Ablong	Assam
Chianki	East Singhbhum, Gumla	Jharkhand
Hisar	Ropar	Haryana
Indore	Jhabua	Madhya Pradesh
Jagdalpur	Bilaspur, Dantewada	Chhattisgarh
Jhansi	Jhansi, Hamirpur	Uttar Pradesh
Kovilpatti	Ramanathapuram	Tamil Nadu
Parbhani	Aurangabad, Jalna	Maharashtra
Rajkot	Rajkot, Amreli	Gujarat
Rakh Dhiansar	Kathua	J&K
SKNagar	Banaskantha	Gujarat

AICRPDA centre	Domain NICRA KVK (s)	State
Solapur	Ahmednagar, Nandurbar	Maharashtra
Varanasi	Sonbhadra	Uttar Pradesh
Vijayapur (Bijapur)	Gadag, Kalburgi (Gulbarga)	Karnataka

Based on the recommendations of the Workshop, during the second phase of NICRA, the on-farm programme under AICRPDA-NICRA was extended to 22 more adjoining villages to the existing 32 villages in 24 districts across 15 states and 2017-18 technical programme is being implemented in 54 villages (Fig. 2 and Table 2).

Fig.2. Location map of AICRPDA-NICRA villages

Table 2: Details of AICRPDA-NICRA villages

AICRPDA centre	Present village(s)	New village (s) 2017-18	District	State
Agra	Nagla Duleh khan	Kherra	Agra	Uttar Pradesh
Akola	Warkhed	Kajleshwar	Akola	Maharashtra
Anantapur	Vannedoddipally	Bachepalli	Anantapur	Andhra Pradesh
Arjia	Kochariya and Lapsiya	Bagatpura and Tara ka Kheda	Bhilwara Rajsamand	Rajasthan
Ballowal Saunkhri	Naiwan and Achalpur	Bhanivpur	Hoshiarpur	Punjab
Bengaluru	Chikkamaranahalli	Chikkahosapalya	Bengaluru Rural	Karnataka
Biswanath Chariali	Chamua, Ganakdoloni	-	Lakhimpur	Assam
Vijayapura	Kavalagi	Honnutagi	Bijapur	Karnataka
Chianki	Kumbhi and Bankheta	Chiraunjiya	Garhwa	Jharkhand
Faizabad	Hardoiya	Pero Saraiya	Faizabad	Uttar Pradesh
Hisar	Budhshelly, Balawas	-	Bhiwani	Haryana
Indore	Ningnoti	Bishakhedi	Indore	Madhya Pradesh
Jagdalpur	Tahakapal, Tandapal and Gumiyapal	Jhartarai	Bastar	Chattishgarh
Jhansi	Kadesara Kala	Hanauta	Lalitpur	Uttar Pradesh
Kovilpatti	Toppureddiapatti	Dharmathanpatti	Thoothukkudi	Tamil Nadu
Parbhani	Babhulgaon	Ujalamba	Parbhani	Maharashtra
Phulbani	Budhadani	Gunjidraga	Kandhamal	Odisha
Rajkot	Pata meghapar	Dangarvala	Jamnagar	Gujarat
Rakh Dhiansar	Khaner	Madana	Samba	Jammu& Kash-mir

AICRPDA centre	Present village(s)	New village (s) 2017-18	District	State
Rewa	Patauna, Raura	Khira	Rewa	Madhya Pradesh
SK Nagar	Kalimati, Dholia	Gagu	Banaskantha	Gujarat
Solapur	Narotewadi	Banegoan	Solapur	Maharashtra
Varanasi	Tedha	Patharaha (Hinauti)	Mizapur	Uttar Pradesh

Experienced weather at AICRPDA- NICRA villages during 2017-18

During 2017-18, the onset of monsoon was delayed by 25, 13 and 11 days respectively in NICRA villages located in Jamnagar (Gujarat), Garhwa (Jharkhand) and Banaskantha (Gujarat) districts (Table 3). Further, there were 3-6 dry spells at different stages of crops in NICRA villages in Akola, Ananthapuramu, Bengaluru, Jagdalpur, Lakhimpur, Garhwa, Kandhamal, Parbhani and Kovilpatti districts.

Table 3: Details of onset of monsoon in AICRPDA-NICRA villages (2017)

Villages & District	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Nagla Dulhe Khan and Kherra (Agra)	South–western semiarid zone in Uttar Pradesh	2-July	3-July	1
Warkhed and Kajleswar (Akola)	Western Vidarbha Zone in Maharashtra	10-June	14-June	4
Vannedoddipally and Bachepalli (Anantapuramu)	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh	7-June	7-June	-
Kochariya, Lapsiya, Bagatpura and Tara ka Kheda (Bhilwara)	Southern zone in Rajasthan	1-July	24-June	-
Naiwan, Achalpur and Bhanivpur (Hoshiarpur)	Kandi region in Punjab	1-July	26-June	-
Chikkamaranahalli and Chikkahosapalya (Bengaluru Rural)	Central, eastern and southern dry zone in Karnataka	2-June	11-June	9
Kavalagi and Honnutagi (Vijayapura)	Northern dry zone in Karnataka	7-June	7-June	-
Chamua and Ganakdoloni (Lakhimpur)	North Bank plain zone in Assam	5-June	1-June	-
Kumbhi, Bankheta and Chiraunjiya (Garhwa)	Western plateau zone of Jharkhand	10-June	23-June	13
Hardoiya and Pero Saraiya (Faizabad)	Eastern plain zone in Uttar Pradesh	21-June	21-June	-
Balawas & Budhshelly (Bhiwani)	South-western dry zone in Haryana	1-July	29-June	-
Ningnoti and Bishakhedi (Indore)	Malwa plateau in Madhya Pradesh	12-June	4-June	-
Tahakapal, Tandapal, Gumiyapal and Jhartarai (Bastar)	Basthar Plateau zone in Chattisgarh	15-June	3-June	-
Kadesara Kala and Hanauta (Lalitpur)	Bundhelkhand zone in Uttar Pradesh	25-June	23-June	-
Toppureddiapatti and Dharmathanpatti (Toothukkudi)	Southern zone of Tamil Nadu	1-June	6-June	5
Babhulgaon and Ujalamba (Parbhani)	Central Maharashtra Plateau Zone in Maharashtra	20-June	7-June	-
Budhadani and Gunjidraga (Kandhamal)	Eastern Ghat Zone in Orissa	10-June	10-June	-
Pata meghapar and Dangarvala (Jamnagar)	North Saurashtra zones in Gujarat	16-June	11-July	25
Khaner and Madana (Samba)	Low altitude subtropical zone in J&K	27-June	30-June	3

Villages & District	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Patauna, Raura and Khira (Rewa)	Keymore plateau and Satpura Hill zone in Madhya Pradesh	23-June	30-June	7
Kalimati, Dholia and Gagu (Banaskantha)	Northern Gujarat in Gujarat	15-June	10-June	11
Narotewadi and Banegoan (Solapur)	Scarcity zone in Maharashtra	20-June	6-June	-
Tedha and Patharaha (Mirzapur)	Eastern Plain and Vindhyan Zone in Uttar Pradesh	1-July	21-June	-

In general, the total rainfall during *kharif* season (June-September), 2017 was below normal in all NICRA villages except in Chikamanahalli (Bengaluru), Kavalagi (Vijayapura), Chamuha (Lakhimpur), Balawas (Bhiwani), Tahakapal (Bastar), Kadesara Kalan (Lalithpur), Muttukrishnapuram (Toothukkudi), Babhulgaon (Parbhani), Petameghapar (Jamnagar) and Kalimati (Banastantha) (Fig 3).

Similarly, during *rabi* season (October-December) 2017, the rainfall was less than normal seasonal rainfall in NICRA villages of Varkhed (Akola), Achalpur (Hoshiarpur), Chikamanahalli (Bengaluru), Kavalagi (Vijayapur), Kumbhi & Bankheta (Garhwa), Nignoti (Indore), Kadesara Kala (Lalitpur), Khaner (Samba), Kalimati (Banaskanta) and Nerotewadi (Solapur). No rainfall was received in 6 NICRA vilages in *rabi* season at Nagala Dulhe Khan (Agra), Kochariya (Bhilwara), Hardoya (Faizabad), Babhulgaon (Parbhani), Patameghpar (Jamnagar) and Tedha (Mirzapur) (Fig 4).

The rainfall was deficit by more than 50% during June 2017 in NICRA-villages of Hoshiarpur, Jamnagar and Mirzapur districts. In July, the deficit in rainfall was more than 60% in villages of Agra, Anantapuramu, Bengaluru rural, Vijayapur, Toothukkudi, and Solapur districts. Similarly, in August, villages in Akola, Bhilwara, Garhwa, Kandhamal, Banaskantha and Mirzapur districts recorded more than 50% deficit rainfall. In September, NICRA villages in Agra, Garhwa, Bhiwani, Indore, Parbhani, Jamnagar, Samba, and Banaskantha districts received 50-75% deficit rainfall. Similarly, in October, 5 villages in Agra, Bhilwara, Hoshiarpur, Faizabad, Parbhani, Jamnagar, Samba, Banaskantha and Mirzapur districts did not receive any rainfall (Table 4).

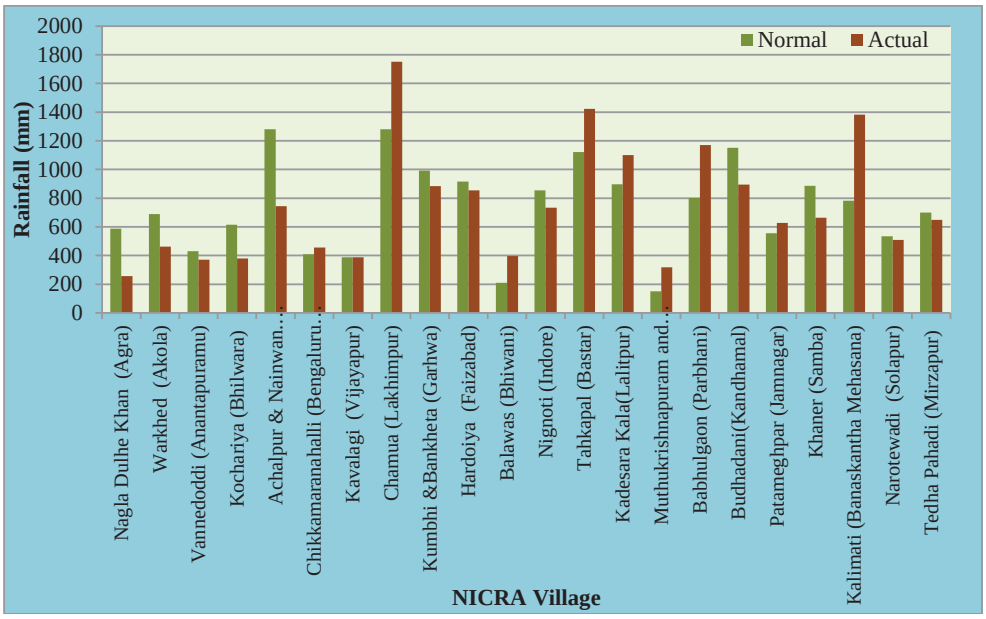


Fig 3: Normal and actual (2017) rainfall in AICRPDA-NICRA villages (June - September)

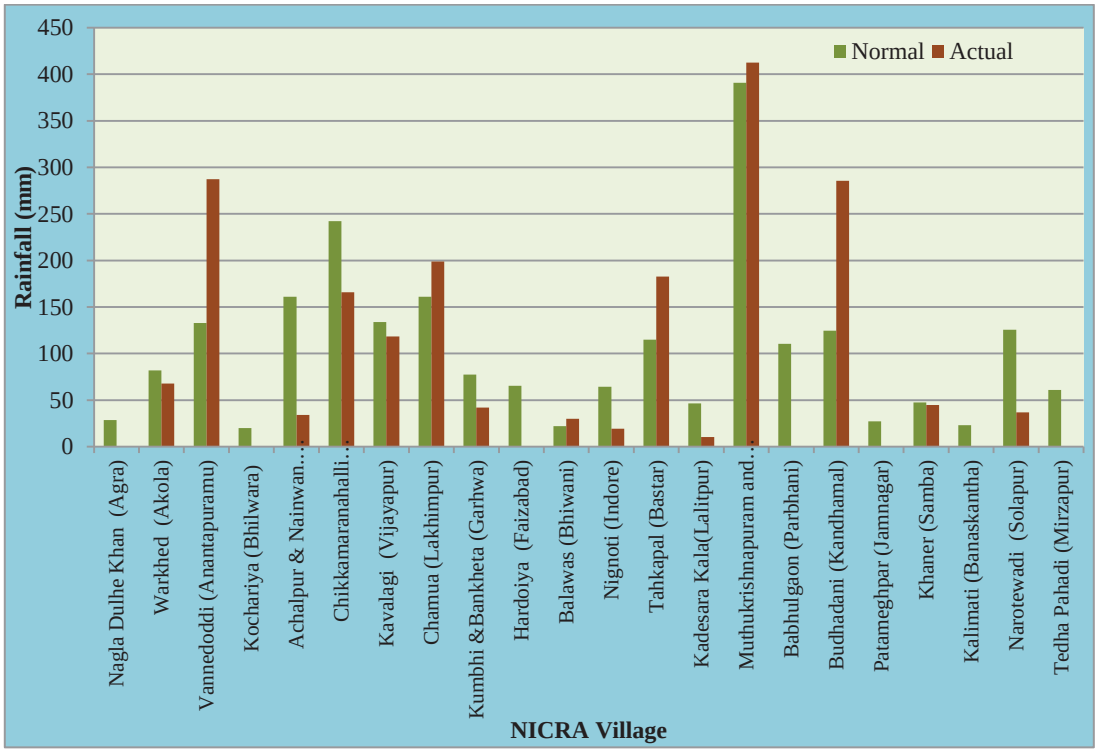


Fig 4: Normal and actual (2017) rainfall in AICRPDA-NICRA villages (October - December)

During 2017-18, 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 agroclimatic zone-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, 2017

NICRA 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	37	-28	239	66	-72	207	129	-38	90	25	-72	25	0	-100	2	0	-100	2	0	-100
Warkhed (Akola)	152	107	-30	209	199	-5	216	84	-61	111	72	-35	52	68	30	21	0	-100	9	0	-100
Vannedoddi (Anantapuramu)	94	77	-18	97	10	-89	97	140	44	142	145	2	21	287	1268	107	0	-100	5	0	-100
Kochariya (Bhilwara)	74	46	-38	196	170	-13	249	86	-65	97	77	-20	10	0	-100	7	0	-100	4	0	-100
Achalpur & Nainwan. (Hoshiarpur)	360	131	-64	364	242	-33	316	221	-30	241	151	-38	130	0	-100	20	0	-100	11	34	215
Chikkamaranahalli (Bengaluru rural)	59	12	-80	80	20	-75	131	149	14	139	273	97	154	159	3	61	5	-92	27	2	-93
Kavalagi (Vijayapur)	85	88	3	73	21	-72	78	108	39	152	171	13	97	114	18	30	0	-100	7	4	-44
Chamua (Lakhimpur)	360	468	30	364	737	103	316	286	-9	241	261	8	130	182	40	20	17	-16	11	0	-100
Kumbhi &Bankheta (Garhwa)	162	99	-39	320	531	66	359	180	-50	152	74	-51	62	38	-40	10	5	-53	6	0	-100
Hardoiya (Faizabad)	137	72	-48	293	377	29	294	206	-30	191	200	5	51	0	-100	4	0	-100	11	0	-100
Balawas (Bhiwani)	20	206	917	80	72	-10	60	101	68	50	19	-63	9	11	22	10	10	-5	3	10	194
Nignoti (Indore)	121	242	100	261	190	-27	225	192	-15	248	110	-56	40	18	-54	18	0	-100	7	1	-83
Tahkapal (Bastar)	236	296	26	343	481	41	351	336	-4	193	309	60	88	183	107	20	0	-100	6	0	-100
Kadesara Kala(Lalitpur)	95	133	40	323	329	2	337	292	-13	142	346	144	19	11	-44	6	0	-100	22	0	-100
Muthukrishnapuram and Thoppured-dipatti (Toothukkudi)	11	9	-21	20	0	-100	35	156	344	84	154	83	199	139	-30	139	127	-8	54	146	172
Babhulgaon (Parbhani)	172	187	8	225	543	141	236	359	52	167	82	-51	80	0	-100	21	0	-100	9	0	-100
Budhadani(Kandhamal)	189	246	30	350	218	-38	383	176	-54	228	255	12	96	263	174	24	23	-4	5	0	-100
Patameghpar (Jamnagar)	103	50	-51	252	414	64	103	125	21	97	39	-60	22	0	-100	5	0	-100	0	0	-100
Khaner (Samba)	91	127	40	324	284	-12	334	208	-38	137	45	-67	19	0	-100	6	3	-48	22	42	90
Kalimati (Banaskantha Mehasana)	87	186	113	278	1033	271	275	122	-56	142	43	-70	20	0	-100	3	0	-100	1	0	-100
Narotewadi (Solapur)	107	246	130	116	27	-77	140	108	-23	173	129	-25	98	37	-62	22	0	-100	6	0	-100
Tedha Pahadi (Mirzapur)	87	39	-55	283	528	87	327	47	-86	3	35	1284	49	0	-100	7	0	-100	5	0	-100

N: Normal A: Actual during 2017 % Dev: % Deviation

1.1 Dry Semi-Arid Zone (500-750 mm)

1.1.1 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 2017-18

During the year 2017, the onset of monsoon was early by 6 days (27th June). A rainfall of 701.7 mm was received which was excess by 44 mm compared to normal rainfall of 657.7 mm. During south-west monsoon (June to September), 640.4 mm rainfall was received which was excess by 25.9 mm (42.1%). During October-December, there was 3.7 mm of rainfall against normal rainfall of 20.2 mm. During summer (March- May), 47.6 mm of rainfall was received which was excess by 32.5 mm compared to normal (15.1 mm) (Fig.5).

Normal onset of monsoon	:	2 July
Onset of monsoon during 2017	:	27 June
Annual mean rainfall	:	657.7 mm
Annual rainfall during 2017-18	:	701.7 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	614.5 and 20.2 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	640.4 and 3.7 mm, respectively

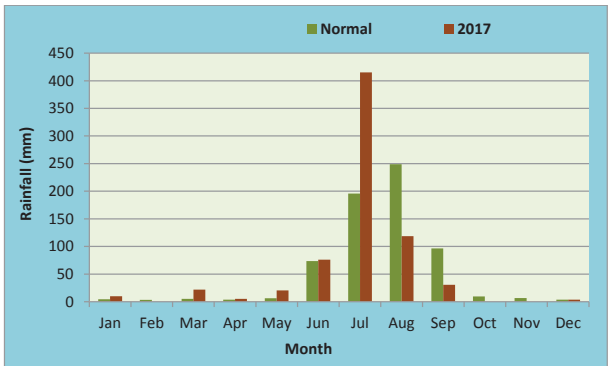


Fig.5: Normal and actual (2017) monthly rainfall at Arjia

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
-	17 September to till harvest	Maize	Grain filling to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought	Maize	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

During *kharif* 2017, the rainfall received during cropping season was 592.9 mm with uneven distribution. There was terminal drought from 17th September to crop harvest due to early cessation of monsoon. Foliar application of macro- and micronutrients during dry spell (>10 days dry spell) in maize significantly enhanced the grain yield (2730 kg/ha) by 13.6% compared to foliar application at sufficient moisture just after dry spell (2403 kg/ha). Further, foliar application of water soluble NPKS complex fertilizer (18:18:18:6) @ 0.5% + $ZnSO_4$ @

0.5% increased grain yield (2961 kg/ha) by 36.4% compared to control (2171 kg/ha), with higher net returns (Rs 41179/ha), B:C ratio (3.24) and RWUE (5.0 kg/ha-mm) (Table 5).

Table 5: Yield and economics of maize with foliar spray

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Main plot						
Foliar spray after relieving of stress	2403	4965	17763	30691	2.73	4.06
Foliar spray during dry spell	2730	5538	17763	37024	3.08	4.61
CD at 5%	240	499				
Sub plot						
Urea @ 1%	2461	4993	17685	31708	2.79	4.16
Urea @ 2%	2465	5081	17745	31937	2.80	4.16
NPK soluble (18:18:18) @ 0.5%	2912	5977	18099	40524	3.24	4.92
NPKS soluble (18:18:18) @ 0.5% + $ZnSO_4$ @ 0.5%	2961	6067	18399	41179	3.24	5.00
$ZnSO_4$ @ 0.5%	2801	5718	17965	38343	3.13	4.73
Water spray	2192	4475	17625	26444	2.50	3.70
Control (no spray)	2171	4449	16825	26867	2.60	3.67
CD at 5%	217	394	-	-	-	-

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 and 253 ha 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.

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. 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 2017-18

During 2017, in Lapsiya village, onset of monsoon was advanced by 7 days (24th June). A rainfall of 378.5 mm was received which was deficit by 279.2 mm compared to normal (657.7 mm) (Fig.6). During south-west monsoon (June to September), 378.5 mm rainfall was received which was deficit by 236 mm (38.4%) than normal rainfall of 614.5 mm. During *rabi* and summer, there was no rain as against normal of 20.2 and 15.1 mm, respectively.

Normal onset of monsoon	:	2 July
Onset of monsoon during 2017	:	24 June
Annual mean rainfall	:	657.7 mm
Annual rainfall during 2017-18	:	378.5 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	614.5 and 20.2 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	378.5 and 0 mm, respectively

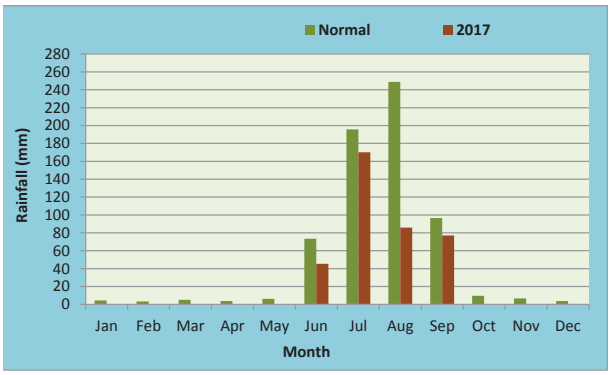


Fig.6: Normal and actual (2017) monthly rainfall at Lapsiya

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	26 June -07 July	Maize, sorghum, black-gram	Germination
-	17 September to till harvest		Grain filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought	Maize + black-gram (2:2) Groundnut + sesame (6:2)	Foliar spray, supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

During the year, terminal drought occurred coinciding with grain filling and maturity stages of crops, due to early cessation of monsoon (17th September). One supplemental irrigation in maize + blackgram (2:2) intercropping system from harvested rainwater in farm pond gave 26.2% higher maize equivalent yield (MEY) (2192 kg/ha) over farmers' practice of no supplemental irrigation (1737 kg/ha) with higher net returns (Rs 17303/ha), B:C ratio (2.03) and WUE (5.79 kg/ha-mm) (Table 6).

Table 6: Effect of supplemental irrigation in maize + blackgram (2:2) intercropping system in Dagoliya ka kheda village

Treatment	Yield (kg/ha)				MEY (kg/ha)		WUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Stover							
	Maize	Black gram	Maize	Black gram	Grain	Straw				
With supplemental irrigation	1995	53	3025	95	2192	3120	5.79	16800	17303	2.03
Without supplemental irrigation	1615	33	2725	75	1737	2800	4.59	15600	12243	1.78

In village Tara ka Kheda (Lapsiya), one supplemental irrigation in maize + blackgram (2:2) intercropping system gave 27% higher maize grain equivalent yield (2290 kg/ha) over farmers' practice (1803 kg/ha) with higher net returns, B:C ratio and WUE (Table 7).

Table 7: Effect of supplemental irrigation in maize + blackgram (2:2) intercropping system at Tara ka Kheda (Lapsiya) village

Treatment	Yield (kg/ha)				MEY (kg/ha)		Mean MEY (kg/ha) (2 yrs)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Stover								
	Maize	Black gram	Maize	Black gram	Grain	Stover					
With supplemental irrigation	2065	60	3275	150	2290	3425	2585	6.05	17050	18993	2.11
Without supplemental irrigation	1675	34	2875	98	1803	2973	2074	4.76	15850	13211	1.83

MEY: Maize equivalent yield

Similarly, one supplemental irrigation during drought in groundnut+ sesame (6:2) intercropping system in village Lapsiya gave 52.2% higher groundnut pod equivalent yield (GPEY) (659 kg/ha) over farmers' practice (433 kg/ha) with higher net returns (Rs 15086/ha), B:C ratio (1.84) and WUE (1.74 kg/ha-mm) (Table 8).

Table 8: Effect of supplemental irrigation in groundnut+ sesame (6:2) intercropping system at Tara ka Kheda (Lapsiya) village

Treatment	Yield (kg/ha)				GPEY (kg/ha)		Mean GPEY (2 yrs)	WUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Pod/seed		Stalk								
	Main crop	Inter crop	Main crop	Inter crop	Pod	Haulm					
With supplemental irrigation	585	35	815	95	659	834	787	1.74	17900	15086	1.84
Without supplemental irrigation	385	23	645	75	433	660	583	1.14	16700	5403	1.32

GPEY: Groundnut pod equivalent yield

In village Dagoliya ka kheda, supplemental irrigation during drought in groundnut + sesame (6:2) intercropping system gave 53.8% higher GPEY (603 kg/ha) over farmers' practice (392 kg/ha) with higher net returns (Rs 12536/ha) and B:C ratio (1.71) (Table 9).

Table 9: Effect of supplemental irrigation in groundnut+ sesame (6:2) intercropping system at Dagoliya ka kheda village

Treatment	Yield (kg/ha)				GPEY (kg/ha)		WUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Pod/seed		Stover							
	Main crop	Inter crop	Main crop	Inter crop	Pod	Haulm				
With supplemental irrigation	545	28	745	85	603	762	1.59	17650	12536	1.71
Without supplemental irrigation	350	20	605	60	392	617	1.04	16450	3668	1.22

GPEY: Groundnut pod equivalent yield

Preparedness

Rainwater management

In village Tara ka Kheda (Lapsiya), improved practices (chiseling, peripheral bunding and ridging 30 DAS) gave 27% higher maize grain yield (2233 kg/ha) over farmers' practice of cultivator twice only (1758 kg/ha) with higher net returns and B:C ratio (Table). Further, the mean grain yield of last 7 years (2011-2017) also revealed that *in-situ* moisture conservation practices gave higher grain yield (1654 kg/ha) by 23.3% higher over farmers' practice (1341kg/ha) (Table). In village Dagoliya ka kheda, improved practices gave 25% higher grain yield (2125 kg/ha) over farmers' practice (1698 kg/ha) with higher net returns, B: C ratio and RWUE (Table 10).

Table 10: Yield and economics of maize as influenced by *in-situ* moisture conservation practices

Village	Treatment	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover				
Tara ka Kheda (Lapsiya)	With *in-situ* practices	2233	3375	5.90	15780	19448	2.23
	Without *in-situ* practices	1758	2938	4.64	15180	13254	1.87
Dagoliya ka kheda	With *in-situ* practices	2125	3175	5.61	15500	17938	2.16
	Without *in-situ* practices	1698	2813	4.48	14900	12501	1.84

In village Tara ka Kheda (Lapsiya), improved practices (chiseling, peripheral bunding and ridging 30 DAS) gave 26.8% higher sorghum grain yield (2380 kg/ha) over farmers' practice (2203 kg/ha) with higher net returns, B:C ratio and RWUE (Table). Further, the mean grain yield of last 3 years (2015-2017) also revealed that *in-situ* moisture conservation gave 27.5% higher grain yield (2059 kg/ha) over farmers' practice (1615 kg /ha). In village Dagoliya ka kheda, improved practices gave 24.4% higher sorghum grain yield (2327 kg/ha) over farmers' practice (1870 kg/ha) with higher net returns and B:C ratio (Table 11).

Table 11 : Yield and economics of sorghum as influenced by *in-situ* moisture conservation practices

Village	Treatment	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover				
Tara ka Kheda (Lapsiya)	With *in-situ* practices	2380	3710	6.29	15400	20055	2.30
	Without *in-situ* practices	1877	3133	4.96	14800	13677	1.92
Dagoliya ka kheda	With *in-situ* practices	2327	3633	6.15	15150	19527	2.29
	Without *in-situ* practices	1870	3070	4.94	14550	13695	1.94

Cropping systems

In village Tara ka Kheda (Lapsiya), improved variety of maize (PEHM-2) gave 24.4% higher grain yield (2082 kg/ha) compared to local cultivar (1674 kg/ha). Mean yield of 5 years also revealed that variety PEHM-2 gave higher mean grain yield (1728 kg/ha) over the local cultivar (1369 kg/ha). In village Dagoliya ka kheda, improved variety of maize (PEHM-2) gave 27.6% higher grain yield (1970 kg/ha) compared to local cultivars (1544 kg/ha), with higher net returns (Rs 17740/ha) and B:C ratio (2.25) (Table 12).

Table 12: Yield and economic of maize varieties

Village	Variety	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover				
Tara ka Kheda (Lapsiya)	PEHM-2	2082	3442	5.50	14270	19319	2.35
	Local	1674	2930	4.42	13900	13513	1.97
Dagoliya ka kheda	PEHM-2	1970	3300	5.20	14150	17740	2.25
	Local	1544	2928	4.08	13700	12148	1.89

In village Tara ka Kheda (Lapsiya), improved sorghum variety CSV-15 gave 24.7% higher grain yield (2254 kg/ha) over local cultivar and recorded higher net returns (Rs 20029/ha), B:C ratio (2.45) and RWUE of 5.96 kg/ha-mm (Table). Mean grain yield of 7 years (2011-2017) was also higher with the variety CSV-15 (1646 kg/ha) compared to local cultivar (1228 kg/ha). In village Dagoliya ka kheda, improved variety of sorghum (CSV-15) gave 21.9% higher grain yield (2068 kg/ha) compared to local cultivars (1696 kg/ha), with higher net returns (Rs 17298/ha), B:C ratio (2.24) and RWUE of 5.46 kg/ha-mm (Table 13).

Table 13: Yield and economic of sorghum varieties

Village	Variety	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover				
Tara ka Kheda (Lapsiya)	CSV-15	2254	3614	5.96	13800	20029	2.45
	Local	1808	3060	4.78	13450	14088	2.05
Dagoliya ka kheda	CSV-15	2068	3380	5.46	13900	17298	2.24
	Local	1696	2878	4.48	13550	12301	1.91

In village Tara ka Kheda (Lapsiya), improved intercropping system of maize + blackgram (2:2) gave 25.4% higher maize equivalent yield (2212 kg/ha) compared to mixed cropping of maize and blackgram (1764 kg/ha) with higher net returns (Rs. 19211/ha) and B:C ratio (2.22) (Table). Mean data of 7 years also revealed that improved practice of maize + blackgram (2:2) intercropping system gave higher mean maize grain equivalent yield (1594 kg/ha) compared to mixed cropping (1237 kg/ha) (Table 14).

Table 14: Performance of maize + blackgram (2:2) intercropping system at Tara ka Kheda (Lapsiya) village

Treatment	Yield (kg/ha)				MEY (kg/ha)		Mean MEY (kg/ha) (7 years)	RWUE (kg/ha -mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Stover								
	Maize	Black gram	Maize	Black gram	Grain	Straw					
Improved practice	2015	53	3218	130	2212	3348	1594	5.84	15700	19211	2.22
Farmers' practice	1675	24	2850	95	1764	2945	1237	4.66	15150	13381	1.88

MEY: Maize equivalent yield; Improved practice: maize + blackgram (2:2) intercropping; Farmers' practice: mixed cropping of maize and blackgram

Similarly in village Dagoliya ka kheda, intercropping system of maize + blackgram (2:2) gave 28.1% higher maize equivalent yield (2109 kg/ha) compared to mixed cropping of maize and blackgram (2638 kg/ha) with net returns of Rs. 15630/ha and B:C ratio of 1.91 (Table 15).

Table 15: Performance of maize + blackgram (2:2) intercropping system at Dagoliya ka kheda village

Treatment	Yield (kg/ha)				MEY (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Stover							
	Maize	Black gram	Maize	Black gram	Grain	Straw				
Improved practice	1940	45	2925	105	2109	3030	5.57	17250	15630	1.91
Farmers' practice	1548	26	2563	75	1646	2638	4.35	16500	9845	1.60

MEY: Maize equivalent yield; Improved practice: maize + blackgram (2:2) intercropping; Farmers' practice: mixed cropping of maize and blackgram

In Dagoliya ka kheda village, improved practice of groundnut + sesame (6:2) intercropping system recorded higher pod equivalent yield of 567 kg/ha with net returns of Rs. 9303/ha and B:C ratio of 1.52 while farmers' practice of mixed cropping of groundnut and sesame gave a groundnut pod equivalent yield of 396 kg/ha (Table 16).

Table 16: Yield and economics of groundnut + sesame (6:2) intercropping at Dagoliya ka kheda village

Treatment	Yield (kg/ha) (Pod/ seed)		Yield (kg/ha) (Stover)		GPEY (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Ground nut	Sesame	Ground nut	Sesame	Pod	Stover				
Improved practice	490	37	623	123	567	648	1.50	17850	9303	1.52
Farmers' practice	340	27	407	107	396	428	1.05	17180	1723	1.10

gpey: Groundnut pod equivalent yield; Improved practice: Groundnut + Sesame (6:2) in intercropping; Farmers' practice: Mixed cropping of groundnut and sesame.

In Tara ka Kheda (Lapsiya) village, sorghum+ greengram (2:1) intercropping system recorded higher sorghum equivalent grain yield of 2358 kg/ha with net returns of Rs.19209/ha and B:C ratio of 2.25 compared to farmers' practice of mixed cropping of sorghum and greengram (1919 kg/ha) (Table 17).

Table 17: Performance of sorghum+ greengram (2:1) intercropping at Tara ka Kheda (Lapsiya) village

Treatment	Yield (kg/ha) (Grain/ seed)		Yield (kg/ha) (Stover)		SEY (kg/ha)		Mean SEY (kg/ha) (5 yrs)	RWUE (kg/ha /mm)	Cost of cultivation (Rs/ha)	Net Returns (Rs/ha)	B:C Ratio
	Sor-ghum	Green gram	Sor-ghum	Green gram	Grain	Stover					
Improved practice	2147	52	3350	98	2358	3448	2132	6.23	15350	19209	2.25
Farmers' prac-tice	1823	23	2783	62	1919	2845	1630	5.07	14900	13319	1.89

SEY: Sorghum equivalent yield; Improved practice: Sorghum + greengram (2:1) intercropping; Farmers' practice: Mixed cropping of sorghum and greengram.

In Dagoliya ka kheda village, sorghum + greengram (2:1) intercropping system gave maximum sorghum grain equivalent yield of 2274 kg/ha with net returns of Rs. 17793/ha and B:C ratio of 2.17 compared to farmers' practice of mixed cropping of sorghum and greengram (1762 kg/ha) (Table 18).

Table 18: Yield and economics of sorghum+ greengram (2:1) intercropping at Dagoliya ka kheda village

Treatment	Yield (kg/ha)				SEY (kg/ha)		RWUE (kg/ha -mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Stover							
	Sorghum	Green gram	Sorghum	Green gram	Grain	Stover				
Improved practice	2077	48	3117	93	2274	3210	6.01	15250	17793	2.17
Farmers' practice	1660	25	2617	67	1762	2683	4.66	15000	11093	1.74

SEY: Sorghum equivalent yield

In Tara ka Kheda (Lapsiya) village, blackgram + sesame (2:2) intercropping system gave maximum blackgram seed equivalent yield of 259 kg/ha compared to farmers' practice of mixed cropping of blackgram and sesame (156 kg/ha) (Table 19). Mean yield of 7 years revealed that improved practice of blackgram + sesame (2:2) intercropping system gave higher BEY (379 kg/ha) compared to farmers' practice of mixed cropping of blackgram and sesame (266 kg/ha).

Table 19: Performance of blackgram + sesame (2:2) intercropping at Tara ka Kheda (Lapsiya) village

Treatment	Yield (kg/ha)				BEY (kg/ha) 2017	Mean BEY (kg/ha) (7 yrs)	RWUE (kg/ha -mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed		Stover							
	Black gram	Sesame	Black gram	Sesame						
Improved practice	102	78	220	187	259	379	0.69	11250	1912	1.17
Farmers' practice	65	45	120	127	156	266	0.41	10840	-2967	0.73

BEY: Blackgram equivalent yield

1.1.2 ANANTAPURAMU

a. Agro-ecological setting

Anantapuramu is in Rayalaseema - Karnataka plateau (AESR 3). The climate is hot arid. Annual potential evapo-transpiration is 641 mm. Annual average rainfall is 615 mm. Length of growing period is 90-120 days. The predominant soils are shallow red soils.

b. On-station experiments

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was delayed by 2 days (7th June). A total rainfall of 720.4 mm was received which was excess by 150.4 mm (26.4%) compared to normal (570 mm). Out of total rainfall, 497 mm was received in *kharif* season which was 145 mm excess (41.2%) than normal of 352 mm. In *rabi*, it was 214.4 mm and was excess by 70.4 mm (48.9%) than normal of 144 mm and in summer season, 9.0 mm rainfall was received which was deficit by 62.5 mm (87.4%) than normal of 71.5 mm (Fig.7).

Normal onset of monsoon	:	1-5 June
Onset of monsoon during 2017	:	7 June
Annual mean rainfall	:	570 mm
Annual rainfall during 2017-18	:	720.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	352 & 144 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	497 & 214.4, respectively

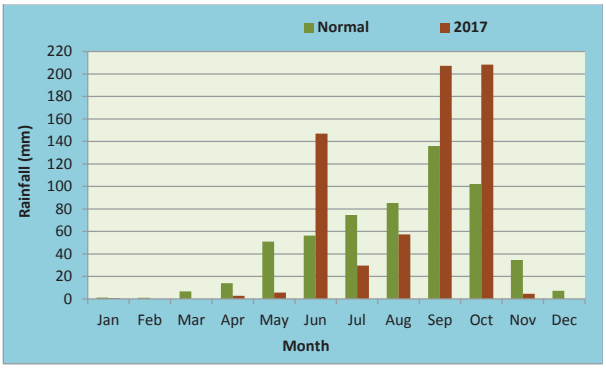


Fig.7: Normal and actual (2017) monthly rainfall at Anantapuramu

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
20	22 June - 11 July	Groundnut Pigeonpea, castor	Vegetative to flowering Vegetative
10	1 - 10 August	Groundnut Pigeonpea, castor	Flowering to pegging Vegetative
20	17 October - 5 November	Pigeonpea Castor	Vegetative to flower initiation Flowering to spike development
56	7 November - 31 December	Pigeonpea Castor	Flowering to pod development Capsule development to seed filling

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Groundnut	-	Sowing of drought tolerant groundnut varieties Dharani, K – 9 and K-6
	Pigeonpea	-	Sowing of high yielding pigeonpea variety-PRG-176
	Castor	-	Sowing of castor drought tolerant varieties (Haritha and PCH-111)
Mid season drought	Groundnut	Flowering	Supplemental irrigation (10 mm) with farm pond water at 30 DAS
	Castor	Vegetative	Supplemental irrigation (10 mm) with farm pond water at 30 DAS
	Groundnut, pigeonpea and castor	Vegetative	Mulching with groundnut shell and pigeonpea stalk

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed sowing

During *kharif* 2017, there was no delay in onset of monsoon. However, on receipt of rainfall during August, contingent crops were sown on 24-8-17. Among different contingent crops, foxtail millet recorded higher yield (1468 kg/ha), net returns (Rs.20413/ha), B:C ratio (3.91) and RWUE (3.22 kg/ha-mm) closely followed by horsegram with seed yield of 768 kg/ha, net returns of Rs.20078/ha and B:C ratio of 3.68 (Table 20).

Table 20: Yield and economics of contingent crops sown in the month of August

Crop	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Green gram	472	1.03	6694	1.60
Foxtail millet	1468	3.22	20413	3.91
Sorghum	826	1.81	8825	1.85
Cowpea	168	0.37	-3501	0.74
Pearl millet	844	1.85	7493	1.65
Horsegram	768	1.68	20078	3.68
Little millet	256	0.56	232	1.03
Fieldbean	395	0.87	3330	1.25
Castor	182	0.40	-7320	0.52
Pigeonpea	80	0.18	-8006	0.28

Foxtail millet

Horsegram

Situation: Early season drought

During *kharif* 2017, there was a dry spell of 20 days from 22 June to 11 July coinciding with vegetative to flowering stage in groundnut and vegetative stage in castor and pigeonpea. Due to application of groundnut shell mulch (15 t/ha) at 20 DAS, the yield in groundnut, castor and pigeonpea crops were increased by 11.8, 16.9 and 16.8%, respectively when compared to without mulch. Among these crops, groundnut crop recorded higher pod yield (1845 kg/ha), RWUE (3.92 kg /ha-mm), net returns (Rs.55037/ha) and B:C ratio (2.95) (Table 21).

Table 21: Yield and economics of crops as influenced by groundnut shell mulch

Crop / variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With groundnut shell mulch	Without mulch				
Groundnut (Dharani)	1845	1650	11.8	3.92	55037	2.95
Castor (Haritha)	650	556	16.9	1.37	6354	1.32
Pigeonpea (PRG-176)	292	250	16.8	0.62	-3346	0.77

Mulching with pigeonpea stalk (15 t/ha) in castor and pigeonpea at 20 DAS increased yields by 12.4 and 12.0%, respectively compared to without mulch. Among these crops, castor recorded higher RWUE (1.32 kg/ha-mm), net returns (Rs.5354/ha) and B:C ratio (1.27) with pigeonpea stalk mulching (Table 22).

Table 22: Yield and economics of crops as influenced by pigeonpea stalk mulch

Crop /variety	Seed yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With mulch	Without mulch				
Castor (Haritha)	625	556	12.4	1.32	5354	1.27
Pigeonpea (PRG-176)	280	250	12.0	0.59	-3906	0.73

Situation: Mid season drought

A dry spell of 10 days occurred during flowering stage of groundnut. Supplemental irrigation (10 mm) was given to the groundnut at flowering stage with harvested rainwater in farm pond. Supplemental irrigation improved the pod yield by 18.1, 16.0 and 14.6% in K-6, K-9 and Dharani varieties of groundnut, respectively compared to control. Among varieties, higher net returns (Rs 45915/ha) and B:C ratio (2.78) were recorded in K-6 with supplemental irrigation (Table 23).

Table 23: Performance of groundnut varieties under supplemental irrigation

Crop	Variety	Pod yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With irrigation	Without irrigation				
Groundnut	K-6	1620	1372	18.1	3.37	45915	2.78
	K-9	1598	1378	16.0	3.33	45883	2.76
	Dharani	1612	1406	14.6	3.36	45895	2.77

Since there was a short dry spell of only 10 days in August, no significant differences were found in groundnut pod yields among the treatments except for foliar spray after relieving of stress/dry spell (with favorable soil moisture) over foliar spray during dry spell in groundnut. However, foliar spray after relieving of stress/dry spell with water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient recorded higher groundnut pod yield (2466 kg/ha). However, regarding haulm yields, significant differences observed among the treatments (Table 24).

Table 24: Performance of groundnut (cv: Dharani) as influenced by different foliar sprays

Treatmen	Pod yield (kg/ha)	Haulm yield (kg/ha)	Shelling (%)
Main plots			
M1: Foliar spray during dry spell	2385	3241	79.3
M2: Foliar spray after relieving of stress	2451	3256	80.1
CD at 5%	62.42	15.55	7.65
Sub plots			
T1: Urea @ 1%	2402	3185	77.8
T2: Urea @ 2%	2425	3245	79.6
T3: Water soluble complex fertilizer (19:19:19) @ 0.5%	2452	3334	80.8
T4: Water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient	2466	3266	82.2
T5: Recommended dose of micronutrient for foliar spray	2417	3274	79.5
T6: Water spray	2388	3271	78.9
T7: Control (no spray of any material/water)	2376	3164	78.9
CD at 5%	NS	76.00	NS

Recommended fertilizer dose: 20:40:40 N: P_2O_5: K_2O/ha

Foliar spray in groundnut

Preparedness

Rainwater management

Higher groundnut equivalent yield (2823 kg/ha) and net returns (Rs. 81239/ha) were recorded with groundnut + pigeonpea intercropping system (8:1) with one supplemental irrigation (20 mm) to groundnut at flowering stage (40 DAS) through micro sprinklers and two irrigations (20 mm each) given to pigeonpea at flowering and pod filling stages through furrow method (Table 25).

Table 25: Yield and economics of groundnut + pigeonpea intercropping system (8:1) as influenced by supplemental irrigation

Treatment	Ground nut pod yield (kg/ha)	Pigeonpea seed yield (kg/ha)	GEY (kg/ha)	Net returns (Rs./ha)
T1: Sole groundnut	2224	-	2224	68660
T2: Groundnut + pigeonpea (8:1)	1512	549	2034	53055
T3: Groundnut + pigeonpea (15:1)	1635	382	1998	54746
T4: Sole groundnut two irrigations (sprinkler) of each 20 mm at flowering & pod filling stage	2384	-	2384	70025
T5: Groundnut + pigeonpea (8:1) two irrigations of each 20 mm at flowering & pod filling in groundnut (sprinkler) and pigeonpea (furrow)	1795	1082	2823	81329
T6: Groundnut + pigeonpea (8:1) two irrigations of each 20 mm at flowering & pod filling in groundnut (sprinkler) and pigeonpea (drip)	1788	973	2712	77284
T7: Groundnut + pigeonpea (15:1) two irrigations of each 20 mm at flowering & pod filling in groundnut (sprinkler) and pigeonpea (furrow)	1900	785	2646	77265
T8: Groundnut + pigeonpea (15:1) two irrigations of each 20 mm at flowering & pod filling in groundnut (sprinkler) and pigeonpea (drip)	1892	654	2513	72232

GEY: Groundnut equivalent yield

Farm pond with harvested rainwater

Supplemental irrigation (micro srinklers) in groundnut

Drip irrigation in pigeonpea

c. On-farm demonstrations

Village profile

The programis being implemented in Vannedoddi village in Gooty Mandal, Ananthapuramu district, Andhra Pradesh. The total geographical area of the village is 810 ha. Predominant rainfed crops in this village are groundnut, pigeonpea, castor, setaria, cotton and sorghum. Groundnut crop covered 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 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 2017-18

During 2017, in Vannedoddipally village, onset of monsoon was timely (7th June) and total rainfall received was 657 mm which was excess by 39 mm than normal rainfall of 618 mm. Out of the total annual rainfall received, *kharif* season recorded 351.7 mm (18.2% deficit than normal of 430 mm) and in *rabi* 287.3 rainfall was recorded against normal rainfall of 133 mm and summer rainfall was 18 mm over normal rainfall of 53 mm (Fig.8).

Normal onset of monsoon	:	7-8 June
Onset of monsoon during 2017	:	7 June
Annual mean rainfall	:	618 mm
Annual rainfall during 2017-18	:	657 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	430 and 133 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	351.7 and 287.3 mm, respectively

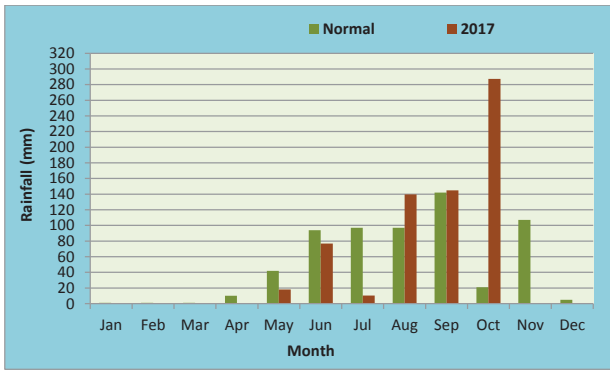


Fig.8: Normal and actual (2017) monthly rainfall at Vannedoddipally

Dry spells during crop growing season (2017-18)

Dry spell		Crop / stage of the crop			
Duration (days)	Dates & months	Groundnut	Pigeonpea	Foxtail millet	Pearlmillet
21	19 June to 9 July 2017	Seedling emergence	Seedling emergence	Seedling emergence	Seedling emergence
16	20 July to 4 August 2017	Vegetative stage	Vegetative stage	Vegetative stage	Vegetative stage
13	13 to 25 August 2017	Pegging & pod initiation	Vegetative	Flowering	Flowering
11	9 to 19 September 2017	Pod development	Vegetative	Grain filling & maturity	Grain filling & maturity
-	13 October 2017 onwards no rainfall	Pod development & maturity	Flowering to harvest		

Real time Contingency practices (RTCP) implemented

Weather aberration	Farming situation/ Soil type	Crop	RTCP implemented
Early season drought	Rainfed, alfisols	Groundnut, pigeonpea	Supplemental irrigation
Mid season drought	Rainfed, alfisols	Groundnut, pigeonpea	Supplemental irrigation
Terminal drought	Rainfed, alfisols	Groundnut, pigeonpea	Supplemental irrigation
	Rainfed, alfisols	Groundnut	Foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed Sowing

Although onset of monsoon was not delayed at Vannedoddipally village, due to very low rain during July, the sowings were done in first fortnight of August. No rainfall was received during November and December, 2017 and the crops encountered prolonged dry spell until maturity. Under delayed sowing conditions, groundnut variety Western-44 recorded highest net returns (Rs.48317/ha) with B:C ratio of 2.68 compared to other crops. However, cultivation of pearlmillet (local) + pigeonpea (Aiswarya) intercropping (1:1) recorded higher B:C ratio of 3.15 (Table 26).

Table 26: Performance of different crops under delayed sowing

Farming situation/ Soil type	Crop/ variety	Duration (days)	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Rainfed, alfisols	Foxtail millet (SiA- 3085)	103	500	6500	2.30
Rainfed, alfisols	Groundnut (Dharani)	110-115	875	11831	1.41
Rainfed, alfisols	Pigeonpea (Aiswarya)	155	263	4675	1.49
Rainfed, alfisols	Groundnut (Western 44)	110-115	1667	48317	2.68
Rainfed, alfisols	Pearlmillet (local) + pigeonpea (Aiswarya) (1:1)	90 155	937 312	29062	3.15

Contingency crops: Foxtail millet and pearlmillet

Situation: Early season drought

Opening of conservation furrows adjacent to every pigeonpea row for *in-situ* moisture conservation recorded 15.5% higher seed yield (268 kg/ha), net returns (Rs.3945/ha) and B:C ratio (1.38) compared to without conservation furrow (232 kg/ha).

Among the intercropping systems, highest PEY (1453 kg/ha) was recorded with groundnut + pigeonpea (11:1) intercropping system, with higher net returns of Rs. 35215/ha and RWUE of 2.42 kg/ha-mm. However, pearlmillet + pigeonpea (1:1) intercropping system recorded highest B:C ratio of 2.97 (Table 27).

***In-situ* moisture conservation through conservation furrows in pigeonpea**

Table 27: Yield and economics of different intercropping systems as influenced by *in-situ* moisture conservation

Farming situation/ Soil type	Cropping system	Intervention	Yield (kg/ha)		MCEY	Cost of cultivation (Rs/ ha)	Net returns (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)
			Main crop	Inter-crop					
Rainfed alfisols	Foxtail millet + pigeonpea (5:1)	With conservation furrows	625	275	1368	12500	16726	2.33	1.02
		without conservation furrows	571	229	1189	11500	14336	2.24	0.89
	Pearlmillet + pigeonpea (1:1)	With conservation furrows	792	278	1392	12500	24688	2.97	1.26
		Without conservation furrows	713	247	1246	11500	22359	2.94	1.13
	Groundnut + pigeonpea (11:1)	With conservation furrows	1263	150	1453	29750	35215	2.12	2.42
		Without conservation furrows	1113	133	1282	28750	29853	2.03	2.13

Supplemental irrigation (10 mm depth) in groundnut and castor from harvested rainwater in farm pond gave 13% higher pod yield of groundnut (1895 kg/ha) while castor seed yield was increased by 13.8 and 12.9% in Haritha and PCH-111 varieties, respectively compared to no irrigation. Among dryland crops, groundnut realized higher net returns (Rs.58,038/ha) and BC ratio (3.24) with supplemental irrigation (Table 28).

Table 28: Performance of dryland crops under supplemental irrigation

Crop	Variety	Pod/seed yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With irrigation	Without irrigation				
Groundnut	Dharani	1895	1672	13.3	3.95	58038	3.24
Castor	Haritha	788	692	13.8	1.62	13374	1.74
	PCH-111	716	634	12.9	1.48	10494	1.58

Caster cv. PCH-111 Caster cv. Haritha

Preparedness

Rainwater management

Deep ploughing with chisel plough after receiving pre-monsoon showers during the month of May recorded higher pod and haulm yield of groundnut (1611 and 3175 kg/ha), net returns (Rs.43567/ha), B:C ratio (2.39) and RWUE of 3.16 kg/ha-mm compared to the farmers' practice (1371 and 3015 kg/ha) (Table 29).

***In-situ* moisture conservation by deep ploughing with chisel plough**

Table 29: Effect of *in-situ* moisture conservation through deep tillage with chisel plough in groundnut

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Pod	Haulm				
Rainfed alfisols	Deep tillage with chisel plough	1611	3175	31250	43567	2.39	3.16
	without deep tillage	1371	3015	28750	35547	2.24	2.69

Energy management

Sowing of groundnut with bullock drawn Ananta planter recorded higher pod yield of 1667 kg/ha compared to the farmer's practice (1535 kg/ha), with higher net returns (Rs.48793/ha), B:C ratio (2.74) and RWUE of 3.39 kg/ha-mm (Table 30).

Table 30: Effect of sowing methods on groundnut yield and economics

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Pod	Stalk				
Rainfed alfisols	Bullock drawn Ananta planter	1667	2973	28000	48793	2.74	3.39
	Bullock drawn local seed drill	1535	2691	28750	41869	2.45	3.12

1.1.3 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 2017-18

During 2017, the onset of monsoon was on time (2nd June) in Agra. An annual rainfall of 346.2 mm was received which was deficit by 322 mm (48.4%) than normal (665 mm). During *kharif*, there was a rainfall of 246.3 mm, deficit by 342.8 mm (58.3%) than normal (589.1 mm) and in *rabi* season, 1.2 mm rainfall was recorded which was deficit by 57.2 mm (99%) against normal of 58.4 mm. (Fig.9)

Normal onset of monsoon	:	2 July
Onset of monsoon during 2017	:	2 July
Annual mean rainfall (mm)	:	665.0 mm
Annual mean rainfall received during 2017-18	:	346.2 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	:	589.1 & 58.4 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* & *rabi*)	:	246.3 &1.2 mm, respectively

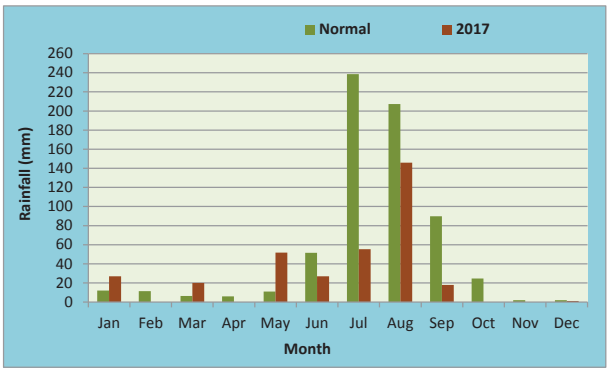


Fig.9: Normal and actual (2017) monthly rainfall at Agra

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	10-21 August	Pearlmillet	Panicle initiation
		Clusterbean, sesame	Vegetative
11	12-22 September	Pearlmillet	Flag leaf /ear emergence
		Clusterbean	Flowering
		Sesame	Early bloom
27	27 September - 23 October	Pearlmillet, clusterbean, sesame	Flowering to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Pearlmillet	Ear emergence to maturity	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

During *kharif* 2017, a dry spell of 27 days occurred due to early withdrawal of monsoon. Foliar spray during dry spell significantly enhanced grain yield of pearlmillet (1177 kg/ha) as compared to foliar spray after relieving of stress/dry spell (999 kg/ha). Foliar spray of water soluble complex fertilizer (19:19:19 NPK) @ 0.5% + recommended dose of micronutrient for foliar spray produced significantly higher grain yield (1465 kg/ha) with higher net returns (Rs 13436/ha), B:C ratio (1.81) and RWUE (8.93 kg/ha-mm) as compared to all other treatments (Table 31).

Table 31: Effect of foliar spray on pearlmillet yield and economics

Treatment	Yield (kg/ha)		RWUE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Stover				
Main plot						
Foliar spray during dry spell	1177	4692	7.18	16324	7485	1.46
Foliar spray after relieving of stress	999	3871	6.09	16040	4004	1.25
CD at 5%	163	696	--	-	-	-
Sub plot						
Urea @ 1.0 %	962	3787	5.87	16082	3308	1.21
Urea @ 2.0 %	1167	4439	7.11	16160	7122	1.44
Water soluble complex fertilizer (19:19:19 NPK) @ 0.5%	1246	5052	7.60	16274	9057	1.56
Water soluble complex fertilizer (19:19:19 NPK) @ 0.5% + recommended dose of micro-nutrient for foliar spray	1465	6124	8.93	16624	13436	1.81
Recommended dose of micronutrient for foliar spray	1162	4612	7.08	16379	7091	1.43
Water spray	905	3374	5.52	16004	1952	1.12
Control	710	2583	4.33	15749	-1752	0.89
CD at 5%	205	776	--	-	-	-

Preparedness

Rainwater management

In-situ moisture conservation with summer ploughing by MB plough followed by sowing with ridger seeder in pearlmillet produced 69% higher grain yield (1090 kg/ha) as compared to conventional tillage with broadcasting (854 kg/ha), higher net returns of Rs.23028/ha, B:C ratio (2.33) and RWUE (12.22 kg/ha-mm) (Table 32**)**.

Table 32: Effect of tillage and sowing implements on yield and economics of pearlmillet

Treatment	Grain yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	2017	Mean (6 yrs)				
Conventional tillage + broadcasting	854	1588	6.91	16241	8770	1.53
Conventional tillage + ridger seeder	920	2034	8.74	16502	15525	1.91
Summer tillage (MB plough) + broadcasting	1074	1928	8.83	16617	14097	1.83
Summer tillage (MB plough) + ridger seeder	1090	2682	12.22	16774	23028	2.33

Summer ploughing with MB plough

Sowing by ridger seeder

Pearlmillet on ridges

Cropping systems

Among pearlmillet hybrids, Pro-Agro-9450 gave higher grain yield of 1092 kg/ha compared to 86-M-88 (1037 kg/ha) and JKBH-26 (980 kg/ha), with higher net returns of Rs 3968/ha and B:C ratio of 1.25 and RWUE (1.25 kg/ha-mm) (Table 33).

Table 33: Performance of pearlmillet hybrids

Hybrid	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Stover				
Pro-agro 9450	1092	2904	6.66	15949	3968	1.25
86-M-88	1037	2452	6.32	15949	2506	1.16
JKBH-26	980	2156	5.97	15949	1250	1.08

Cluster bean variety RGC- 1055 produced 8% higher seed yield (455 kg/ha) than RGC-1017 (420 kg/ha) with higher net returns (Rs. 1590/ha), B:C ratio (1.11) and RWUE (2.77 kg/ha-mm) (Table 34). Among two varieties of sesame, higher seed yield (348 kg/ha), net returns (Rs.8804/ha) and B:C ratio (1.64) were recorded with var. Shekhar compared to var. HT-1 (310 kg/ha).

Table 34: Performance of improved varieties of cluster bean

Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk				
RGC-1055	455	1547	2.77	14562	1590	1.11
RGC-1017	420	1369	2.56	14562	348	1.02

Among different crops and strip cropping systems, the highest pearlmillet equivalent yield (PMEY) of 2061 kg/ha was recorded with sesame (sole), with higher net returns of Rs. 8804/ha and B:C ratio of 1.64, followed by strip cropping of pearlmillet + sesame (4:4) with net returns of Rs 6214/ha and B:C ratio of 1.42 (Table 35).

Table 35: Performance of different crops and cropping systems

Crop/variety	Yield (kg/ha)		Pearlmillet equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	BC ratio
	Grain	Stover				
Pearlmillet (sole) (Pro-agro 9450)	1092	2904	1092	15949	3968	1.25
Cluster bean (sole) (RGC-1055)	455	1547	1133	14562	1590	1.11
Sesame (sole) (Shekhar)	348	1392	2061	13659	8804	1.64
Pearlmillet + cluster bean (4:4)	575+242	1581+748	1178	15255	3901	1.25
Pearlmillet + sesame (4:4)	590+195	1600+805	1475	14804	6214	1.42

c. On-farm demonstrations

Village profile

Nagla Dulhe Khan is situated in the South-western part of Agra district and lies between $26^0$55’ to 26^0 56’ North latitude and 77^0 40’30” to 77^0 42’30” East longitude. It is 60 km away from Agra city. The soil of the village varied from sandy loam to loamy sand in texture. The bulk density and particle density varies from1.42 to1.50 gm/cm^3 and 2.40 to 2.71 gm/cm^3 respectively. The field capacity and wilting point on volume basis are 15 to 21 and 4.0 to 8.0 per cent, respectively. The soils are low in availability of nitrogen, potash and medium in availability of phosphorus. Soil and ground water are saline in alkaline in nature.

Experienced weather conditions during 2017-18

During *kharif* 2017, the onset of monsoon was on time (3rd July). An annual rainfall of 365.8.mm was received, which was deficit by 45% as compared to normal annual rainfall (665 mm). During south-west monsoon (*kharif*), rainfall of 257.4 mm was received, which was 56.3% less than normal rainfall (589 mm). The rainfall recorded in June, July, August and September was 37, 66, 129 and 25 mm which was 28, 72, 38 and 72% less as compare to normal values of respective months. Three long dry spells were observed during the year 2017. (Fig.10)

Normal onset of monsoon	:	2 July
Onset of monsoon during 2017	:	3 July
Annual mean rainfall	:	664.5 mm
Annual rainfall during 2017-18	:	365.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	589.1 & 58.4 mm
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	257.4 mm

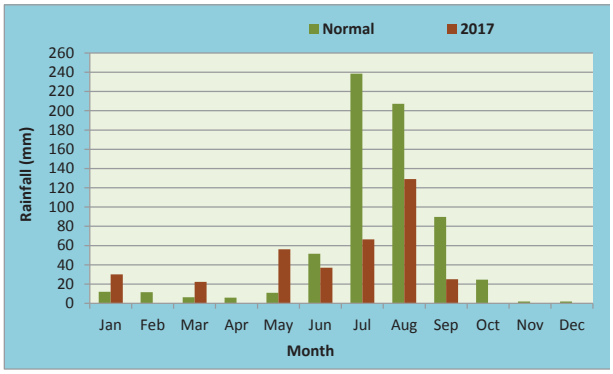


Fig.10: Normal and actual (2017) monthly rainfall at Nagla Dulhe Khan

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
16	23 July - 7 August	Pearlmillet, clusterbean, sesame	Tillering/ Branching Stage
15	8 - 22 September	Pearlmillet, clusterbean, sesame	Ear formation/flowering
15	25 September to maturity	Pearlmillet, clusterbean, sesame	Seed/grain filling, maturity

Real time contingency practices (RTCP) implemented: Nil

Salient achievements of on-farm demonstrations

Real time contingency planning: Nil

Preparedness

Rainwater management

In-situ moisture conservation with summer ploughing by MB plough and sowing by ridger seeder in pearlmillet produced 33.1% higher grain yield (2302 kg/ha) as compared to conventional tillage + broadcasting (1729 kg/ha), with higher net returns (Rs.22036/ha), B:C ratio (2.40) and RWUE (6.65 kg/ha-mm) as compared to conventional tillage + broadcasting (Table 36).

Table 36: Response of pearlmillet (Pro-agro 9450) to *in-situ* moisture conservation

Farming situation	Treatment	Grain yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2017	Mean (7 years)				
Medium deep alluvial soil	Ridger seeder	2000	2302	15902	22036	2.40	6.65
	Farmers' practice	1380	1729	14787	13784	1.95	4.94

Pearlmillet under ridge sowing

Pearlmillet under farmers' practice (broadcasting)

In-situ moisture conservation through compartmental bunding gave higher grain yield of pearlmillet (2019 kg/ha) compared to farmers' practice (1459 kg/ha), with higher net returns (Rs.19435/ha), B:C ratio (2.24) and RWUE (6.35 kg/ha-mm) (Table 37).

Table 37: Performance of pearlmillet under compartmental bunding

Farming situation	Treatment	Grain yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2017	Mean (7 years)				
Medium deep alluvial soil	Compartmental bunding	2019	2149	15890	19435	2.24	6.35
	Farmers' practice	1459	1652	14646	12829	1.61	5.08

Cropping systems

Pearlmillet hybrid Pro-agro-9450 gave higher mean grain yield (1869 kg/ha) as compared to JKBH-26 (1699 kg/ha), with higher net returns of Rs. 16768/ha and B:C ratio 1.88 (Table 38).

Table 38: Performance of pearlmillet varieties under normal onset of monsoon and terminal drought

Farming situation	Variety	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Medium deep alluvial soil	Pro-agro- 9450	1869	9.73	19122	16768	1.88
	JKBH-26	1699	8.85	19122	12695	1.66

Sesame variety Shekhar gave higher seed yield of 271 kg/ha as compared to HT-01 (245 kg/ha), with net return of Rs. 2446/ha and B:C ratio 1.16 (Table 39).

Table 39: Performance of sesame varieties under normal onset of monsoon and terminal drought

Farming situation	Variety	Yield (kg/ha)	RWUE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Medium deep alluvial soil	Shekhar	271	1.41	15069	2446	1.16
	HT-01	245	1.28	15069	746	1.05

The maximum mean pearlmillet equivalent yield of 2823 kg/ha was recorded with pearlmillet + cluster bean strip cropping system (4:4), than pearlmillet sole (1318 kg/ha), with higher net returns of Rs.19818/ha and B:C ratio of 2.19 (Table 40).

Table 40: Performance of pearlmillet + cluster bean strip cropping system (4:4)

Farming situation	Crop	Grain/seed yield (kg/ha)		PEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		2017	Mean (7 yrs)				
Medium deep alluvial soil	Pearlmillet + clusterbean (4:4)	1851	1197+ 260	2823	14806	19818	2.19
	Pearlmillet sole	1318	1597	1318	14173	10746	1.49

Pearlmillet + cluster bean strip cropping (4:4)

Pearlmillet sole

Pearlmillet + sesame strip cropping system (4:4) gave higher pearlmillet equivalent yield (PEY) of 2996 kg/ha, net returns of Rs 24441/ha and B:C ratio of 2.79 compared to sole pearlmillet (1621 kg/ha) (Table 41).

Table 41: Performance of pearlmillet + sesame (4:4) strip cropping system

Farming situation	Treatment	PEY (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		2017	Mean (7 yrs)			
Medium deep alluvial soil	Pearlmillet + sesame	2996	1422	14159	24441	2.79
	Pearlmillet	1395	1621	14168	11469	1.85

Chickpea + mustard intercropping system (5:1) recorded 35.3% higher chickpea equivalent yield of 2500 kg/ha as compared to sole chickpea (1848 kg/ha) with higher net returns (Rs.87113/ha) and B:C ratio (5.87) (Table 42).

Table 42: Performance of chickpea + mustard (5:1) intercropping system

Farming situation	Treatment	Yield (kg/ha)	CEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Medium deep alluvial soil	Chickpea + mustard	1863+705	2500	17887	87113	5.87
	Chickpea	1848	1848	15646	61949	4.96

Mustard grown after sesbania green manuring gave 25.2% higher seed yield of 2190 kg/ha as compared to fallow-mustard sequence (1750 kg/ha), with higher net returns of Rs. 73202/ha and B:C ratio of 5.34 (Table 43).

Table 43: Performance of mustard with and without green manuring

Farming situation	Crop sequence	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Medium deep alluvial soil	Green manuring-mustard	2190	16849	73202	5.34
	Fallow –mustard	1750	16655	55087	4.31

Application of recommended dose of fertilizer (60+40 kg/ha N &P) with 50 kg K/ha in mustard gave 25.9% higher seed yield (2315 kg/ha) with net returns of Rs. 78638/ha and B:C ratio of 5.67 as compared to without K application (1810 kg/ha) (Table 44).

Table 44: Effect of potassium application on mustard yield and economics

Farming situation	Treatment	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Medium deep alluvial soil	RDF +50 kg K_2O/ha	2315	78638	5.67
	RDF (without K_2O)	1810	57636	4.46

1.1.4 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 (*AESR2.3)* and South-western dry zone in Haryana. The climate is hot arid. Annual rainfall is 411mm. Annual potential evapotranspiration is 769 mm.

b. On-station experiments

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was normal (29 June) and an annual rainfall of 482 mm was received which was excess by 70 mm (16.9%) compared to normal (412 mm) (Fig.11). During *kharif*, 461 mm rainfall was received which was excess by 125.2 mm (37.3%) than normal of (335.8 mm). In *rabi*, 21 mm rainfall was received which was 11.8 mm excess than normal (9.2 mm).

Normal onset of monsoon	:	1st week of July
Onset of monsoon during 2017	:	29 June
Annual mean rainfall	:	412 mm
Annual rainfall during 2017-18	:	482 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	335.8 (*kharif*) and 9.2 mm (*rabi*)
Crop seasonal rainfall during 2017-18 (*kharif* & *rabi*)	:	461 mm (*kharif*) and 21 mm (*rabi*)

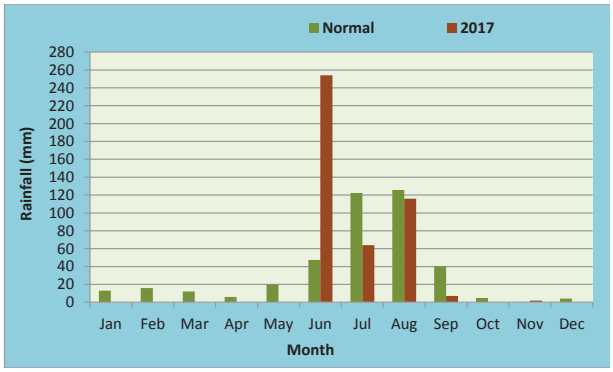


Fig.11: Normal and actual (2017) monthly rainfall at Hisar

Dry spells during crop growing season (2017-18)

Dry spells		Crop	Stages of the crop
Duration (days)	Dates & months		
38	8 September to 15 October	pearlmillet	Grain filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought	Pearlmillet	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

A dry spell of 38 days occurred coinciding with grain filling and maturity stage of crops. Foliar spray during dry spell and after relieving the stress/ dry spell did not show any significant improvement in both grain and stover yields of pearlmillet. Among foliar spray treatments, foliar spray of water soluble complex fertilizer (18:18:18) @ 0.5% + recommended dose of micronutrient for foliar spray (0.5% zinc) recorded higher grain yield (1295 kg/ ha) and net returns (Rs 5700/ha) compared to other treatments (Table 45).

Table 45: Effect of treatments on yield and economics of pearlmillet

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Main plot						
Foliar spray during dry spell	1240	2959	16250	5363	1.34	7.01
Foliar spray after relieving the stress	1267	2953	16250	5197	1.32	7.16
CD at 5%	NS	NS	-	-	-	-
Sub plot						
Urea @ 1%	1247	2948	16286	5220	1.33	6.93
Urea @ 2%	1265	2983	16341	5438	1.34	6.98
Water soluble complex fertilizer (18:18:18) @ 0.5%	1261	2932	16326	5301	1.33	6.88
Water soluble complex fertilizer (18:18:18) @ 0.5% + recommended dose of micronutrient for foliar spray (0.5% zinc)	1295	2944	16441	5700	1.36	7.12
Recommended dose of micronutrient for foliar spray (0.5% Zinc)	1273	2970	16346	5361	1.34	7.29
Water spray	1234	2980	16231	5104	1.36	7.10
Control	1202	2937	15781	4838	1.32	6.75
CD at 5%	35.1	NS				

Preparedness

Among peralmillet hybrids, recently developed hybrid HHB 272 recorded highest grain yield (3378 kg/ha) followed by HHB-197 (3210 kg/ha) and HHB-226 (3022 kg/ha). Among four clusterbean varieties, HG 2-20 recorded highest seed yield (710 kg/ha) followed by HG 870 (675 kg/ha), HG-563 (660 kg/ha) and HG-365 (632 kg/ha). Overall performance of the crop was poor due to less rainfall in the month of July and during maturity. Greengram variety MH-421 recorded the highest seed yield (902 kg/ha) followed by MH 318 (846 kg/ha), Basanti (775 kg/ha) and Sattya (756 kg/ha). Sesame variety, HT 2 and sunhemp variety, PAU 1691 also recorded 413 and 1289 kg/ha seed yield, respectively (Table 46).

Title 46: Performance of improved varieties/hybrids of different crops

Crop	Variety/ hybrid	Yield (kg/ha)	RWUE (kg/ha- mm)	Net returns (Rs/ha)	B:C ratio
Pearlmillet	HHB-67 (Improved)	2533	14.07	16795	1.87
	HHB 197	3210	17.83	26443	2.37
	HHB 226	3022	16.78	23764	2.23
	HHB 272	3378	18.76	28837	2.49
	HC 10	2244	12.47	12677	1.66
	HC 20	2222	12.34	12364	1.64
Clusterbean	HG 365	632	2.51	3052	1.15
	HG 563	660	2.66	4060	1.21
	HG 870	675	2.75	4600	1.23
	HG 2-20	710	2.94	5860	1.30
Greengram	Sattya	756	4.20	22547	2.15
	Basanti	775	4.30	23606	2.20
	MH 421	902	5.00	30687	2.57
	MH 318	846	4.70	27565	2.41
Sesame	HT 2	413	2.29	3089	1.16
Sunhemp	PAU 1691	1289	7.16	-	-

c. On-farm demonstrations

Village profile

The program is being implemented in Balawas village, Hisar Tehsil, Hisar district, 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.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is arid. The south-west monsoon contributes 85-90%, The historical (30 years) rainfall data indicated the variability in rainfall during south-west monsoon and 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 during 2017-18

The onset of monsoon was normal (29th June). An annual rainfall of 435.1 mm was received which was excess by 135.1 mm (45%) compared to normal (300 mm) (Fig.12). During *kharif*, 396.8 mm rainfall was received which was excess by 186.1 mm (88.3%) than the normal (210.7 mm); *rabi*

season recorded 38.3 mm rainfall as against normal of 22 mm.

Normal onset of monsoon	:	1st week of July
Onset of monsoon during 2017	:	29 June
Normal annual mean rainfall	:	300 mm
Actual annual rainfall during 2017-18	:	435.1 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	:	210.7 and 22 mm, respectively
Crop seasonal rainfall during 2017-18 *(kharif* and *rabi)*	:	396.8 and 38.3 mm, respectively

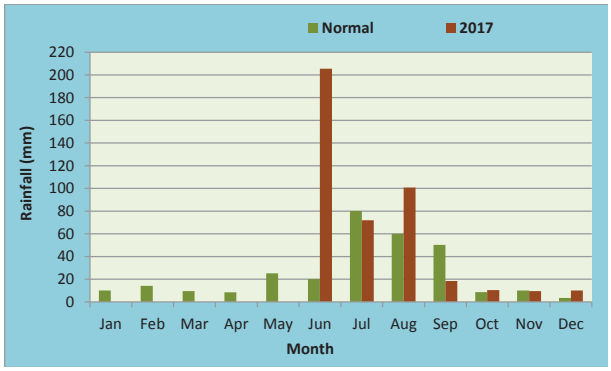


Fig.12: Normal and actual (2017) monthly rainfall at Balawas

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
17	22 July to 8 August	Pearlmillet, clusterbean, greengram	Vegetative
32	4 September to 6 October		Grain filling and maturity

Real time contingency practices (RTCP) implemented (2017-18): Nil

Salient achievements of on-farm demonstrations

Real time contingency planning: Nil

Preparedness

Cropping systems

Weeding/interculture using improved implement (wheel hand hoe) resulted in higher seed yield of mustard (1710 kg/ha) and chickpea (740 kg/ha) when compared to weeding with *Kasola* (a traditional implement) which resulted in low yields (1585 and 620 kg/ha in mustard and chickpea, respectively. Similarly, the net returns, B:C ratio and RWUE were also improved with wheel hand hoe over *kasola* (Table 47).

Table 47: Effect of weeding with wheel hand hoe on crop yield and economics

Crop	Intervention	Yield (kg/ha)	RWUE (kg/ha- mm)	Net returns (Rs/ha)	B:C
Mustard	Weeding/ interculture with wheel hand hoe	1710	61.5	48600	3.45
	Weeding/ interculture with *kasola*	1585	57.0	42600	3.05
Chickpea	Weeding/ interculture with wheel hand hoe	740	26.6	14060*	1.76
	Weeding/ interculture with *kasola*	620	22.3	7780	1.47

Adoption of recommended package of practices increased the yield of mustard and chickpea by13.3% and 19.7%, respectively with higher net returns (Rs.43400 and 16260/ha), B:C ratio (3.19 and 1.88) and RWUE of 56.83 and 28.41 kg/ha-mm, respectively compared to farmers' practice (Table 48).

Table 48: Effect of recommended package of practice crop yields and economics

Treatment	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Mustard (RH 30)				
Package of practice	1580	43400	3.19	56.83
Farmers' practice	1395	37000	2.96	50.17
Chickpea (HC 1)				
Package of practice	790	16260	1.88	28.41
Farmers' practice	660	10540	1.57	23.74

Among chickpea cultivars, HC-1 recorded 10.1% higher seed yield (815 kg/ha), net returns (Rs.17360/ha), B:C ratio (1.94) and RWUE (29.3 kg/ha-mm) compared to C-235 a long duration variety (Table). Among mustard varieties, RH 0406 4.3% higher seed yield (1690 kg/ha), net returns (Rs 48800/ha) B:C ratio (3.67) and RWUE (60.8 kg/ha-mm) compared to RH-30 (Table 49).

Table 49: Performance of improved varieties of chickpea and mustard

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Chickpea	HC-1	815	29.3	17360	1.94
	C-235	740	26.6	14060	1.76
Mustard	RH 0406	1690	60.8	47800	3.65
	RH-30	1620	58.3	45000	3.27

1.1.5 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 soil organic C and P, and high in K content. Deficient nutrients are sulphur, calcium and zinc.

b. On-station experiments

Experienced weather conditions during 2017-18

During 2017-18, the onset of south-west monsoon was delayed by 5 days and onset of north-east monsoon was delayed by 7 days. A rainfall of 790.9 mm was received which was excess by 68.3 mm compared to normal (722.6 mm). During *kharif* (June-September), 318.7 mm rainfall was received which was excess by 168.5 mm than normal of 150.2 mm; in *rabi* season (October-December), 412.5 mm rainfall was received which was excess by 21.5 mm than normal of 391 mm and during summer (March to May), 38.7 mm rainfall was received which was deficit by 102.2 mm than normal of 140.9 mm (Fig.13)

Normal onset of monsoon	:	1 June (South-west) 20 October (North-east)
Onset of monsoon during 2017	:	6 June (South-west) 27 October (North-east)
Annual mean rainfall	:	722.6 mm
Annual rainfall during 2017-18	:	790.9 mm
Mean crop seasonal rainfall	:	150.2 and 391 mm, during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	318.7 and 412.5 mm, during *kharif* and *rabi*, respectively

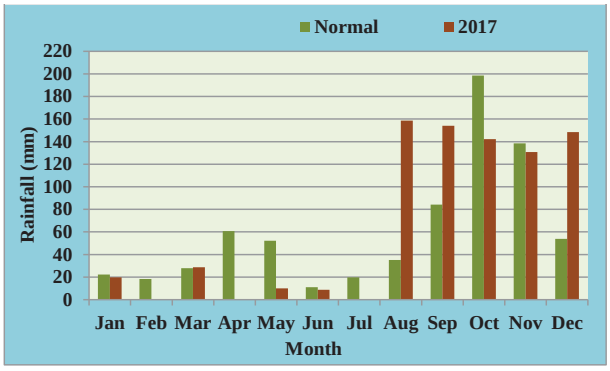


Fig.13: Normal and actual (2017) monthly rainfall at Kovilpatti

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
7	12-18 November	Pearlmillet, sorghum	Vegetative
21	10- 31 December	Pearlmillet	Flowering, maturity
		Sorghum	Flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Delayed onset of monsoon	Pearlmillet, sorghum	Improved varieties
Mid season drought	Sorghum	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

The onset of monsoon was delayed by 7 days. Short duration pearlmillet varieties were evaluated under different *in-situ* moisture conservation practices. Among the varieties, TNAU Cumbu hybrid Co 9 recorded significantly higher grain yield (2643 kg/ha), net returns (Rs.11859/ha), B:C ratio (1.43) and RWUE (6.27 kg/ha-mm) compared to other varieties and local check. Among the land configuration practices, both ridges and furrow and compartmental bunding recorded on par yield (2188 and 2074 kg/ha). However, ridges and furrow method recorded higher net returns (Rs 5944/ha) and B:C ratio (1.26) compared to compartmental bunding (Table 50).

Table 50: Evaluation of pearlmillet varieties under different moisture conservation practices

Treatment	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Variety					
Co(Cu)9	2450	8.7	5.81	9350	1.42
TNAU Cumbu hybrid Co9	2643	17.3	6.27	11859	1.53
Pioneer 86M86 (Check)	2253	-	5.35	6789	1.30
CD at 5%	280.0				
Land configuration					
Compartmental bunding	2074	5.2	4.92	4462	1.20
Ridges and furrow	2188	-	5.19	5944	1.26
CD at 5%	192.0				

Short duration (95 days) sorghum variety, K12 produced 51% higher grain yield (1435 kg/ha) over K 8 (950 kg/ha) and also recorded higher net returns (Rs.3300/ha), B:C ratio (1.15) and RWUE of 3.40 kg/ha-mm (Table). Similarly, among land configuration practices, ridges and furrow method recorded significantly higher grain yield (1350 kg/ha) compared to compartmental bunding (935 kg/ha) (Table 51).

Table 51: Evaluation of sorghum varieties under different moisture conservation practices

Treatment	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Variety					
K 8 (Check)	950	-	2.25	-5400	0.76
K 12	1435	51.1	3.40	3300	1.15
CD at 5%	125	-	-	-	-
Land configuration					
Compartmental bunding	935	-	2.21	-10170	0.62
Ridges and furrow	1350	10.9	3.20	-2700	0.90
CD at 5 %	107	-	-	-	-

Situation: Mid season drought

A dry spell of 21 days occurred during December, which coincided with the flowering stage of crops. Foliar spray in sorghum during dry spell recorded higher grain yield (1629 kg/ha), net returns (Rs.6822/ha), B:C ratio (1.30) and RWUE of 3.87 kg/ha-mm as compared to foliar spray after relieving of stress/dry spell (1427 kg/ha). Further, foliar spray of both water soluble complex fertilizer (19:19:19) @ 0.5% and water soluble complex fertilizer (19:19:.19) @ 0.5% + recommended dose of micronutrient for foliar spray were statistically on par with each other and recorded significantly higher yield (1686 and 1649 kg/ha) with higher net returns (Rs.7848 and 7182/ha), B:C ratio (1.35 and 1.32) and RWUE of 4.0 and 3.91 kg/ha-mm, respectively compared other treatments (Table 52).

Table 52: Effect of foliar sprays to cope with dry spells and higher productivity of rainfed sorghum (K12)

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Main plot (M)				
M_1-Foliar spray during dry spell	1629	3.87	6822	1.30
M_2-foliar spray after relieving of stress/dry spell (with favorable soil moisture)	1427	3.39	3186	1.14
CD at 5%	44.4			
Sub plot (F)				
T_1 - Foliar spray of 1% urea,	1305	3.10	990	1.04
T_2 - Foliar spray of 2% urea,	1392	3.30	2556	1.11
T_3 - Water soluble complex fertilizer (19.19.19) @ 0.5%	1686	4.00	7848	1.35
T_4 - T_3 + recommended dose of micronutrient for foliar spray	1649	3.91	7182	1.32
T_5 - Recommended dose of micronutrient for foliar spray	1590	3.77	6120	1.27
T_6 - Water spray	1485	3.52	4230	1.19
T_7 - Control	1150	3.78	6138	1.27
CD at 5%	50.0			
CD at 5% M × F	76.0			
CD at 5% F × M	70.7			

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. 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^{o}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 2017-18

During 2017, in Muthukrishnapuram village, onset of south-west monsoon was delayed by 6 days (6th June) and by 7 days (27th October) during north-east monsoon. An annual rainfall of 790.9 mm was received against the normal rainfall of 722.6 mm. During *kharif*, 318.7 mm of rainfall was received which was excess by 168.5 mm (112%) compared to normal (150.2 mm). During *rabi*, 412.5 mm rainfall was received which was excess by 21.6 mm (4%) compared to normal rainfall of 391 mm. During summer, 39.3 mm of rainfall was received which was deficit by 101.0 mm compared to normal of 140.9 mm (Fig.14).

Normal onset of monsoon	:	1 June (South-west) 20 October (North-east)
Onset of monsoon during 2017-18	:	6 June (South-west) 27 October (North-east)
Annual mean rainfall	:	722.6 mm
Annual mean rainfall during 2017-18	:	790.9 mm
Mean crop seasonal rainfall	:	150.2 and 391.0 mm during *kharif* & *rabi*, respectively
Crop seasonal rainfall during 2017 -18	:	318.7 and 412.5 mm *during kharif* & *rabi*, respectively

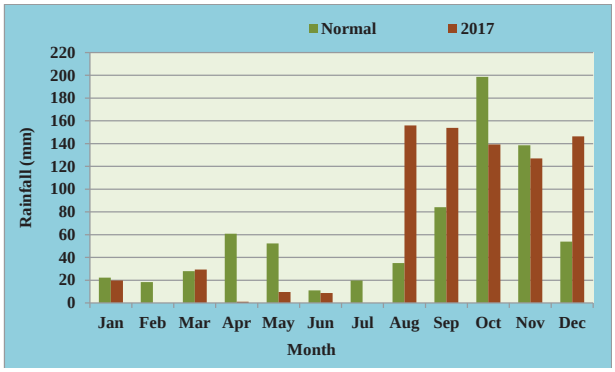


Fig. 14: Normal and actual (2017) monthly rainfall at Muthukrishnapuram

Dry spells during crop growing season (2017-18)

Dry spells		Crop	Stage of the crop
Duration (days)	Dates & months		
7	12-18 November	Pearlmillet, sorghum	Vegetative
21	10-31 December	Pearlmillet, sorghum	Flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of the crop	RTCP implemented
Delayed onset of monsoon	Pearlmillet	-	Improved varieties and moisture conservation practices
Mid season drought	Cotton	Flowering	Foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2017, the onset of monsoon was delayed by 6 days (6th June) and 7 days (27th October North-East monsoon). Soil moisture conservation practice of ridges and furrow method of sowing recorded 2.4% higher pearlmillet grain yield (2100 kg/ha), net returns (Rs.9000/ha), B:C ratio (1.40) and RWUE (5.37 kg/ha-mm) compared to farmers method of check basin method (2050 kg/ha) (Table 53).

Table 53: Effect of moisture conservation practices on the yield and economics of pearlmillet

Farming situation/ Soil type	Intervention	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep black soil	Ridges and furrow	2100	5.37	9000	1.40
	Check basin	2050	5.24	8786	1.36

Maize variety COH(M)7 recorded higher grain yield (2950 kg/ha), net returns (Rs 10850/ha) and B:C ratio (1.39) compared to COH(M)6 (2800 kg/ha). Among the land configuration treatments, ridges and furrow method recorded 6.7% higher maize grain yield (2975 kg/ha), net returns (Rs.11175/ha), B:C ratio (1.41) and RWUE (7.21 kg/ha-mm) compared to check basin method (2775 kg/ha) (Table 54).

Table 54: Effect of soil moisture conservation practices and varieties on yield of maize

Farming situation/ Soil type	Intervention	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep black soil	**Variety**					
	COH(M)6	2800	-	6.79	8900	1.32
	COH(M)7	2950	5.1	7.15	10850	1.39
	Land configuration					
	Ridges and furrow	2975	6.78	7.21	11175	1.41
	Check basin	2775	-	6.73	8575	1.31

Situation: Mid season drought

A dry spell of 21 days occurred coinciding with flowering stage of cotton. Foliar spray of both TNAU cotton plus and pink pigmented facultative methylotrophs (PPFM) were on par with each other and recorded significantly higher cotton yield (920 and 800 kg/ha) compared to control (650 kg/ha). However, higher net returns (Rs.8440/ha), B:C ratio (1.28) and RWUE (2.23 kg/ha-mm) were recorded with foliar spray of TNAU cotton plus compared to other treatments (Table 55).

Table 55: Effect of foliar spray on yield and economics of cotton (KC 3)

Farming situation/ Soil type	Treatment	Cotton yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep black soil	TNAU cotton plus (6.25 kg/ha)	920	29.0	2.23	8440	1.28
	PPFM spray (500 ml/ha)	800	19.0	1.94	3400	1.11
	Control	650				

PPFM: Pink pigmented facultative methylotrophs

Preparedness

Rainwater management

Among the cotton varieties, SVPR 4 recorded higher seed cotton yield (894 kg/ha), net returns (Rs.7730/ha) and B:C ratio (1.24) compared to SVPR 2 (835 kg/ha). Among the land configuration treatments, ridges and furrow method recorded 4.4% higher seed cotton yield (884 kg/ha) compared to check basin method (845 kg/ha) (Table 56).

Table 56: Effect of *in-situ* moisture conservation on yield and economics of cotton

Farming situation/ Soil type	Intervention	Seed cotton yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep black soil	**Variety**					
	SVPR 2	835	6.6	2.02	5075	1.16
	SVPR 4	894	-	2.16	7730	1.24
	Land configuration					
	Ridges and furrow	884	4.4	2.14	7280	1.22
	Check basin	845	-	2.05	5525	1.17

Cropping systems

Though the crops experienced terminal dry spell, all the cotton based intercropping systems recorded higher cotton equivalent yield, net return, LER and MAI over sole cotton. Cotton + blackgram (2:1) intercropping system recorded higher cotton equivalent yield (1120 kg/ha) while cotton + onion (2:1) recorded higher net returns (Rs.9925/ha) and B:C ratio (1.33) as compared to sole cotton with lowest net returns (Rs.6875/ha) (Table 57).

Table 57: Performance of cotton based intercropping systems

Farming situation/ Soil type	Intervention	Yield (kg/ha)		CEY (kg/ha)	LER	MAI	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Main crop	Inter crop						
Deep black soil	Sole cotton (KC3)	875	-	875	-	-	2.12	6875	1.21
	Cotton + clusterbean (2:1)	815	375	981	1.23	1388	1.98	7425	1.23
	Cotton + blackgram (2:1)	780	340	1120	1.11	743	1.89	7500	1.17
	Cotton + onion (2:1)	765	570	891	1.15	1295	1.85	9925	1.33

LER: Land equivalent ratio; CEY: Cotton equivalent yield; MAI: Monetary advantage index

1.1.6 RAJKOT

a. Agro-ecological setting

The centre is located 14 km North-East of Rajkot city (latitude of 20°17'N and longitude of 70°48'E and 137.7 meters above mean sea level). Annual rainfall is 648.8 mm. The climate is hot arid.

b. On-station experiments

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was delayed by 18 days (4th July). A rainfall of 1328.5 mm was received which was exceed by 679.7 mm compared to normal of 648.8 mm. During *kharif*, 1328.5 mm rainfall was recorded. During the rainy season heavy rainfall was recorded during 26th, 28th, 29th and 30th std. weeks. The maximum rainfall 959.8 mm was recorded during the month of July with 18 rainy days, which was 277.2% departure than the normal rainfall (254.5 mm). The least amount of rainfall i.e. 22.3 mm with 3 rainy days was recorded during the month of September, which was -79.6% departure than the normal rainfall 109.1 mm. Early cessation of monsoon was observed during the 38th MSW (17th September) with only 3.4 mm rainfall. (Fig.15). On account of higher amount of rainfall during the months of June, July and August ground water table recharge was significant

Normal onset of monsoon	:	16 June (24th SMW)
Onset of monsoon during 2017	:	04 July (27th SMW)
Annual mean rainfall	:	648.8 mm
Annual rainfall during 2017-18	:	1328.5 mm
Mean crop seasonal rainfall during *kharif*	:	648.8 mm
Crop seasonal rainfall during 2017 (*kharif*)	:	1328.5 mm

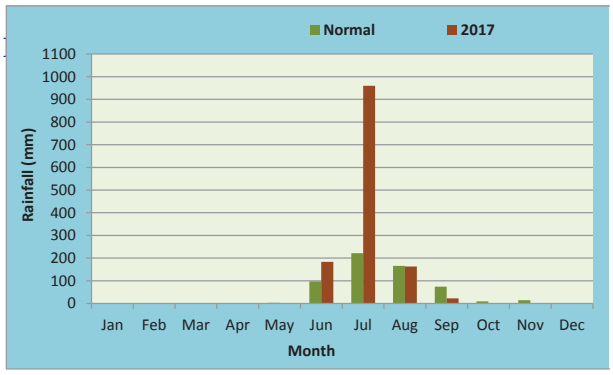


Fig.15: Normal and actual (2017) monthly rainfall at Rajkot

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
7	14 - 20 August	Groundnut, greengram, blackgram	Flowering
		Cotton, sesame	Vegetative
		Castor	Vegetative
11	6 - 16 September	Groundnut	Pegging & pod formation
		Cotton	Flowering
		Sesame	Flowering and capsule formation
		Green/black gram	Pod development
		Castor	Vegetative

Real time contingency plan (RTCP) implemented

Weather aberration	Crop	Stage of the crop	RTCP
Delayed onset of monsoon	Groundnut, greengram, blackgram, soybean	-	Improved varieties
Mid-season drought	Groundnut, greengram blackgram	Flowering	Interculture and weeding
	Cotton, sesame, castor	Vegetative	Interculture and weeding

Weather aberration	Crop	Stage of the crop	RTCP
Terminal drought	Groundnut	Pegging & pod formation	Interculture and weeding, Foliar spray and supplemental irrigation
	Cotton	Flowering	Interculture and weeding
	Sesame	Flowering and capsule formation	Interculture and weeding
	Greengram, blackgram	Pod development	Interculture and weeding
	Castor	Vegetative	Interculture and weeding

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

The onset of monsoon was delayed by 18 days (4th July). Among different semi-spreading varieties of groundnut, GG-20 recorded higher pod yield (1883 kg/ha) as compared to other varieties. In case semi-bunch groundnut varieties, GJG-9, JL-501 and TGA-37A recorded 19.1, 12.8 and 25.4% higher pod yield as compared to GG-7 (2187 kg/ha), respectively. In case of spreading varieties, GJG-17 performed better with pod yield of 1778 kg/ha and net returns of Rs 93550/ha compared to var. GG11 (1447 kg/ha) and Somnath (1567 kg/ha) (Table 58).

Table 58: Performance of groundnut varieties under delayed onset of monsoon

Variety	Yield (kg/ha)		% increase in pod yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Pod	Haulm				
Semi-spreading						
GG-20	1883	3812	17.7	1.42	68657	3.67
GJG-22	1627	4450	1.9	1.22	61607	3.40
Kaushal	1597	4787	-	1.20	62092	3.41
Semi-bunch						
GG-7	2187	3815	-	1.65	80832	4.14
GJG-9	2604	4490	19.1	1.96	98887	4.84
JL-501	2466	3634	12.8	1.86	91087	4.54
TG-37A	2743	3302	25.4	2.06	100507	4.91
Spreading						
GG-11	1447	4557	-	1.09	80665	3.14
GJG-17	1778	4486	22.9	1.34	93550	3.64
Somnath	1567	4578	8.3	1.18	85570	3.33

Among blackgram varieties, T-9 gave 8.9% higher seed yield (1185 kg/ha) compared to GU-1 with higher net returns (Rs 24975/ha) and B:C ratio (2.51). Among greengram varieties, GM-4 gave 82% higher seed yield, net returns (Rs 36820/ha) and B:C ratio (3.23) compared to cv. Meha (731 kg/ha). Among cowpea varieties, GC-4 gave 22.5% higher seed yield than GC-3 (1579 kg/ha) with higher net returns (Rs 57030/ha) and B:C ratio (4.46) (Table 59).

Table 59: Performance of pulses varieties under delayed onset of monsoon

Crop	Variety	Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Blackgram	GU-1	1088	-	0.82	21580	2.31
	T-9	1185	8.9	0.89	24975	2.51
Greengram	GM-4	1333	82.4	1.00	36820	3.23
	Meha	731	-	0.55	12740	1.77
Cowpea	GC-5	1769	12.0	1.33	50722	4.07
	GC-4	1935	22.5	1.46	57030	4.46
	GC-3	1579	-	1.19	43502	3.64

Among soybean varieties, higher seed yield (3684 kg/ha), net returns (Rs 92020/ha), RWUE (2.77 kg/ha-mm) and B:C ratio (5.97) was recorded by G.Soy-3 followed by JS-335 (3442 kg/ha) compared to other varieties (Table 60).

Table 60: Performance of soybean varieties under delayed onset of monsoon

Variety	Seed yield (kg/ha)	RWUE (kg/hamm)	Net returns (Rs/ha)	B:C ratio
JS-335	3442	2.59	84760	5.58
G.Soy.-1	3241	2.44	78730	5.26
G.Soy.-2	2436	1.83	54580	3.95
G.Soy.-3	3684	2.77	92020	5.97

Situation: Mid season drought

A dry spell of 7 days occurred during 14-20 August coinciding with flowering stage of groundnut. The pod and haulm yield of groundnut was increased due to foliar sprays during dry spells and higher pod (2429 kg/ha) and haulm (5153 kg/ha) yield was recorded with foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1%, and foliar spray of $FeSO_4$ @ 1%, respectively. Similarly higher RWUE (1.75 kg/ha-mm), net returns (Rs 54792/ha) and B:C ratio (3.05) was recorded with foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1% during dry spells compared to other treatments (Table 61).

Table 61:. Effect of different foliar sprays during dry spell on yield and economics of groundnut

Treatment	Yield (kg/ha)		% increase pod in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Pod	Haulm				
Urea @ 1%	2076	4723	10.7	1.56	45987	2.72
Urea @ 2%	2024	4605	7.9	1.52	44617	2.70
Water soluble complex fertilizer (19:19:19) @ 0.5%	2097	4771	11.8	1.58	46422	2.72
Water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1%	2429	4959	24.2	1.75	54792	3.05
$FeSO_4$ @ 1%	2265	5153	20.8	1.70	52302	2.94
$ZnSO_4$ @ 1%	2099	4775	11.9	1.58	46742	2.75
Water spray	1929	4388	2.9	1.45	41592	2.60
Control	1875	3924	-	1.41	39902	2.55

Similarly, the pod and haulm yield of groundnut was increased due to foliar sprays after relieving of dry spells. Maximum pod and haulm yield (2416 and 5057 kg/ha, respectively) was obtained with water soluble complex fertilizer -19:19:19 @ 0.5% $FeSO_4$ @ 1% compared to other treatments, with higher RWUE (1.82), net returns (Rs 57837/ha) and B:C ratio (3.16) (Table 62).

Table 62: Effect of different foliar sprays after relieving of dry spell on yield and economics of groundnut

Treatment	Yield (kg/ha)		% increase pod in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Pod	Haulm				
Urea @ 1%	2316	5058	20.4	1.74	54387	3.04
Urea @ 2%	2257	5135	17.4	1.70	52772	3.01
Water soluble complex fertilizer (19:19:19) @ 0.5%	2226	5064	15.8	1.68	50937	2.89
Water soluble complex fertilizer (19:19:19) @ 0.5% $FeSO_4$ @ 1%	2416	5057	25.6	1.82	57837	3.16
$FeSO_4$ @ 1%	2138	4864	11.2	1.61	47857	2.77
$ZnSO_4$ @ 1%	2022	4600	5.1	1.52	44047	2.65
Water spray	1951	4439	1.5	1.47	42362	2.63
Control	1923	4025	-	1.45	41582	2.62

The beneficial effect of interculture and weeding was observed on seed cotton yield of Bt cotton (1810 kg/ha) which was 10.4% higher compared to normal practice of no interculture and weeding (1640 kg/ha). Similarly, the increase in pod yield of groundnut was 13.1% due to interculture and weeding as compared to normal practice (1990 kg/ha), with net returns of Rs 73550/ha and B:C ratio of 3.66. The seed yields of greengram and blackgram were increased by 17.8 and 16.7% due to interculture and weeding as compared to normal practice (Table 63).

Table 63: Effect interculture and weeding on yield and economics of different crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Interculture and weeding	Normal practice				
Cotton	G.cotton-8 BGII	1810	-	10.4	1.36	56675	2.93
		-	1640	-	1.23	49600	2.75
Groundnut	GG20	2250		13.1	1.69	73550	3.66
			1990		1.50	61850	3.23
Green gram	GM-4	1260	-	17.8	0.95	33400	2.96
		-	1070		0.81	26300	2.59
Urdbean	GU-1	1330	-	16.7	1.00	34040	3.06
		-	1140		0.86	26820	2.63

The pod yield of groundnut was increased by 22.1, 35.3 and 9.6% due to supplemental irrigation through rain gun, mini sprinkler and flood irrigation compared to without irrigation, respectively. Higher net returns (Rs 96810/ha), B:C ratio (4.37) and WUE (1.72 kg/ha-mm) was recorded with supplemental irrigation through mini-sprinklers (50 mm) compared to other treatments (Table 64).

Table 64: Effect of supplemental irrigation and method of irrigation on yield and economics of groundnut

Treatment	Pod yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rain gun (50 mm)	2058	22.1	1.55	79345	3.76
Mini sprinkler (50 mm)	2282	35.3	1.72	96810	4.37
Flood (50 mm)	1848	9.6	1.39	73440	3.60
Control	1686	-	1.27	39740	2.43


Supplemental irrigation in groundnut through mini-sprinklers (left) and with rain gun (right)

c. On-farm demonstrations

Village profile

The NICRA village Patameghpar (22°14.33' N longitude 70°31.0' E and 95.7 m above MSL) is in Taluka Kalavad of Jamnagar district (Gujarat). The total cultivated area is 2793 ha out of which 1675 ha is rainfed. The annual rainfall for last 20 years ranged from 128.5 mm to 1197 mm, with an average of 543.6 mm during *kharif* (June-September). The major soil type is medium black soil. The soils are generally high in available K and low to moderate in available N and P. It is neutral to alkaline in reaction and salinity is normal. The major crops are groundnut, cotton, sesame, castor, sesame and pulses in *kharif* and wheat, cumin, chickpea, fenugreek and coriander in *rabi*. The percentage of small, marginal, medium and large farmers is 28.7, 27.3, 27.8 and 16.1, respectively. The source of irrigation is open/bore wells covering 40.5% of cultivated area and quality of irrigation water is normal.

Climatic vulnerability in general

The climate of this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 549.5 mm, the south-west monsoon contributes 70-80%. The historical rainfall data (30 years) indicates that the variability in rainfall during south-west monsoon was 62.5% of the average rainfall. The onset of south-west monsoon was during 24 SMW. Onset of monsoon during 2017-18 was 11th July 2017 (28th SMW). 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 monsoon is normal.

Experienced weather conditions during 2017-18

During 2017, at Patameghpar village, the onset of monsoon was delayed by 25 days. A rainfall of 628 mm was received which was higher by 78.5 mm compared to normal (549.5 mm). During *kharif* season, 568 mm of rainfall was recorded against normal rainfall of 549.5 mm (Fig. 16).

Normal onset of monsoon	:	16 June (24th SMW)
Onset of monsoon during 2017-18	:	11 July (28th SMW))
Annual mean rainfall	:	549.5 mm
Annual rainfall during 2017-18	:	628 mm
Mean crop seasonal rainfall during *kharif*	:	549.5 mm
Crop seasonal rainfall during 2017 (*kharif)*	:	568 mm

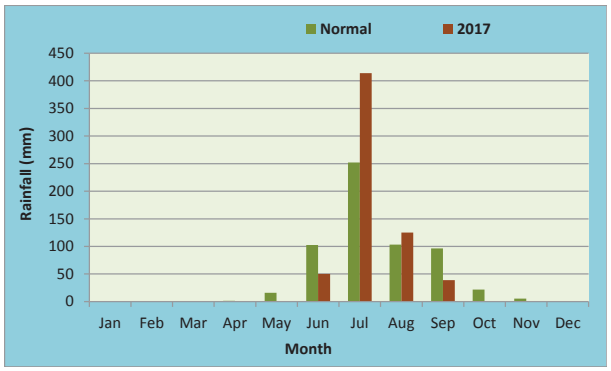


Fig.16: Normal and actual (2017) monthly rainfall at Patameghpar

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
26	1 - 26 August	Groundnut, cotton, sesame, greengram, blackgram, castor	Vegetative
9	1 - 9 September	Groundnut	Flowering & pegging
		Cotton	Square formation
		Sesame	Flowering and capsule formation
		Greengram, blackgram	Flowering & pod development

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	Crop	RTCP implemented
Delayed onset of monsoon	Medium black soils	Groundnut	Short duration varieties
		Cotton	
		Sesame	
Mid season drought	Medium black soils	Groundnut	Weeding/ interculture
		Cotton	
Terminal drought	Medium black soils	Groundnut	Supplemental irrigation
		Cotton	

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2017, the onset of monsoon was delayed by 25 days. The pod yield of groundnut was increased by 16% with groundnut var. GJG 9 as compared to var, GG 20 (1940 kg/ha), with higher net returns (Rs 71200/ha) and B:C ratio (3.99). Similarly, seed cotton yield was increased 13.8% with cotton var. G.Cot. 8 BGII compared to different Bt cotton research varieties grown by the farmers (1950 kg/ha), with higher net returns (Rs 78550/ha), B:C ratio (3.40) and RWUE of 3.54 kg/ha-mm (Table 65).

Table 65: Performance of groundnut and cotton cultivars under delayed onset of monsoon

Farming situation/ Soil type	Crop	Variety (duration)	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed /medium black	Groundnut	GJG 9 (100 days)	2250	16.0	4.53	71200	3.99
		GG20 (110 days)	1940	-	3.09	60450	3.65
Rainfed /medium black	Bt cotton	G.Cotton-Hy-8BGll (140 days)	2220	13.8	3.54	78550	3.40
		Research variety (160 to 180 days)	1950	-	3.10	65650	3.07

Situation: Early season drought

A dry spell of 26 days occurred during 1 to 26 August coinciding with vegetative stage of crops. The pod yield of groundnut was increased by 25.4% due to timely weeding and interculture practices as compared to normal practice of no weeding (1718 kg/ha) with net returns of Rs 70666/ha and B:C ratio of 4.1 (Table 66).

Table 66: Effect of interculture and weeding on yield and economics of groundnut

Farming situation/ Soil type	Intervention	Pod yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed /medium black	Weeding/interculture	2149	3.42	70666	4.10
	No weeding/ interculture	1718	2.74	38846	2.82

Interculture with tractor drawn implement in groundnut

In cotton, weeding and interculture gave 18.3% higher seed cotton yield (2355 kg/ha), with net returns of Rs 86050/ha, B:C ratio of 3.71 and RWUE of 3.75 kg/ha-mm compared to no weeding/ interculture (1991 kg/ha) (Table 67).

Table 67: Effect of interculture and weeding on yield and economics of cotton

Farming situation/soil type	Intervention	Seed cotton yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed /medium black	Weeding/interculture	2355	18.3	3.75	86050	3.71
	No weeding/ interculture	1991	-	3.17	69350	3.30

Foliar spray of $FeSO_4$ @ 1% + citric acid @ 1% on 6th August in groundnut gave 9.7% higher pod yield (2385 kg/ha), net returns (Rs 89588/ha), B:C ratio (4.78) and RWUE (3.80 kg/ha-mm) compared to no foliar spray (Table 68).

Table 68: Effect foliar spray on yield and economics of groundnut

Farming situation/Soil type	Intervention	Pod yield (kg/ ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed /medium black	Foliar spray of $FeSO_4$ @ 1% + citric acid @ 1%	2385	3.80	89588	4.78
	No foliar spray	2175	3.46	81113	4.65

Situation: Terminal drought

Two supplemental irrigations, from harvested water, each of 30 mm in alternate rows applied at square formation and boll development stage of cotton gave 30.6% higher seed cotton yield (2628 kg/ha), with higher net returns (Rs 99150/ha), B:C ratio (3.07) and RWUE (3.88 kg/ha-mm) compared to rainfed crop (Table 69).

Table 69: Effect of supplemental irrigation on yield and economics of cotton

Farming situation/Soil type	Intervention	Yield (kg/ha)	% increase in yield	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed/ medium black	Supplemental irrigation	2628	30.6	3.88	99150	3.07
	No supplemental irrigation	2012		3.20	70150	2.30

Similarly, supplemental irrigation at pod development stage of groundnut gave 22% higher pod yield (2466 kg/ha) with higher net returns (Rs 86174/ha), B:C ratio (4.47) and WUE (3.64 kg/ha-mm) compared to rainfed crop (Table 70).

Table 70: Effect of supplemental irrigation on yield and economics of groundnut

Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed/ medium black	Supplemental irrigation	2466	22.0	3.64	86174	4.47
	No supplemental irrigation	2021		3.22	67605	3.90

Preparedness

Rainwater management

Opening of dead furrow between two rows for *in-situ* moisture conservation in cotton recorded 20% higher seed cotton yield (2360 kg/ha) compared to farmers' practice (1964 kg/ha) with higher RWUE kg/ha-mm (1.78), net returns (Rs. 77980/ha) and B:C ratio (3.21) (Table 71).

Table 71: Effect of opening of dead furrow on yield and economics of cotton

Farming situation/ Soil type	Intervention	Seed cotton yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2017-18	Mean (3 years)				
Rainfed/ medium black	Dead furrow (30 cm wide)	2360	2497	35300	77980	3.21	1.78
	Farmers' practice*	1964	2073	32600	61672	2.89	1.48

*Wide spacing 180 cm between rows

Cropping systems

Cotton + sesame intercropping system (1:1) gave higher seed cotton equivalent yield (2520 kg/ha), LER (1.17), net returns (Rs 91468/ha), B:C ratio (3.62) and RWUE (1.90 kg/ha-mm) compared to farmers' practice of sole cotton (2360 kg/ha) (Table 72).

Table 72: Performance of cotton + sesame (1:1) intercropping system

Farming situation/ Soil type	Intervention	Yield (kg/ha)		CEY		LER	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter crop	2017-18	Mean (4 years)					
Rainfed/ medium black	Cotton + sesame (1:1)	1970	550	2520	2632	1.17	34880	91468	3.62	1.90
	Farmers' practice*	2360	-	2360	2235	-	32600	74680	3.29	1.77

*Sole cotton; CEY: Cotton equivalent yield

Similarly, groundnut + castor (3:1) intercropping system gave higher groundnut pod equivalent yield (3120 kg/ha), net returns (Rs 85500/ha), B:C ratio (4.61) and RWUE (4.97 kg/ha-mm) compared to farmers' practice of sole groundnut (2300 kg/ha) (Table 73).

Groundnut + castor (3:1) intercropping system

Table 73: Yield and economics under groundnut + castor intercropping system (3:1)

Farming situation/ Soil type	Intervention	GPEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed/ medium black	Groundnut+ castor (3:1)	3120	4.97	85500	4.61
	Sole groundnut	2300	3.66	58300	3.63

GPEY: Groundnut pod equivalent yield

1.1.7 S.K. 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 2017-18

During 2017, the onset of monsoon was delayed by just 2 days (27th June). A rainfall of 2067.1 mm was received which was excess by 1429.1 mm compared to normal (638 mm) (Fig.). During south-west monsoon (*kharif*), 2067.1 mm rainfall was received which was excess by 1469 mm than normal rainfall of 598.1 mm; during *rabi* (October-December), no rainfall was received as against normal rainfall of 27.1mm and in summer (March-May), no rainfall was received. Terminal drought in different crops occurred due to early withdrawal of monsoon.

Normal onset of monsoon	:	25 June
Onset of monsoon during 2017	:	27 June
Annual mean rainfall	:	638 mm
Annual rainfall during 2017-18	:	2067.1 mm
Mean crop seasonal rainfall during	:	598.1 and 27.1 mm during *kharif* & *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	2067.1 and 0 mm during *kharif* & *rabi*, respectively

Dry spells during crop growing season (2017-18)

Dates & months	Crop	Stage of the crop
Dry spell		
25 September till maturity	Pearlmillet, pulses	Grain filling to maturity
	Castor	Seed filling
High intensity rainfall (wet spell)		
02 July (210 mm)	Pearlmillet, pulses	Sowing
23 - 26 July (1224 mm)	Pearlmillet, pulses, castor	Vegetative

All the crops were sown at onset of monsoon during first week of July 2017. Continuous high intense rainfall during 23 to 26 July, 2017 at seedling/vegetative stage adversely affected plant stand of pearlmillet, blackgram, clusterbean and greengram.

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Castor	Seed filling to maturity	Life saving irrigation Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

Terminal drought occurred due to early withdrawal of monsoon affecting the seed filling and maturity of castor. Two supplemental irrigations from harvested rainwater from farm pond to castor during flowering to capsule development (11th October, 19th December, 2017) of 50 mm being on par with two life saving irrigations of 25 mm each recorded significantly higher seed and stalk yields of 1426 and 3403 kg/ha, respectively compared to other treatments. Further, application of two life saving irrigations of 50 mm each also recorded higher net returns (Rs. 44701/ha), B:C ratio (3.18) and WUE of 0.68 kg/ha-mm closely followed by application of two life saving irrigations of 25 mm each and the lowest seed and stalk yields (925 and 2088 kg/ha) were recorded in control (Table 74).

Table 74: Effect of supplemental irrigation on yield and economics of castor (GCH 7)

Treatment	Yield (kg/ha)		WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Control	925	2088	0.44	27894	2.75
One life saving irrigation (25 mm)	1105	2499	0.53	33799	2.90
Two life saving irrigation (25 mm each)	1259	2881	0.60	38740	2.97
One life saving irrigation (50 mm)	1154	2690	0.55	35345	2.91
Two life saving irrigation (50 mm each)	1426	3403	0.68	44701	3.18
Alternate furrow irrigation(50 mm)	1140	2545	0.55	35273	3.04
CD at 5%	249.2	565.2			

Without irrigation

Performance of castor (cv. GCH7) with two life saving irrigations (25 mm each)

Foliar spray either during dry spell or after relieving of stress/dry spell were found non-significant with respect to pearlmillet yield. Application of water soluble complex fertilizer (19:19:19) @ 0.5% recorded significantly higher seed and straw yields of 318 and 1035 kg/ha, respectively than rest of the treatments. The highest net return of Rs. 4137/ha, B:C ratio (2.03) and RWUE (0.15 kg/ha-mm) were also recorded with application of water soluble complex fertilizer (19:19:19) @ 0.5%. Further, foliar spray of urea, Zn and their combinations were at par with each other with respect to yield and were significantly superior to water spray and control (Table 75).

Table 75: Effect of foliar sprays on yield and economics of pearlmillet

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Seed	Stover				
Main plot						
F1 : Foliar spray during dry spell	285	774	6077	718	1.12	0.14
F2 : Foliar spray after relieving of stress/dry spell	251	744	6077	105	1.02	0.12
C.D. (0.05)	NS	NS				
Sub plot						
N_1: Urea @ 1%	266	758	3930	2522	1.64	0.13
N_2: Urea @ 2%	276	801	3960	2776	1.70	0.13
N_3: Water soluble complex fertilizer (19:19:19) @ 0.5%	318	1035	4000	4137	2.03	0.15
N_4:N_3 + foliar spray of Zn	266	752	4150	2292	1.55	0.13
N_5: Foliar spray of Zn	263	733	3900	2424	1.62	0.13
N_6: Water spray	247	649	3900	1913	1.49	0.12
N_7: Control	241	585	3300	2214	1.67	0.12
CD at 5%	31.7	137				

Preparedness

Rainwater management

The formation of ridges & furrows for *in-situ* moisture conservation recorded 9.8% higher seed yield of castor (1295 kg/ha) over local practice of flat bed method (1180 kg/ha), respectively, with higher net return of Rs 41430/ha, B:C ratio (3.53) and RWUE (0.62 kg/ha-mm) (Table 76).

Table 76: Effect of ridges and furrow method on yield and economics of castor (GCH 7)

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Ridge & furrow	1295	2720	0.62	41430	3.53
Local practice (flat bed)	1180	2360	0.57	38230	3.77

Performance of castor with ridge & furrow and with flat bed system

Cropping systems

Continuous high intense rainfall during 23 to 26 July, 2017 at seedling stage adversely affected plant stand of crops. Among different hybrids of pearlmillet, GHB-558 recorded 9.5% higher grain (230 kg/ha) and 13.6% fodder (750 kg/ha) yields, with higher net returns of Rs. 2200/ha, B:C ratio (0.11) and RWUE (0.11 kg/ha-mm) compared to GHB-538 (Table). Among greengram varieties, Guj. Mung 4 recorded 24.6% higher seed (405 kg/ha) yield with higher net returns (Rs.16490/ha), B:C ratio (2.41) and RWUE (0.19 kg/ha mm) compared to Guj. Mung 3 (Table). Clusterbean variety Guj. Guar 2 recorded 18.8% higher seed (240 kg/ha) yield over Guj. Guar 1 (202 kg/ha) with higher net returns (Rs. 14795/ha), B:C ratio (1.59) and RWUE (0.12 kg/ha-mm) (Table). Castor hybrid GCH 7 recorded 25.5% higher seed yield (1180 kg/ha) compared to local cultivar GCH 5 (940 kg/ha) with higher net returns of Rs.38171/ha, B:C ratio (3.76) and RWUE (0.57 kg/ha-mm) (Table 77).

Table 77: Performance of varieties/hybrids of *kharif* crops

Crop	Variety/ hybrid	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (`Rs/ha)	B:C ratio
		Grain/ seed	Stover/ stalk			
Pearlmillet	GHB 538	210	660	0.10	1630	0.10
	GHB 558	230	750	0.11	2200	0.11
Greengram	GM 3	325	940	0.16	12270	1.80
	GM 4	405	1030	0.19	16490	2.41
Clusterbean	GG 1	202	445	0.10	10780	0.55
	GG 2	240	510	0.12	14795	0.80
Castor	GCH 5	940	2068	0.45	28484	2.81
	GCH 7	1180	2242	0.57	38171	3.76

Pearlmillet hybrid GHB 558

Greengram cv. GM 4

Cluster bean cv. GG 2

Castor hybrid GCH 7

c. On-farm demonstrations

Village profile

The program is being implemented in Kalimati/ Dholiya village, taluka Amirgadh, Banaskantha district, Gujarat. The total cultivated area is 652.91 ha out of which 322.91 ha is rainfed. The mean annual rainfall is 873 mm 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 is semi-arid. The south-west monsoon contributes 94% 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 2017-18

During 2017, in Kalimati village, onset of monsoon was advanced by 15 days (10th June). A total rainfall of 1392.8 mm was received which was excess by 519.8 mm compared to normal (873 mm). Out of total rainfall, *kharif* season received 1383.3 mm which was excess by 600.3 mm (76.7%) than normal of 783 mm. In *rabi*, no rainfall was received as against normal of 23.1 mm and in summer season 9.5 mm rainfall was received.

Normal onset of monsoon	:	25 June
Onset of monsoon during 2017	:	10 June
Annual mean rainfall	:	873 mm
Annual rainfall during 2017-18	:	1392.8 mm
Mean crop seasonal rainfall	:	783 & 23.1 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	1383.3 & 0 mm during *kharif* and *rabi*, respectively

Dry spells during crop growing season (2017-18)

Dates & months	Crop	Stage of the crop
Dry spell		
25 September to maturity	Pearlmillet, pulses	Grain filling to maturity
	Castor	Flowering to capsule development
High intensity rainfall		
02 July (210 mm)	Pearlmillet, pulses, castor	Sowing
23- 26 July (1224 mm)		Seedling/vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Castor	Flowering & capsule formation	Life saving irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

Terminal drought occurred due to early withdrawal of monsoon affecting flowering and capsule development of castor. Supplemental irrigation (30 mm depth) twice through micro-irrigation (MIS) after flowering to capsule development in castor from harvested rainwater in farm pond recorded 39.3% higher seed yield (1943 kg/ha) compared to local practice of no supplemental irrigation (1395 kg/ha), with highest net returns (Rs. 65414/ha), B:C ratio (4.53) and RWUE (2.27 kg/ha-mm) (Table 78).

Table 78: Effect of supplemental irrigation on yield and economics of castor

Farming situation/ Soil type	Intervention Seed	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Stalk	Stalk			
Deep loamy soil	Supplemental irrigation	1943	4321	1.40	65414	4.53
	Local practice	1395	3234	1.01	45949	4.01

Performance of castor with supplemental irrigation an d without supplemental irrigation

Preparedness

Rainwater management

In-situ moisture conservation with compartmental bunding recorded higher grain and stover yield (1239 and 3309 kg/ha) compared to local practice of no compartmental bunding (1083 kg/ha) with higher net returns (Rs. 18768/ha), B:C ratio (1.92) and RWUE (0.90 kg/ha-mm) (Table 79).

Table 79: Effect of *in-situ* moisture conservation practices on yield and economics of pearlmillet

Farming situation/ Soil type	Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover			
Deep loamy soil	Compartmental bunding	1239	3309	0.90	18768	1.92
	Local practice	1083	2782	0.78	15535	1.72

Performance of pearlmillet with compartmental bunding and with flat bed system

In-situ moisture conservation through ridge and furrow method in castor recorded higher seed (1503 kg/ha) and stalk (2943 kg/ha) yields compared to local practice of flat bed method (1299 kg/ha) with higher net returns (Rs. 48949/ha), B:C ratio (3.88) and RWUE (1.09 kg/ha-mm) (Table 80).

Table 80: Effect of *in-situ* moisture conservation practices on yield and economics of castor

Farming situation/ Soil type	Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Seed	Stalk			
Deep loamy soil	Ridge & furrow	1503	2943	1.09	48949	3.88
	Local practice (flat bed)	1299	2392	0.94	41712	3.64

Cropping systems

Pearlmillet hybrid GHB 558 recorded higher grain (1070 kg/ha) and stover (2872 kg/ha) yields over GHB 538 and local variety (MH 179), with highest net returns (Rs.15523/ha), B:C ratio (1.70) and RWUE (0.77 kg/ha-mm). GHB 538 also recorded 10.2% higher grain yield (854 kg/ha) over local variety (Table 81).

Table 81: Performance of different varieties/hybrids of pearlmillet

Farming situation/Soil type	Variety/ Hybrid	Yield (kg/ha)		% increase in grain yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover				
Deep loamy soil	GHB 558	1070	2872	36.5	0.77	15523	1.70
	GHB 538	864	2542	10.2	0.62	11443	1.25
	Local variety (MH 179)	784	2089	-	0.57	9180	1.04

Peralmillet Hybrid GHB 558

Popular Hybrid (MH 179)

HQPM 1 variety of maize recorded higher grain (2598 kg/ha) and stover (4425 kg/ha) yields compared to other varieties, with higher net returns (Rs.40853/ha), B:C ratio (4.04) and RWUE (1.88 kg/ha-mm) (Table 82).

Table 82: Performance of maize varieties

Farming situation/ Soil type	Variety	Yield (kg/ha)		% increase in grain yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover				
Deep loamy soil	GM 2	1605	3375	40.8	1.16	25045	3.00
	HQPM 1	2598	4425	128.0	1.88	40853	4.04
	Local variety	1140	2235	-	0.82	15182	1.89

Maize cv. HQPM-1

Local Hybrid of maize

Blackgram var. Guj. Urad 1 recorded higher seed and stover yields of 664 and 1687 kg/ha, respectively over local check (T 59), with higher net returns (Rs. 35266/ha), B:C ratio (3.65) and RWUE (0.36 kg/ha-mm) (Table 83).

Table 83: Performance of blackgram varieties

Farming situation/ Soil type	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B: C ratio
		Seed	Stover			
Deep loamy soil	GU 1	664	1687	0.48	35266	3.65
	Local variety	500	1325	0.36	25136	2.85

Among greengram varieties, cv. Mung 4 recorded higher seed (636 kg/ha) and stover (1325 kg/ha) yields over local variety (K 851) (483 and 1052 kg/ha, respectively), with higher net returns (Rs. 28116/ha), B:C ratio (3.68) and RWUE (0.46 kg/ha-mm) (Table 84).

Table 84: Performance of greengram varieties

Farming situation/ Soil type	Variety	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Seed	Stover			
Deep loamy soil	GM 4	636	1325	0.46	28116	3.68
	Local variety (K 851)	483	1052	0.35	19946	2.71

Gujarat Guar 2 variety of clusterbean recorded higher seed (650 kg/ha) and stalk (1380 kg/ha) yields over local variety (HG 75) with net returns o f Rs. 19351/ha, B:C ratio (3.10) and RWUE (0.47 kg/ha-mm) were obtained with Gujarat Guar 2 (Table 85).

Table 85: Yield and economics of clusterbean varieties

Farming situation/ Soil type	Variety	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Seed	Stover			
Deep loamy	GG 2	650	1380	0.47	19351	3.10
	Local variety (HG 75)	465	1075	0.34	12890	2.27

Among castor hybrids, GCH 7 recorded higher seed and stalk yields of 1232 and 2464 kg/ha, respectively over local variety (GHC 4) and gave higher net return (Rs 38751/ha), B:C ratio (3.30) and RWUE (0.89 kg/ha-mm) (Table 86).

Table 86: Yield and economics of castor hybrids/varieties

Farming situation/ Soil type	Variety/hybrid (duration)	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Seed	Stalk			
Deep loamy	GCH 5(180-210)	1035	2264	0.75	30755	2.62
	GCH 7(180-210)	1232	2464	0.89	38751	3.30
	Local variety (GCH 4) (200-220)	836	1924	0.60	22969	2.01

Intercropping system (1:1) of castor + greengram (GCH 7 + Gujarat Mung 4) recorded 49% higher castor equivalent yield of 1818 kg/ha, net returns of Rs. 57185/ha, B:C ratio (3.68) and RWUE (1.31 kg/ha-mm) compared to sole crop of castor (1218kg/ha) (Table 87).

Table 87: Effect of castor + greengram intercropping system on yield and economics of castor

Farming situation/ Soil type	Intervention	Castor equivalent yield (kg/ha)	% increase in seed yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep loamy	Castor + greengram (1:1)	1818	49.2	1.31	57185	3.68
	Castor sole	1218	-	0.88	35464	2.67

Castor + greengram intercropping (1:1)

Castor sole

1.1.8 SOLAPUR

a. Agro-ecological setting

Solapur is in Deccan Plateau of South Western Maharashtra and North Karnataka Plateau (AESR6.1). The climate is hot and 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

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was normal (4th June). An annual rainfall of 589.6 mm was received which was deficit by 131.7 mm compared to normal of 721.3 mm (Fig.17). During *kharif*, 430.6 mm rainfall was recorded against the normal of 531.1 mm. *Rabi* season recorded 237.8 mm, which was 112.3 mm higher than normal rainfall of 125.5 mm.

Normal onset of monsoon	:	7 June
Onset of monsoon during 2017	:	4 June
Normal annual rainfall	:	721.4 mm
Annual rainfall during 2017-18	:	589.6 mm
Mean crop seasonal rainfall	:	531.1 & 125.5 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	430.6 & 141.3 mm during *kharif* and *rabi*, respectively

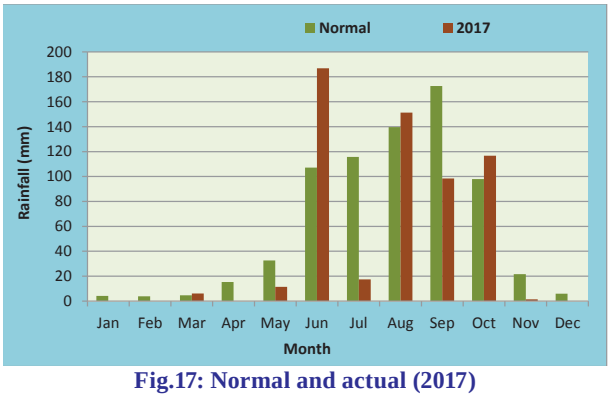


Fig.17: Normal and actual (2017) monthly rainfall at Solapur

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage
Duration (days)	Dates & months		
33	17 June - 19 July	Pigeonpea, sunflower	Vegetative
135	10 October to till harvesting	Sorghum, chickpea	

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season and terminal drought	Sorghum, chickpea	Panicle initiation/flowering and grain filling	weeding and hoeing Protective irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season and terminal drought

A dry spell of more than 100 days occurred (10 October to till crop maturity). Two supplemental irrigations, from harvested rainwater, one irrigation (5 to 6 cm depth) at flag leaf stage and 2nd irrigation at grain filling stage increased yield of sorghum by 56.3% (1250 kg/ha) over farmers' practice of no supplemental irrigation (800 kg/ha), with higher WUE (10.5 kg/ha-mm) and net returns (Rs. 16250/ha).

Performance of sorghum with supplemental irrigation

One weeding at 21 days, and three hoeings at 3rd, 5th and 8th week after sowing with peg tooth hoe increased the *rabi* sorghum yield (1000 kg/ha) by 33.3% as compared without weeding or intercultural operations (750 kg/ha), with higher RWUE (8.46 kg/ha-mm) and net returns (Rs. 10000/ha). Similarly, foliar spray of 1% KNO_3 at 30 and 45 DAS increased yield of chickpea (740 kg/ha) by 19.4% as compared to without foliar spray (620 kg/ha) with higher RWUE (6.26 kg/ha-mm), net returns (Rs. 10700/ha) and B:C ratio (1.70).

Preparedness

Cropping systems

Increase in yield (850 kg/ha) of sorghum by 41.6% was observed with improved variety Revati and recorded higher RWUE (7.19 kg/ha-mm), net returns (Rs. 5950/ha) and B:C ratio (1.39) compared to local variety Maldandi 35-1 (600 kg/ha).

Sorghum cv. Revati

The yield of sunflower and pigeonpea increased by 31% and 18.8% with improved varieties (Phule Bhaskar and BDN-711, respectively) as compared to local varieties. The net returns (Rs 23100/ha) and B:C ratio (2.3) were higher with pigeonpea (BDN-711) compared to sunflower whereas the latter crop recorded higher RWUE (3.07 kg/ha-mm) (Table 88).

Table 88: Performance of improved varieties of sunflower and pigeonpea

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With normal practice				
Sunflower	Phule Bhaskar	820	626	31.0	3.07	10820	1.74
Pigeonpea	BDN-711	950	800	18.8	2.45	23100	2.30

Intercropping of pigeonpea and sunflower (1:2) with improved varieties increased the yields by 20.5%, and gave higher net returns (Rs. 26487/ha), B:C ratio (2.54) and RWUE (1.57 kg/ha-mm) compared to farmer's practice with use of local varieties (Table 89).

Table 89: Performance of pigeonpea (BDN-711) + sunflower (Phule Bhaskar) intercropping system

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop				
Pigeonpea (BDN-711) + sunflower (Phule Bhaskar)	610	591	17175	26487	2.54	1.57
Farmers' practice with Local varieties	553	510	15442	19457	2.25	1.32

c. On-farm demonstrations

Village profile

Programme is being implemented in Narotewadi village, North Solapur Tehsil in Solarpur district. The total cultivated area is 560.7 ha out of which 450 ha is rainfed. The mean annual rainfall is 546.5 mm with seasonal rainfall of 404.5 mm and 123 mm which was deficit by 16.2 and 114.8 mm during *kharif* and *rabi* seasons respectively as compared to normal rainfall (420.7 mm and 237.8 mm during *kharif* and *rabi* respectively). The major soil types are sandy loam, loam and clayloam. The major rainfed crops in *kharif* are sunflower, pigeonpea and blackgram, 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 546.5 mm, the south-west monsoon contributes 80% and north-east 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 of south-west monsoon was during 21 SMW and north-east monsoon was during 40 SMW. 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 monsoon is normal.

Experienced weather conditions during 2017-18

During 2017, in Narotewadi village, the onset of monsoon was timely and a rainfall of 546.5 mm was received which was deficit by 177 mm compared to normal (723.5 mm) (Fig.18). During *kharif* and *rabi* seasons, 404.5 mm and 123 mm of rainfall was recorded which was deficit of 16.2 and 114.8 mm as compared to normal (420.7 and 237.8 mm respectively).

Normal onset of monsoon	:	7 June
Onset of monsoon during 2017	:	6 June
Normal annual rainfall	:	723.5 mm
Annual rainfall during 2017-18	:	546.5 mm
Mean crop seasonal rainfall	:	420.7 mm and 237.8 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	404.5 and 123 mm during *kharif* and *rabi*, respectively

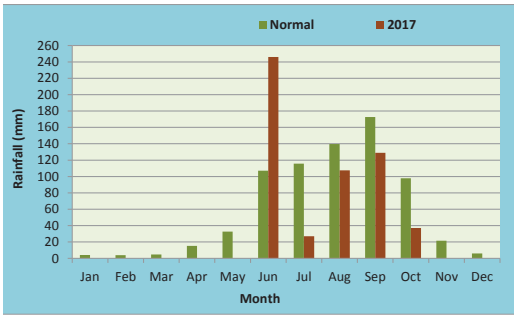


Fig.18: Normal and actual (2017) monthly rainfall at Solapur

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
19	17 June - 5 July	Pigeonpea and sunflower	Vegetative
28	20 July - 16 August	Pigeonpea and sunflower	
126	14 October to till harvesting	Sorghum and chickpea	Vegetative and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season and terminal drought	Sorghum, chickpea	Weeding and hoeing, protective irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid and terminal drought

Mid season and terminal drought of more than 100 days occurred affecting growth and yields of crops. Sorghum var. Revati with two supplemental irrigations, one irrigation (5 to 6 cm depth) at flag leaf stage and 2nd irrigation at grain filling stage (85-90 days) increased yield of sorghum (1050 kg/ha) by 34.6% over without irrigation (780 kg/ha), and gave higher net returns (11450/ha), B:C ratio (1.77) and WUE (28.4 kg/ha-mm).

Sorghum cv. Revati with supplemental irrigation

One weeding at 21 days stage and hoeing at 3rd, 5th and 8th week after sowing with peg tooth hoe increased the sorghum yield (833 kg/ha) by 11.1% over without weeding and intercultural operations (750 kg/ha), and gave higher net returns (5566/ha), B:C ratio (1.36) and RWUE (22.5 kg/ha-mm).

Sorghum cv. Revati with weeding and interculture

Improved chickpea var. Digvijay with foliar spray of 1% KNO_3 at 30 and 45 DAS increased yield of chickpea (600 kg/ha) by 15.4% as compared to local var. Dagadi without foliar spray (520 kg/ha), and recorded higher net returns (7000/ha), B:C ratio (1.50) and RWUE (16.2 kg/ha-mm).

Preparedness

Rainwater management

The grain yield of sorghum was increased by 23.5% (1124 kg/ha) due to adoption of moisture conservation practices (ridges and furrow in *kharif* followed by *rabi* sorghum) over farmer's practice (two harrowing only). *In-situ* moisture conservation also recorded higher RWUE (30.4 kg/ha-mm), net returns (12940/ha) and B:C ratio (1.84) compared to farmers' practice (Table 90).

Table 90: Effect of *in-situ* moisture conservation on yield and economics of *rabi* sorghum

Farming situation/ soil type	Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Medium deep black soils	Ridges and furrow in *kharif* followed by *rabi* sorghum	1124	15200	12940	1.84	30.37
	Farmers' practice (two harrowings)	910	14040	8710	1.61	24.59

The sorghum grain yield increased by 20.5% with compartment bunding in *kharif* season as compared to farmer's practice (two harrowings) and also recorded higher RWUE (28.1 kg/ha-mm), net returns (11000/ha) and B:C ratio (1.73) (Table 91).

Table 91: Effect of *in-situ* moisture conservation on yield and economics of sorghum

Farming s ituation/ soil type	Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2017-18	Mean grain (3 yrs)	Stover				
Medium deep black soils	Compartment bund in *kharif* season	1040	911	2660	15000	11000	1.73	28.10
	Farmers' practice (two harrowing s)	863	560	1680	14200	7375	1.51	23.32

Cropping systems

Improved varieties of sunflower (Phule Bhaskar) and pigeonpea (BDN-711) gave 23 and 23.3% higher yields, respectively over farmers practice (local varieties). Pigeonpea gave higher net returns (Rs. 21516/ha), B:C ratio (2.2) and RWUE (3.04 kg/ha-mm) compared to sunflower (Table 92)

Table 92: Performance of improved varieties of sunflower and pigeonpea

Farming situation/ Soil type	Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With improved practice	With normal practice				
Medium deep black soils	Sunflower	Phule Bhaskar	770	626	23.0	2.92	9470	1.65
	Pigeonpea	BDN -711	916	743	23.3	3.04	21516	2.20

Normal practice: Local varieties

Sunflower cv. Phule Bhaskar

Pigeonpea cv. BDN-711

Intercropping of pigeonpea and sunflower (1:2) with improved varieties BDN-711 and Phule Bhaskar increased the yield of both crops by 37.5% and also recorded higher net returns (Rs 23985/ha) and RWUE (1.83 kg/ha-mm) (Table 93).

Table 93: Performance of sunflower + pigeonpea intercropping with improved varieties

Farming situation/ Soil type	Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter crop				
Medium deep black soils	Pigeonpea (BDN-711) + sunflower (Phule Bhaskar)	550	635	19350	23985	2.23	1.83
	Farmers' practice with local varieties	350	550	17700	10350	1.58	1.33

Pigeonpea (BDN-711) + sunflower (Phule Bhaskar) intercropping (1:2)

Energy management

Sowing of *rabi* sorghum with two bowl fertilizer seed drill increased grain yield (1010 kg/ha), net returns (19260/ha), B:C ratio (2.4) and RWUE (12.78 kg/ha-mm) compared to farmers' practice (Table 94).

Table 94: Effect of sowing methods on yield and economics of *rabi* sorghum

Farming situation/ Soil type	Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain (2017-18)	Mean (4 years)	Stover				
Medium deep black soils	Sowing with two bowl fertilizer seed drill	1010	910	2260	15440	19260	2.40	12.78
	Farmers' method (local seed drill)	820	780	1870	13960	14200	2.01	10.39

1.1.9 VIJAYAPURA

a. Agro-ecological setting

Vijayapura 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 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

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was normal (7th June), and a rainfall of 765.1 mm was received which was excess by 170.7 mm (28.7%) compared to normal (594.4 mm). Out of total rainfall, *kharif* season (June- September) recorded 555.5 mm which was excess by 168.0 mm (43.4%) than seasonal normal of 387.5 mm. During *rabi*, it was 167.0 mm which was excess by 33.0 mm (24.6%) than normal (134.0 mm) and in summer 42.6 mm was recorded compared to normal rainfall of 66.1 mm (Fig.19).

Normal onset of monsoon	:	7 June
Onset of monsoon during 2017	:	7 June
Annual mean rainfall	:	594.4 mm
Annual rainfall during 2017-18	:	765.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	*kharif* 388.6 mm and *rabi* 134.2 mm
Crop seasonal rainfall during 2017-18 (*kharif* & *rabi*)	:	*kharif* 555.5 mm and *rabi* 167.0 mm

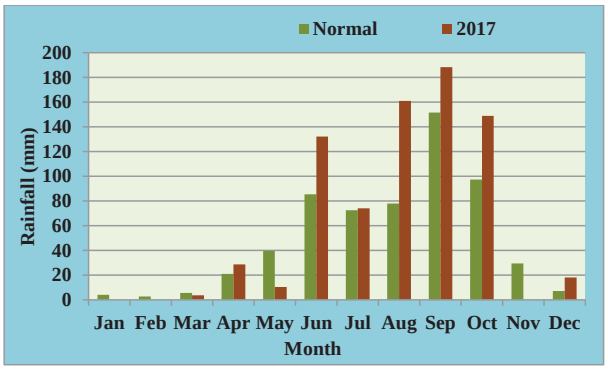


Fig 19: Normal and actual (2017) monthly rainfall at Vijayapura

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
18	21 June - 8 July	Pigeonpea, greengram, pearlmillet	Germination and seedling
25	13 July- 6 August	Pigeonpea, pearlmillet	Vegetative
10	18 - 27 September	Pigeonpea	Vegetative
52	17 October- 10 December	Pigeonpea	Flowering to pod development
		Chickpea	Vegetative
December 12 onwards there was no rainfall until harvest of chickpea			

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Pigeonpea	Mulching
	Chickpea	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Midseason drought

During 2017, a dry spell of 52 days occurred during 17 October - 10 December affecting the flowering and pod development of pigeonpea. Application of supplemental irrigation along with mulching in pigeonpea recorded significantly higher pigeonpea seed yield (777 kg/ha), net returns (Rs.29136/ha), B:C ratio (2.7) and WUE (1.31 kg/ha-mm) compared to other treatments and control (Table 95).

Irrigation at critical stages + mulching in pigeonpea

Table 95: Response of pigeonpea under deficit micro-irrigation from farm pond water

Treatment	Seed yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C Ratio
Irrigation at critical stages + mulch	777	1.31	29136	2.7
Irrigation at critical stages	752	1.27	27600	2.6
Irrigation after more than 20 days RTCP dry spells* + Mulch	536	0.90	15186	1.9
Irrigation after more than 20 days RTCP dry spells*	471	0.79	11264	1.7
Control	458	0.77	10460	1.6
CD at 5%	72	-	-	-

*Irrigation was not given because of no runoff harvested in farm pond

During 2017, a dry spell of 52 days occurred during 17 October - 10 December affecting the vegetative stage of chickpea. Foliar application of water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrients recorded significantly higher seed yield (1591 kg/ha), net returns (Rs.47078/ha), B:C ratio (3.8) and RWUE (77.0 kg/ha-mm) as compared to other treatments and control (Table 96). Statistically non significant results were recorded in case of foliar spray during dry spell and foliar spray after relieving of stress/ dry spell.

Table 96: Effect of foliar spray on chickpea yield and economics

Treatment	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Main plot					
M_1: Foliar spray during dry spell	1318	16167	36562	3.3	64
M_2: Foliar spray after relieving of stress / dry spell	1381	16167	39061	3.4	67
CD @ 5%	NS	-	-	-	-
Sub plot					
T_1: Urea @ 1%	1261	16100	34324	3.1	61

Treatment	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_2: Urea @ 2%	1293	16200	35501	3.2	63
T_3: Water soluble complex fertilizer (19:19:19) @ 0.5%	1503	16200	43929	3.7	73
T_4: T_3 + recommended dose of micronutrients for foliar spray	1591	16560	47078	3.8	77
T_5: Recommended dose of micronutrients for foliar spray	1445	16360	41450	3.5	70
T_6: Water spray	1222	16000	32894	3.1	59
T_7: Control	1131	15750	29506	2.9	55
CD @ 5%	170	-	-	-	-

c. On-farm demonstrations

Village profile

The program is being implemented by AICRPDA Centre, Vijayapura in Kavalagi village, Vijayapur tehsil, 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 to 90 m. The source of irrigation is open-wells and bore- wells covering 1.5% of cultivated area only.

Climate vulnerability in general

The climate 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 12.5% rainfall is received during summer. The historical data (30 years) indicated that variability in rainfall during south-west monsoon was manifested in delayed onset of monsoon and drought.

Experienced weather conditions during 2017-18

During 2017, in Kaulagi village the onset of monsoon was early by 1 day (6 June). An annual rainfall of 505.5 mm was received which was deficit by 46.4 mm (8.47%) than normal (594.4 mm). During *kharif*, there was a rainfall of 387.1 mm, dificit by 0.4 mm (0.1%) than normal (387.5 mm) and in *rabi* season 118.3 mm rainfall was recorded which was deficit by 15.7 mm (11.7%) against normal of 134 mm and during summer it was 42.6 mm, deficit by 23.6 mm (35.6%) than normal of 66.1 mm (Fig.20).

Normal onset of monsoon	:	7 June
Onset of monsoon during 2017	:	6 June
Annual mean rainfall	:	594.4 mm
Annual rainfall during 2017-18	:	505.5 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	*kharif* 387.5 mm and *rabi* 134.0 mm
Crop seasonal rainfall during 2017-18	:	*kharif* 387.1 mm and *rabi* 118.3 mm

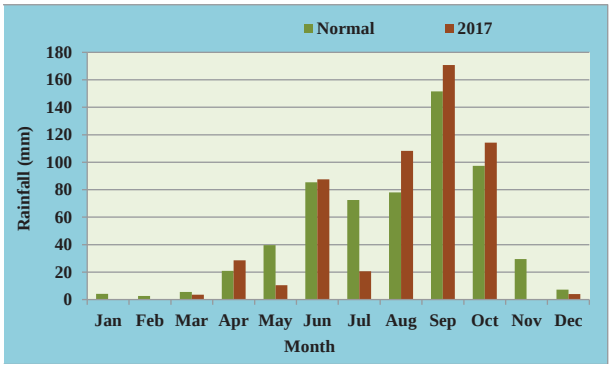


Fig.20: Normal and actual (2017) monthly rainfall at Kavalagi

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
30	9 July - 8 August	Pigeonpea and greengram	Vegetative
56	12 October - 5 December	Pigeonpea	Flowering to maturity
		Chickpea, sorghum and safflower	Vegetative
24	8 December - 31 December	Chickpea, sorghum and safflower	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Early season drought	Pigeonpea, chickpea, sorghum	Thinning and intercultivation
Mid season drought	Pigeonpea, chickpea, sorghum	Foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During 2017, a dry spell of 30 days occurred during 9 July to 8 August and another dry spell of 56 days during 12 October to coinciding with seedling and vegetative stage of *kharif* and *rabi* crops, respectively. Thinning and intercultivation increased the yield of the pigeonpea, chickpea and sorghum crops by 19.2 to 25.1% as compared to farmers' practice of no thinning and intercultivation. Among the crops, pigeonpea variety TS 3R gave higher net returns (Rs.41007/ha), RWUE (2.23 kg/ha-mm) and B:C ratio (3.5) compared to other crops (Table 97).

Table 97: Performance of crops under improved practices

Farming situation/ soil type	Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With improved practice	With farmers' practice				
Shallow black soils	Pigeonpea	TS 3R (135-145 days)	858	700	25.05	2.23	41007	3.5
	Chickpea	JG-11 (90-100 days)	1033	875	24.74	5.30	27911	3.3
	Sorghum	BJV-44 (115-120 days)	1154	979	19.19	5.72	16620	2.7

Farmers' practice: No thinning and intercultivation

Chickpea (JG-11)

Sorghum (BJV-44)

Situation: Mid season drought

At Kavalagi, two dry spells of 56 and 24 days occurred during 12 October - 15 December and 8-31 December coinciding with vegetative growth and flowering stage of pigeonpea, chickpea and sorghum. Foliar spray of KNO_3 @ 0.5% gave an average of 25.4, 25.6 and 19.8% higher yields in pigeonpea, chickpea and sorghum crops, respectively over farmers' practice of without foliar spray and recorded higher net returns, B:C ratio and RWUE (Table 98).

Table 98: Effect of foliar spray on crop yield and economics

Farming situation/ soil type	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				
Medium deep black soil	Pigeonpea	TS 3R (135-145 days)	954	738	25.44	2.22	40713	3.5
	Chickpea	JG-11 (90-100 days)	1217	979	25.59	5.43	28843	3.4
	Sorghum	BJV-44 (115-120 days)	1183	971	19.80	5.90	17424	2.8

Preparedness

Rainwater management

In-situ moisture conservation practice compartmental bunding in chickpea recorded highest seed yield (1200 kg/ha), net returns (Rs.40300/ha), B:C ratio (4.2) and RWUE (6.38 kg/ha-mm) over no compartmental bunding (Table 99).

Table 99: Effect of *in-situ* moisture conservation on yield and economics of chickpea

Farming situation/ soil type	Intervention	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
Medium deep black soil	Compartment bunding	1200	12500	40300	6.38	4.2
	Without compartment bunding	975	12000	30900	5.18	3.6

Cropping systems

In *rabi* season, sorghum and safflower based intercropping systems were demonstrated in the farmers fields. Among the intercropping systems, sorghum + chickpea (2:4) gave higher yield (MCEY 1574 kg/ha), net returns (Rs.28338/ha), B:C ration (3.6), RWUE (8.36 kg/ha-mm) and LER (1.33) followed by safflower + chickpea (2:4) intercropping system with MCEY of 1111/ha, net returns (Rs.21825/ha), RWUE (5.90 kg/ha-mm), B:C ratio (2.9) and LER (1.11) when compared to their respective sole crops sorghum, safflower and chickpea (1003, 694 and 795 kg/ha, respectively) (Table 100).

Safflower + chickpea (2:4)

Sorghum + chickpea (2:4)

Safflower (A-1)

Table 100: Effect of intercropping systems on crop yields and economics

Farming situation/ soil type	Intervention	Yield (kg/ha)		MCEY (kg/ha)	LER	MAI	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter crop						
Medium deep black soil	Sorghum + chickpea (2:4)	738	475	1574	1.33	9829	28338	3.6	8.36
	Sorghum + chickpea (2:4)	700	400	1404	1.20	5883	24100	3.2	7.46
	Sorghum + chickpea (2:4)	525	588	1559	1.26	8109	27975	3.5	8.28
	Sorghum + chickpea (2:4)	450	525	1374	1.11	3385	23350	3.1	7.30
	Safflower + chickpea (2:4)	488	425	1111	1.24	6394	21825	2.9	5.90
	Safflower + chickpea (2:4)	425	400	1012	1.12	3152	18850	2.6	5.38
	Sorghum (Sole)	1003	-	-	-	-	15569	2.6	5.33
	Safflower (Sole)	694	-	-	-	-	10813	2.1	3.69
	Chickpea (Sole)	795	-	-	-	-	19792	2.6	4.22

MAI: Monetary advantage index

Energy management

During *Kharif*, compartmental bunding helped in moisture conservation and also saved energy. On an average energy input for chickpea crop production was 4924 and 4876 MJ/ha in the field with compartment bunds and without compartment bunds, respectively. The energy ratio (output/input energy) was 9.09 in crops with compartment bunds while it was 7.55 in the crops without compartment bunds (Table 101).

Table 101: Effect of interventions on chickpea yield and energy use efficiency

Farming situation/ soil type	Intervention	Yield (kg/ha)	Energy (MJ/ha)		Energy use efficiency
			Input	Output	
Medium deep black soil	Compartment bunding	895	4924	44750	9.09
	Without compartment bunding	736	4876	36813	7.55

Land management units (LMU) based crop planning

On the bases of soil conservation unit (SCU) and soil quality units (SQU) the land management units (LMU) have been derived (Fig.21), which helps in moisture and soil conservation. There are a total of 14 LMUs in the adopted village. However, the results of three LMUs (I, II and III) were been compared. Higher chickpea and sorghum yields, net returns, RWUE and B:C ratios were recorded in LMU-I followed by LMU-II and LMU-III (Table 102).

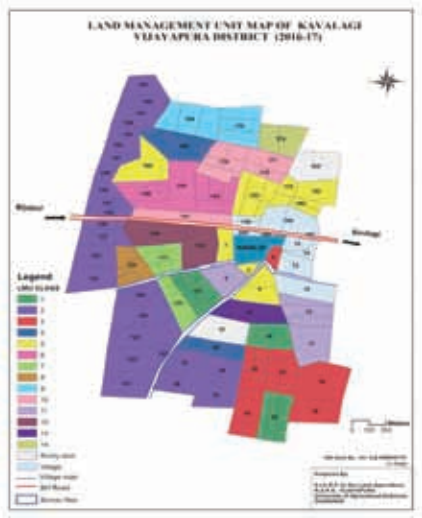


Fig.21: Land management units of Kavalagi village, Vijayapura district

Table 102: Performance of chickpea under different LMUs

Crop/variety	Land management unit (LMU)	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Chickpea (JG-11)	LMU-1	1181	12000	39975	3.3	6.3
Chickpea (JG-11)	LMU-2	1017	12000	32756	2.7	5.4
Chickpea (JG-11)	LMU-3	788	12000	22650	1.9	4.2
Sorghum (BJV-44)	LMU-1	1306	9500	23156	2.4	6.3
Sorghum (M 35-1)	LMU-2	1100	9500	18000	1.9	5.3
Sorghum (M 35-1)	LMU-3	825	9500	11125	1.2	4.0

LMU-III (Chickpea-JG-11)

LMU-I (Sorghum –BJV-44)

1.2 Moist Semi Arid Zone (750-1000 mm)

1.2.1 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 2017-18

During 2017, the onset of monsoon was normal (16th June) and a rainfall of 518.1 mm was received which was deficit by 256.7 mm (33.1%) compared to normal (774.8 mm) (Fig. 22). Out of total rainfall received, 455.3 mm was received during *kharif* season which was deficit by 211 mm compared to normal of 666.3 mm. During *rabi* (October-December), 62 mm of rainfall was received compared to normal of 66.8 mm. During summer (March-May), 0.3 mm of rainfall was received which was deficit by 23 mm compared to normal (23.3 mm).

Normal onset of monsoon	:	11-17 June (24th SMW)
Onset of monsoon during 2017	:	16 June
Annual mean rainfall	:	774.8 mm
Annual mean rainfall during 2017-18	:	518.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	666.3 and 66.8 mm, respectively
Crop seasonal rainfall during 2017-18	:	455.3 in *kharif* and 62 mm in *rabi*

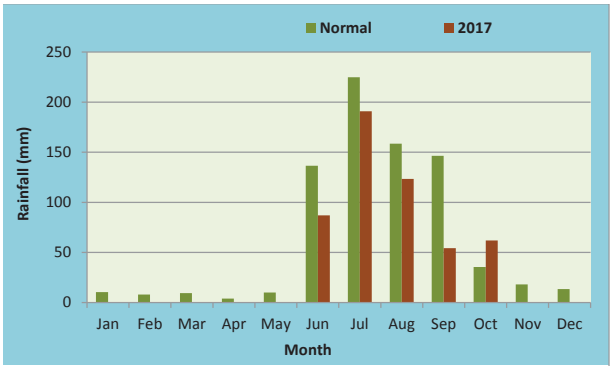


Fig.22: Normal and actual (2017) monthly rainfall at Akola

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
16	3 - 18 July	Soybean, cotton, Pigeonpea, greengram	Vegetative
14 & 8	1 - 14 August 21 - 29August	Soybean, greengram	Flowering
		Cotton, pigeonpea	Vegetative
9 & 11	01 - 09 September 20 - 30 September	Soybean	Pod initiation and development
		Greengram	Pod development
		Cotton	Square formation and boll initiation
		Pigeonpea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Cotton, soybean, sorghum, pigeonpea, greengram	Opening of furrows, mulching, foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* 2017, two dry spells of 14 and 9 days occurred during 1-14 & 21-29 August at flowering and pod development stage in pigeonpea. Opening of furrows + two foliar sprays of 2% urea and KCl at flowering and pod development stage (T_5) as well as two sprays of 2% urea and 2% KCl at flowering and pod development stage (T_4) recorded higher seed yield of 1123 and 1120 kg/ha, respectively (Table 103). Similar trend was recorded with respect to net returns. However, B:C ratio (1.84) was higher with opening of furrow + 2% urea and 2% KCl foliar sprays at flowering and pod development stage, followed by the opening of furrows (1.80).

Table 103: Effect of foliar spray and *in-situ* moisture conservation on pigeonpea (PKV Tara) yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ ha-mm)
	Seed	Stalk				
T_1 - Furrow opening	1057	2272	27928	22462	1.80	2.32
T_2 - Spray 2% urea	1060	2279	28512	22037	1.77	2.32
T_3 - Spray 2% KCl	1067	2293	28521	22346	1.78	2.34
T_4 - T2 + T3	1120	2408	30230	23180	1.77	2.46
T_5 - T1 + T4	1123	2415	29174	24395	1.84	2.46
T_6 - Control	1033	2222	27897	21380	1.77	2.27

During *kharif* 2017, intercropping system of soybean + pigeonpea (4:2) recorded the highest soybean equivalent yield of 1474 kg/ha, net returns (Rs. 11822/ha), B:C ratio (1.39) and RWUE of 1.50 kg/ha-mm with opening of furrow in each row after 30-35 DAS + two sprayings of 2% urea and 2% KCl at flowering and pod development stage (PDS) (T_5) followed by two sprays of 2% urea and KCl at flowering and PDS (T_4) and spraying of 2% urea at flowering (T_2) with yield of 1436 and 1412 kg/ ha, respectively. However, net returns and B:C ratio were higher in T_1 than rest of the treatments except T_5 (Table 104).

Table 104: Effect of *in-situ* moisture conservation and foliar spray on yield and economics of soybean + pigeonpea (4:2) intercropping

Treatment	Seed yield (kg/ha)		SEY	Cost of cultivation (Rs/ ha)	Net returns (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)
	Soybean	Pigeonpea					
T_1- Furrow opening	652	448	1398	28710	10891	1.38	1.43
T_2- Spray 2% Urea	656	454	1412	29303	10702	1.37	1.44
T_3- Spray 2% KCL	653	444	1394	29288	10204	1.35	1.43
T_4- T_2 + T_3	654	469	1436	29901	10783	1.36	1.43
T_5- T_1 + T_4	682	475	1474	29946	11822	1.39	1.50
T_6- Control	650	426	1360	28679	9848	1.34	1.42

SEY: Soybean equivalent yield

Preparedness

Cropping systems

Intercropping system of cotton + sorghum + pigeonpea + sorghum (3:1:1:1) with spacing of 45 cm gave higher cotton equivalent yield (713 kg/ ha) with furrow opening at 30-35 DAS followed by mulching and spraying of 2% urea at flowering and 2% DAP at boll and pod development stage of cotton and pigeonpea (709 and 698 kg/ha, respectively). However, B:C ratio (1.19) was higher in T_2 (furrow opening in each row at 30-35 DAS) than rest of the treatments (Table 105).

Table 105: Effect of *in-situ* moisture conservation in intercropping system of cotton + sorghum + pigeonpea + sorghum (3:1:1:1)

Treatment	Yield (kg/ha)			CEY (kg/ ha)	Cost of cultivation (Rs/ ha)	Net returns (Rs/ ha)	B:C ratio	RWUE (kg/ ha-mm)
	Cotton	Intercrop						
		Sorghum	Pigeonpea					
T_1- Control	355	519	97	661	28080	3152	1.11	0.78
T_2- Furrow opening at 30-35DAS	378	575	104	713	28276	5469	1.19	0.83
T_3- Mulching	390	525	107	709	29876	3503	1.12	0.86
T_4-2 foliar sprays*	384	528	101	698	29302	3592	1.12	0.84

*Spray of 2% urea at flowering and 2% KCl at boll & pod development stage of cotton and pigeonpea; CEY: Cotton equivalent yield

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. 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 2017-18

During 2017, the onset of monsoon was on 14th June. A rainfall of 530 mm was received which was deficit by 262.8 mm compared to normal (792.8 mm) (Fig.23). During *kharif* season (June to September), 462 mm of rainfall was received which was deficit by 226 mm as compared to normal (688 mm). During *rabi* season (October - December), 68 mm rainfall was received which was deficit by 14 mm compared to normal (82 mm). During summer, there was no rainfall compared to normal (22.8 mm).

Normal onset of monsoon	:	11-17 June
Onset of monsoon during 2017	:	14 June
Annual mean rainfall	:	792.8 mm
Annual rainfall during 2017-18	:	530.0 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	688 and 82 mm, respectively
Crop seasonal rainfall during 2017-18	:	462 and 68 mm, during *kharif* and *rabi*, respectively

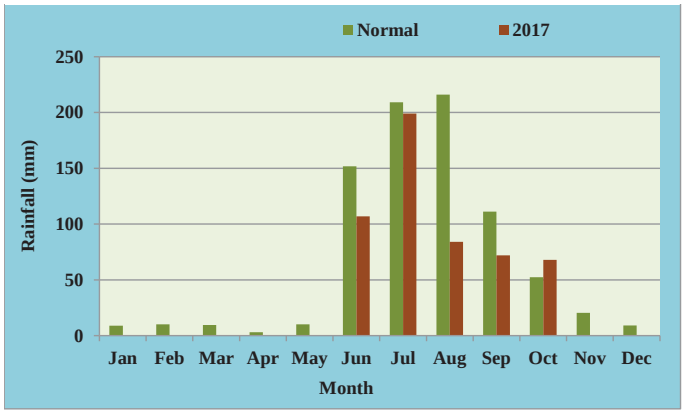


Fig.23: Normal and actual (2017) monthly rainfall at Varkhed

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
11	05 - 15 July	Soybean, cotton, Pigeonpea, greengram	Vegetative
15 and 7	1 - 14 August 22 - 29 August	Soybean, greengram	Flowering
		Cotton and pigeonpea	Vegetative
9 and 11	1 - 9 September 20 - 31 September	Soybean	Pod initiation and development
		Greengram	Pod development
		Cotton	Square formation and boll initiation
		Pigeonpea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Soybean, cotton	Opening of furrow in each row after 30-40 DAS Protective irrigation
Terminal drought	Cotton	Spraying of 2% urea at flowering and 2% DAP at boll development stage
	Pigeonpea	Mulching

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

A dry spell of 9 days occurred during 1-9 September. Application of one protective irrigation from farm pond at pod development stage in soybean resulted in higher mean yield of 1381 kg/ha over the farmers' practice of no protective irrigation (1104 kg/ha), with higher net returns (Rs. 16202/ha), B:C ratio (1.68) and WUE (3.03 kg/ha-mm) (Table 106).

Table 106: Effect of protective irrigation on yield and economics of soybean

Farming situation/ soil type	Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed	Stalk				
Medium deep black soils	Protective irrigation	1381	1861	23941	16202	1.68	3.03
	Farmers' practice (no irrigation)	1104	1380	23580	8498	1.36	2.42

In-situ moisture conservation through opening of furrows in each row after 30-35 DAS of soybean recorded higher seed yield of 1206 kg/ha as compared to farmers practice of without furrow opening (1123 kg/ha) (Table 107).

Table 107: Effect of furrow opening on yield and economics of soybean (JS-335)

Farming situation/ soil type	Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium deep black soils	Farmers' practice	1123	2.46	9042	1.38
	Furrow opening	1206	2.64	13224	1.55

In cotton, opening of furrow in each row after 30-40 DAS of cotton for *in-situ* moisture conservation recorded higher seed cotton yield of 1056 kg/ha as compared to farmers' practice of no furrow opening (981 kg/ha), with higher net returns (Rs. 7652/ha) and B:C ratio of 1.18 (Table 108).

Table 108: Effect of furrow opening on yield and economics of cotton (Mallika)

Farming situation/ soil type	Intervention	Seed cotton yield (kg/ha)	RWUE (kg /ha-m)	Net returns (Rs/ ha)	B:C ratio
Deep black soils	Without opening of furrow	981	1.90	4068	1.10
	With opening of furrow	1056	1.23	7652	1.18

Foliar spray of 2% urea at the time of flowering along with 2% DAP at boll development stage in cotton resulted in higher seed cotton yield (1268 kg/ha) as compared to farmers' practice of no foliar spray (1169 kg/ha), with higher net returns (Rs.16709/ha) and B:C ratio (1.38) (Table 109).

Table 109: Effect of foliar spray on cotton yield and economics

Farming situation/ soil type	Intervention	Seed cotton yield (kg/ha)	RWUE (kg/ ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep black soils	With foliar spray	1268	1.47	16709	1.38
	Without foliar spray	1169	2.26	12037	1.28

Preparedness

Rainwater management

One protective irrigation at sowing and two protective irrigations (at sowing and before flowering) in chickpea resulted in higher seed yield of 1209 and 1297 kg/ha over control (1006 kg/ha). Similarly, higher B:C ratio (1.79 and 2.29) and net returns (Rs 19391 and Rs 32000/ha) were recorded with one and two protective irrigations, respectively as compared to control (Table 110).

Table 110: Effect of protective irrigations on yield and economics of chickpea (JAKI-9218)

Farming situation / soil type	Treatment	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Deep black soils	Control	1006	12270	1.51
	One protective irrigation	1209	19391	1.79
	Two protective irrigations	1297	32000	2.29

Cropping systems

Early maturing soybean varieties, JS-335 (maturity 100-110 days), JS-9305 (maturity 95-100 days) & JS-9560 (maturity 90-95 days) were demonstrated. Among these varieties, early maturing variety, JS-95-60 recorded higher seed yield (1193 kg/ha), net returns (Rs12844/ha), B:C ratio (1.54) and RWUE of 2.62 kg/ha-mm followed by JS-93-05 (1140 kg/ha) compared to regular variety (JS-335) (Table 111).

Table 111: performance of early varieties of soybean

Farming situation/ soil type	Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium deep black soils	JS-335	1087	2.38	8012	1.34
	JS-9305	1140	2.60	11286	1.48
	JS-95-60	1193	2.62	12844	1.54

Soybean + pigeonpea (4:2) intercropping system recorded 15.9% higher soybean equivalent yield (2034 kg/ha) as compared to farmers' practice of soybean + pigeonpea (6:1) system (1758 kg/ha), with higher net returns (Rs. 29508/ha) and B:C ratio (2.00) (Table 112).

Table 112: Performance of soybean + pigeonpea (4:2) intercropping system

Farming situation/ soil type	Cropping system	Soybean equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium deep black soils	Soybean + pigeonpea (4:2)	2034	2.12	29508	2.00
	Soybean + pigeonpea (6:1)	1758	2.12	21349	1.72

Among cotton based intercropping systems, the increase in cotton equivalent yield was 19.8, 55.2 and 28.3% (1452, 1882 and 1555 kg/ha) with cotton + greengram (1:1), cotton + cowpea (1:1) and cotton + clusterbean (1:1) intercropping systems as compared to sole cotton (1212 kg/ha). Cotton + cowpea (1:1) intercropping system gave higher net returns (Rs 32527/ha) and B:C ratio (1.58) compared to other cropping systems (Table 113).

Table 113: Effect of cotton based intercropping system on productivity 12farmers

Farming situation/ soil type	Cropping system	CEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium deep black soils	Cotton + greengram (1:1)	1452	1.87	20424	1.42
	Cotton + cowpea (1:1)	1882	3.64	32527	1.58
	Cotton + clusterbean (1:1)	1555	3.00	20290	1.38
	Sole cotton	1212	2.34	13896	1.32

CEY: Cotton equivalent yield

1.2.2 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 2017-18

During 2017, the onset of monsoon was delayed by 4 days (6th June). A rainfall of 1113.3 mm was received which was excess by 192.9 mm (21%) compared to normal (920.4 mm) (Fig.24). During *kharif* season (June-September), 571.9 mm rainfall was recorded which was excess by 63.6 mm (12.5%) against normal of 508.3 mm. In *rabi* season, rainfall was 283.2 mm which was excess by 29.3 mm (11.5%) than the normal of 253.9 mm and in summer, 258.2 mm rainfall was recorded and was excess by 83.4 mm (47.7%) than normal of 174.8 mm.

Normal onset of monsoon	:	2 June
Onset of monsoon during 2017	:	6 June
Annual mean rainfall	:	920.4 mm
Annual rainfall during 2017-18	:	1113.3 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	:	508.3 & 253.9 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* & *rabi)*	:	571.9 & 283.2 mm, respectively

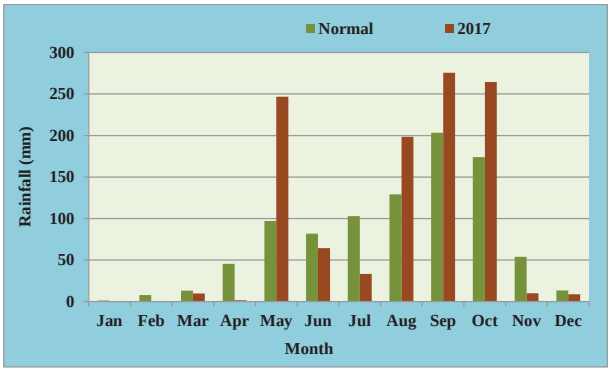


Fig.24: Normal and actual (2017) monthly rainfall at Bengaluru

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
18	17 October - 4 November	Fingermillet	Panicle initiation to grain filling
		Pigeonpea	Vegetative to flowering
		Field bean, cowpea	Flowering to pod filling
22	8 November to till crop harvest	Pigeonpea, field bean, cowpea	Harvesting stage
		Pigeonpea	Flowering to pod formation

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Fingermillet	-	Improved varieties, transplanting
Mid season drought	Fingermillet	Panicle initiation	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During the year, the onset of monsoon was delayed by 4 days. Fingermillet varieties with long (MR-6) (120-130days), medium (GPU-28) (110-120 days) and short (GPU-48) (105-110 days) duration were sown at fortnightly interval during July and August. Long duration variety of fingermillet (MR-6) recorded higher grain yield (4292, 3250 and 4750kg/ha) when sown during 1st fortnight of July, 1st and 2nd fortnight of August, respectively compared to other medium and long duration varieties. However, GPU-28 (4583kg/ha) performed better for July 2nd fortnight sowing (Table 114).

Table 114: Performance of fingermillet varieties under different sowing windows

Sowing time	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw			
July first fortnight (12th July)	GPU-48	2417	3975	3.27	29067	2.15
	GPU-28	4083	5608	5.52	64836	3.57
	MR-6	4292	5633	5.81	69054	3.74

Sowing time	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw			
July second fortnight (30th July)	GPU-48	4425	5742	5.98	71877	3.85
	GPU-28	4583	5800	6.19	75124	3.98
	MR-6	2917	3667	3.94	38605	2.53
August first fortnight (10th August)	GPU-48	2250	3542	3.07	25077	1.99
	GPU-28	2392	3708	3.26	28166	2.12
	MR-6	3250	5375	4.43	47827	2.90
August second fortnight (30th August)	GPU-48	2833	3692	4.67	36962	2.46
	GPU-28	3850	5633	6.34	60214	3.39
	MR-6	4750	6467	7.83	79465	4.15

Among different methods of establishment, transplanting of fingermillet recorded higher grain and straw yield (7583 and 10500 kg/ha), net returns (Rs.111664/ha), B:C ratio (5.72) and RWUE of 9.43 kg/ha-mm compared to other methods of establishment (Table 115).

Table 115: Yield of fingermillet as influenced by different methods of establishment

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Transplanting	6583	10500	48.1	9.43	111664	4.66
Dry sowing	4250	7883	40.8	6.09	64744	4.20
DAP + seed drill sown	4058	7467	37.5	5.82	60404	3.91
Normal method of sowing	3417	4667	-	4.89	50105	2.98

Transplanted fingermillet

Dry sown fingermillet

DAP + seed drill sown fingermillet

Situation: Mid season drought

Foliar spray in fingermillet during dry spell recorded higher grain and straw (4478 and 7421 kg/ha) yield compared to foliar spray after relieving of stress/dry spell (3864 and 6242 kg/ha), respectively. Among different sources of nutrients, foliar spray with recommended dose of micronutrient (borax at 75 g/ha and zinc sulphate at 75 g/ha) recorded higher grain yield (4897 kg/ha) compared to control (4407 kg/ ha).The interaction effect among different foliar sprays on grain yield of fingermillet was found to be non-significant (Table 116).

Table 116: Fingermillet yield as influenced by different foliar sprays

Treatment	Yield (kg/ha)		Net returns (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw			
Main plot					
M_1: Foliar spray during dryspell	4478	7421	74457	3.84	6.48
M_2: Foliar spray after relieving of stress/ dry spell	3864	6242	60440	3.31	5.59
CD at 5%	NS	NS	-	-	-

Treatment	Yield (kg/ha)		Net returns (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw			
Subplot					
T_1:Urea @1%	4312	7003	71039	3.76	6.24
T_2:Urea @ 2%	4575	7744	77374	4.01	6.62
T_3:Water soluble complex fertilizer (19: 19: 19) @ 0.5%	4107	7006	66173	3.50	5.94
T_4:T_3 + recommended dose of micronutrient as foliar spray*	3613	6181	53803	2.94	5.23
T_5:Recommended dose of micronutrient as foliar spray	4897	7121	81692	4.03	7.09
T_6:Water spray	3283	5594	48402	2.89	4.75
T_7:Control (no spray of any nutrient/ water)	4407	7171.50	73655	3.92	6.38
CD at 5%	NS	NS	-	-	-

*Recommended dose of micronutrient as foliar spray: Borax @ 75 g/ha and zinc sulphate @75 g/ha

Preparedness

Cropping systems

In an assessment of risk resilient fingermillet based cropping systems, fingermillet (GPU-28) + transplanted pigeonpea (BRG-2) in 8:2 ratio with conservation furrow between paired rows of pigeonpea recorded higher fingermillet equivalent yield (4545 kg/ha), net returns (Rs. 62069/ha) and B:C ratio (3.15) compared to other treatments (Table 117).

Table 117: Performance of fingermillet based intercropping systems

Cropping system	Yield (kg/ha)		FEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop				
Fingermillet (MR-6) + pigeonpea (BRG-2) (DS)	3667	222	4111	5.89	54389	2.95
Fingermillet (MR-6) + pigeonpea (BRG-2) (TP)	4083	231	4545	6.04	62069	3.15
Fingermillet + akkadi	2917	14	2945	4.22	29874	2.03

DS: Direct sown pigeonpea, TP: Transplanted pigeonpea, FEY: Fingermillet equivalent yield

Fingermillet + pigeonpea (TP)

Fingermillet + *akkadi*

Among pulse based intercropping systems, pigeonpea + field bean (1:1) recorded higher pigeonpea equivalent yield (988 kg/ha) compared to sole pigeonpea (422 kg/ha) with higher net returns (Rs.12628/ha), B: C ratio (1.40) and RWUE of 1.05 kg/ha-mm (Table 118).

Table 118: Evaluation of pigeonpea based intercropping systems

Cropping system	Yield (kg/ ha)		PEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop				
Pigeonpea (BRG-2) + soybean (1:1)	563	138	721	0.76	1073	1.03
Pigeonpea (BRG 2) + cowpea (1:1)	545	304	850	0.90	10918	1.35
Pigeonpea (BRG 2) + field bean (1:1)	554	433	988	1.05	12628	1.40
Sole pigeonpea (BRG-5)	422	-	422	0.87	-12062	0.58

PEY: Pigeonpea equivalent yield

Pigeonpea + field bean (1:1) system

Sole pigeonpea

c. On-farm demonstrations

Village profile

The programme 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 2017-18

During the year 2017, in Chikkamaranahalli village, onset of monsoon was delayed by 9 days (11th June). A rainfall of 758.8 mm was received which was excess by 5.4 mm (0.7%) compared to normal (753.4 mm). Out of total rainfall, *kharif* season received 454.8 mm, which was excess by 39.7 mm (9.6%) compared to normal of 415.1 mm (Fig.25). *Rabi* season received 166 mm which was

deficit by 75.6 mm (31.3%) compared to normal of 241.6 mm and in summer, it was 138 mm against normal of 95.6 mm which was excess by 42.4 mm (44.4%).

Normal onset of monsoon	:	2 June
Onset of monsoon during 2017	:	11 June
Annual mean rainfall	:	753.4 mm
Annual mean rainfall during 2017-18	:	758.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	415.1 & 241.6 mm, respectively
Crop seasonal rainfall during 2017-18 *(kharif* and *rabi)*	:	454.8 & 166 mm, respectively

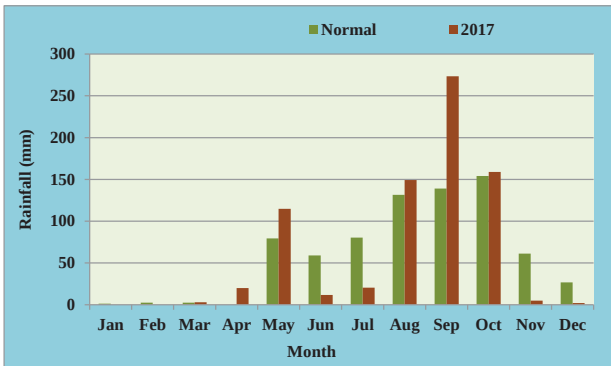


Fig.25: Normal and actual (2017) monthly rainfall at Chikkamaranahalli

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
20	17 June -5 July	Field bean, cowpea	Vegetative
20	7 - 27 July	Fingermillet, pigeonpea	Germination
		Field bean, cowpea	Flowering to pod filling
21	16 October - 5 November	Fingermillet	Grain filling
		Pigeonpea	Flowering
25	7 - 30 November	Fingermillet	Dough stage
		Pigeonpea	Pod filling
33	2 November - 5 January	Pigeonpea	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Delayed onset of monsoon	Finger millet	Suitable varieties, transplanting
Early season drought	Finger millet, pigeonpea	Opening of conservation furrows

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2017, the onset of monsoon was delayed by 9 days. Among different varieties of fingermillet, long duration (120-125 days) variety (MR-6) recorded higher grain yield, net return and B: C ratio (2610 kg/ ha, Rs. 58989/ha and 3.34, respectively) compared to medium duration (110-115 days) variety (GPU-28) and short duration (100-105 days) variety (GPU-48) (Table 119).

Table 119: Performance of different fingermillet varieties

Farming situation	Variety	Date of sowing	Yield (kg/ha)		RWUE (kg/ha-mm)	Net return (Rs/ha)	B:C ratio
			Grain	Straw			
Upland-loamy sand	MR-6	29-07-2017	2610	3950	4.38	58989	3.34
	GPU-28	09-08-2017	2520	3770	4.31	30819	2.22
	GPU-48	17-08-2017	2490	3600	4.85	29964	2.19

Transplanted fingermillet (MR-6) (20-25 days old seedlings) recorded higher grain yield (2625 kg/ha), net returns **(**Rs**.** 29866/ha) and B: C ratio (2.12) as compared to direct sown fingermillet (Table 120).

Table 120: Performance of transplanted and direct sown fingermillet

Farming situation	Treatment	Duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Grain	Straw			
Upland-loamy sand	Transplanting	87	2695	2910	5.11	29866	2.12
	Direct sown	113	2152	2879	4.19	22068	1.87

Transplanted fingermillet

Direct sown fingermillet

Situation: Early season drought

During 2017, intercropping of fingermillet (MR-6) + pigeonpea (BRG-2) in 8:2 with (*in-situ* moisture) conservation furrow between paired rows of pigeonpea recorded higher fingermillet equivalent yield, net returns and B: C ratio (2483 kg/ha, Rs. 52678 /ha and 2.89, respectively) compared to farmers practice of growing fingermillet + *Akkadi* cropping with an yield advantage of 21 % (Table 121).

Table 121: Effect of *in-situ* moisture conservation in fingermillet + pigeonpea (8:2) intercropping system

Farming situation/ Soil type	Crop	Duration (days)	FEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland- loamy sand	Fingermillet + pigeonpea (8:2) with *in-situ* moisture conservation	147	2483	4.21	52678	2.89
	Fingermillet + *Akkadi*	128	1962	3.42	17646	1.61

FEY: Fingermillet equivalent yield

Fingermillet + pigeonpea (8:2) with conservation furrow

Fingermillet + *Akkadi*

Preparedness

Rainwater management

For adoption of ground water recharge, two bore wells were made by excavation of pits and filling of materials. Observations were recorded twice in a week at Hosapalya, Nelamangala during 2017. After imposing recharge treatment, the average discharge rate of bore well with filter bed was 9.15 l/min throughout the year.

Cropping systems

Among pulse based intercropping systems, pigeonpea (BRG-1) + cowpea (1:1) system recorded higher pigeonpea equivalent yield (1221 kg/ha), net returns (Rs.11151/ha) and B:C ratio (1.29) while the farmers' practice of sole pigeonpea gave lower pigeonpea equivalent yield (523 kg/ha) with negative net returns (Rs. -10637/ha) (Table 122).

Table 122: Yield and economics of pulse based intercropping systems

Farming situation/ Soil type	Crop	PEY (kg/ ha)	% increase in yield	RWUE (kg/ ha-mm)	Net returns (Rs/ ha)	B:C ratio
Upland-Loamy sand	Pigeonpea + cowpea (1:1)	1221	57.16	2.19	11151	1.29
	Pigeonpea + field bean (1:1)	1202	56.48	2.42	10222	1.26
	Sole pigeonpea	523	-	1.34	-10637	0.61

PEY: Pigeonpea equivalent yield, Date of sowing: 17th May, Duration (days): 184

Pigeonpea + cowpea (1:1)

Pigeonpea + field bean (1:1)

Among different weed management practices in groundnut, pre-emergence spray of alachlor @ 2.5 l/ha coupled with one hand weeding recorded higher pod yield (2770 kg/ha), net returns (Rs. 83675/ha) and B:C ratio (4.08) compared to control (Table 123).

Table 123: Yield and economics of groundnut as influenced by weed management treatments

Farming situation/ soil type	Treatment	Pod yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Upland-loamy sand	Pre-emergence spray of alachlor @ 2.5 l/ha + one hand weeding	2470	63267	2.78	3.32
	Two hand weedings	1950	41767	1.68	2.62
	Control (weed check)	923	2187	1.41	1.24

Similarly, in fingermillet, pre-emergent spray of pendimethalin @ 1.5 l/ha coupled with one hand weeding recorded higher grain yield (4250 kg/ha) and B:C ratio (4.20) compared to traditional method of hand weeding twice (Table 124).

Table 124: Yield of fingermillet as influenced by weed management

Farming situation/ soil type	Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B: C ratio	RWUE (kg/ha-mm)
		Grain	Straw			
Upland-loamy sand	Pre-emergent spray of pendimethalin @ 1.5 l/ha + with one hand weeding	4250	5417	64744	4.20	9.13
	Hand weeding twice	3217	4667	46103	2.83	4.61

Nutrient management

Application of 100% RDF + 12.5 kg/ha of $ZnSO_4$ in fingermillet (MR-6) + pigeonpea (BRG-2) (8:2) intercropping system recorded higher finger millet equivalent yield (3016 kg/ha), net returns (Rs. 34844/ha) and B:C ratio (2.16) compared to application of only 100% RDF (Table 125).

Table 125: Effect of nutrient management on fingermillet + pigeonpea (8:2) intercropping

Farming s ituation/ Soil type	Treatment	FEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland-loamy sand	100% RDF + 12.5 kg/ha of $ZnSO_4$/ha	3016	4.67	34652	2.16
	100% RDF	2749	4.26	31418	2.12

FEY: Finger millet equivalent yield, Date of sowing: 7th July to 29th July

1.2.3 INDORE

a. Agro-ecological setting

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 2017-18

During 2017, the onset of monsoon was normal (11th June), and an annual rainfall of 880.4 mm was received which was deficit by 77.6 mm compared to normal (958 mm). During south-west monsoon (*kharif),* the rainfall received was 871.9 mm against the normal (854.5 mm) which was excess by 17.4 mm. During winter (October-December), 1.4 mm rainfall was received which was deficit by 63.1 mm (97.8%) compared to normal (64.5 mm). During summer, 7.1 mm rainfall was received which was deficit compared to normal (30.6 mm).

Normal onset of monsoon	:	12-18 June
Onset of monsoon during 2017	:	11 June
Annual mean rainfall	:	958 mm
Annual rainfall during 2017-18	:	880.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	854.5 and 64.5 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi)*	:	871.9 and 1.7 mm, respectively

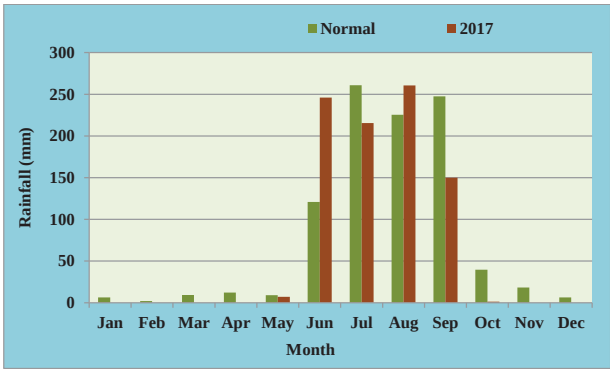


Fig.26: Normal and actual (2017) monthly rainfall at Indore

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
9	4-12 July	Soybean	Seedling and vegetative
19	31 July -18 August	Soybean	Flowering
12	01-12 September	Soybean	Pod filling

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Soybean	Early vegetative	Weeding, interculture
Mid season drought	Soybean	Flowering	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

During *kharif* season, there was a dry spell of 9 days (4-12 July) coinciding with the seedling and vegetative stage of soybean. Planting soybean in raised bed enhanced the yield by 8.3% (762 kg/ha) over sunken bed (697 kg/ha) system of planting. Similarly, higher net returns (2845/ha) and B:C ratio (1.14) was recorded with raised bed planting system (Table 126).

Table 126: Effect of land configuration on soybean (RVS 2001-4) yield and economics

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Raised bed	762	144	2845	1.14
Sunken bed	697	83	921	1.05

In-situ moisture conservation practice of weeding/interculture during the moisture stress conditions reduced the soil moisture losses and increased the soybean yield by 19.5% (938 kg/ha), net returns (Rs.8140/ha) and B:C ratio (1.41) when compared to without weeding/intercultural operations (758kg/ha) (Table 127).

Table 127: Effect of weeding/interculture on soybean (JS 95-60) yield and economics

Treatment	Seed yield (kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio
With weeding	938	19.5	8140	1.41
Without weeding	758	-	2740	1.14

* One intercultural at seedling stage on 9 July 2017 and one interculture by doura on 1 August, 2017

Situation: Mid season drought

During *kharif* 2017, there was a dry spell of 19 days coinciding with the flowering stage of soybean. All the treatments of foliar spray increased the yield of soybean by 3.7 to 45.4%. Foliar spray of 2% urea at 35 DAS (branching and flower initiation stage) recorded higher soybean seed and stalk yield (996 and 3700 kg/ha), net returns (Rs.9360/ha) and B:C ratio (1.46) closely followed by spray of 2% 19:19:19 NPK + Trizaophos @ 800 ml/ha and chlormequat chloride 50% @375 ml/ha (994 and 980 kg/ha) (Table 128).

Table 128: Effect of foliar spray on soybean yield and economics during mid season drought

Treatment	Yield (kg/ha)		% increase in seed yield	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk				
T_1: Farmers' practice (control)	685	2642	-	19500	1050	1.05
T_2: Water spray	710	3267	3.65	20000	1300	1.07
T_3: Spray of Chlormequat chloride (VAM-C) 50% @ 375 ml/ha	980	3565	43.07	20360	9044	1.44
T_4: Spray of thiourea @ 250 g/ha	824	3154	20.29	20317	4400	1.22
T_5: Spray of 2% 19:19:19 NPK	923	3338	34.74	20320	7380	1.36
T_6: T5 + Trizaophos @ 800 ml/ha	994	3693	45.11	20620	9211	1.45
T_7: Spray of urea @ 2%	996	3700	45.40	20520	9360	1.46

Preparedness

Cropping systems

Among different soybean varieties, JS 20-29 produced highest yield (1943 kg/ha) with higher net returns (Rs.38290/ha) and B:C ratio (2.91), followed by JS 20-34 (1305kg/ha) (Table 129).

Table 129: Performance of soybean varieties

Variety	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
JS 20-29	1943	20000	38290	2.91
JS 20-34	1305	20000	19150	1.95
JS 95-60	953	20000	8590	1.42
NRC 86	685	20000	550	1.02
Local-1025	385	20000	(-) 8450	

Among different chickpea varieties, JAKI 9218 gave higher seed yield (813 kg/ha), net returns (Rs.22585/ha) and B:C ratio (2.61) followed by JG 593 (664 kg/ha) (Table 130).

Table 130: Performance of chickpea varieties

Variety	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
JAKI 9218	813	14000	22585	2.61
JG 593	664	14000	15880	2.13
JG 130	547	14000	10615	1.76

Among the pigeonpea varieties, JKM 189 produced higher seed yield (1692 kg/ha), net returns (Rs.64600/ha) and B:C ratio (4.23) closely followed by ICP 8863-08-39 (1597 kg/ha) (Table 131).

Table 131: Performance of pigeonpea varieties

Varieties	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
JKM 189	1692	20000	64600	4.23
ICP 8863-08-39	1597	20000	59850	3.99
TJT 501	1446	20000	52300	3.62

Date of sowing-26.06.2017

c. On-farm demonstrations

Village profile

The program is being implemented in Nignoti village, Indore district, Madhya Pradesh. The total cultivated area is 248 ha out of which 100 ha is rainfed. The mean annual rainfall is 958 mm with seasonal rainfall of 854.5 mm during *kharif* (June-September). 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 zone is semi-arid. The south-west monsoon contributes 90–94%, winter rains contribute 3-6% and summer rain contribute 3-4% of the total annual average rainfall of 958 mm. The normal 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 2017-18

During 2017, the onset of monsoon was normal (11th June) and annual rainfall of 763.6 mm was received which was deficit by 194.4 mm compared to normal (958.0 mm) (Fig.27). During south-west monsoon (*kharif),* 734.5 mm of rainfall was received where as the normal was 854.5 mm, which was deficit by 120 mm (14%). During winter, 19.4 mm of rainfall was received against the normal of 64.5 mm and in summer, 9.7 mm of rainfall was received against 30.7 mm.

Normal onset of monsoon	:	12-18 June
Onset of monsoon during 2017	:	11 June
Annual mean rainfall	:	958.0 mm
Annual rainfall during 2017-18	:	763.6 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	854.5 and 64.5, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	734.5 and 19.4 mm, respectively

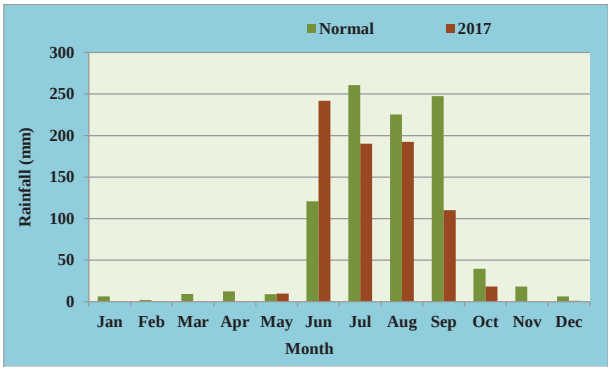


Fig.27 : Normal and actual (2017) monthly rainfall at Nignoti

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
10	3-12 July	Soybean, maize, pigeonpea	Seedling
13	1-13 August	Soybean, maize, pigeonpea	Vegetative, early flowering
7	24-30 September	Soybean, maize, pigeonpea	Late maturity, vegetative (pigeonpea)

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Early season drought	Soybean	Interculture, fliar spray
	Pigeonpea, maize	Interculture

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

At Nignoti village, a dry spell of 10 days occurred during 3-12 July coinciding with seedling and early vegetative stage of soybean. Foliar spray increased the yield of soybean by 3.3 to 11.7% when compared to farmer's practice of no foliar spray. Among the soybean varieties, 1025(1) gave higher seed yield (1800 kg/ha), net returns (Rs.34900/ha), B:C ratio (6.71) and RWUE (2.45 kg/ha-mm) with foliar spray of thiourea during dry spell (Table 132)

Table 132: Effect of foliar spray on the yield and economics of soybean

Farming situation/ soil type	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray				
Medium deep black soil	**Foliar spray of VAM C @ 375 ml/ha**						
	JS95-60	1620	1473	9.1	2.21	29210	5.62
	1025	1720	1530	11.1	2.34	32460	6.24
	Foliar spray of thiourea @ 250 g/ha						
	JS95-60	1588	1473	7.1	2.16	28434	5.47
	1025	1800	1590	11.7	2.45	34900	6.71
	JS93-05	1513	1465	3.1	2.06	26131	5.02
	Foliar spray of 19.19.19 @ 2%						
	JS95-60	1568	1465	6.5	2.13	27824	5.35
	1025	1720	1535	10.8	2.34	32460	6.24
	JS93-05	1516	1465	3.3	2.07	26246	5.05

Preparedness

Cropping systems

During *rabi* 2017-18, among the chickpea varieties, JAKI 9218 produced 6.5% higher seed yield (1175 kg/ha), net returns (Rs.27800/ha), B:C ratio (1.92) and RWUE of 1.60 kg/ha-mm compared to Vishal (Table 133).

Table 133: Effect of *in-situ* rainwater management on chickpea

Farming situation/ soil type	Variety	Seed yield (kg/ha)	RWUE kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium deep black soil	JAKI 9218	1175	1.60	27800	1.92
	Vishal	1145	1.56	26720	1.84

During *kharif* 2017, soybean varieties RVS2001-4 and JS-20-34 produced higher seed yield of 1558 and 1707 kg/ha with net returns of Rs.27512 and 32053/ha, B:C ratio of 1.38 and 1.60 and RWUE of 2.12 to 2.32 kg/ha-mm, respectively compared to local varieties JS93-05 and JS95-60 (1412 and 1572 kg/ha, respectively) (Table) .

1.2.4 PARBHANI

a. Agro-ecological setting

Parbhani centre is located in Central and Western Maharashtra plateau eco-sub-region. Marathwada region of Maharashtra state comprises 8 districts with average annual precipitation of 807 mm. The region is dominated by medium black cotton soils (60%), followed by heavy and shallow soils 15-20% each. Though the majority area falls under assured rainfall zone, it is characterized by 2-3 prolonged dry spells during crop growth. During recent past soybean, cotton and pigeonpea are major crops in dryland areas.

b. On-station experiments

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was early by 13 days (7th June). A rainfall of 987.2 mm was received which was excess by 24.2 mm (2.51%) compared to normal (963 mm). During *kharif* season, 825.5 mm rainfall was recorded which was excess by 25 mm (3.1%) than normal rainfall of 800.5 mm (Fig. 28); *rabi* season received 161.7 mm rainfall and was excess by 51.2 mm (46.3%) than normal of 110.5 mm and in summer no rainfall was received against normal of 36.5 mm.

Normal onset of monsoon	:	20 June
Onset of monsoon during 2017	:	7 June
Annual mean rainfall	:	963 mm
Annual mean rainfall during 2017-18	:	987.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	800.5 &110.5 mm, respectively
Crop seasonal rainfall during 2017-18	:	825.5 mm in *kharif* and 161.7 mm in *rabi*

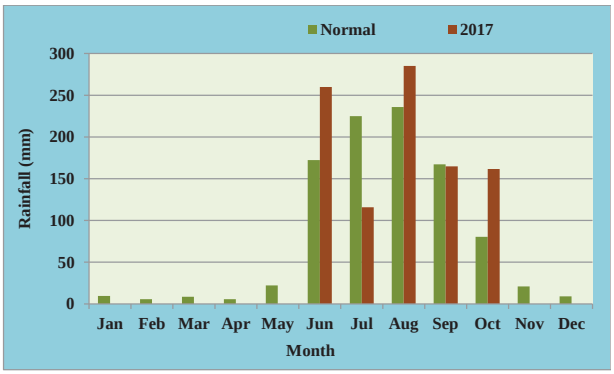


Fig. 28: Normal and actual (2017) monthly rainfall at Parbhani

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
16	25 June - 10 July	Soybean, pigeonpea, greengram, blackgram, cotton	Early vegetative
13	26 July - 07 August	Soybean, pigeonpea, greengram, blackgram, cotton	Late vegetative
09	31 August - 08 September	Soybean, pigeonpea, greengram, blackgram, cotton	Flowering & pod formation
16	17 September - 02 October	Soybean, pigeonpea, greengram, blackgram, cotton	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Soybean, cotton, Pigeonpea, blackgram	Seedling	Dust mulching and straw mulching
Mid season drought	Cotton, pigeonpea	Vegetative	Conservation furrow after every 4 rows; Residue mulching; Foliar sprays
Terminal drought	Cotton	Square formation	Protective irrigation
	Pigeonpea	Branching	

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

During *kharif* 2017, a dry spell of 16 days occurred (25 June - 10 July) at seedling stage of crops. All the crops and varieties produced higher yields with weeding and hoeing (10.8 to 11.2%). Soybean variety MAUS-158 produced higher seed yield (1700 kg/ha), net returns (Rs.30530/ha) and RWUE (2.67 kg/ha-mm), whereas pigeonpea recorded higher B:C ratio (1.43) (Table 134).

Table 134: Effect of weeding/interculture on soybean and pigeonpea yield 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				
Soybean	MAUS- 158	1700	1525	11.2	2.67	30530	1.43
	MAUS- 162	1670	1510	11.1	2.62	29615	1.38
Pigeonpea	BDNS - 711	1375	1280	10.7	2.16	25950	3.35

Situation: Mid season drought

During *kharif* 2017, a dry spell of 13 days occurred (26 July to 7 August) at vegetative and flowering stage of crops. Opening of furrow/ conservation furrow after every 4 rows in soybean and after every 2 rows in pigeonpea increased the yield by 10.9 and 10.4%, respectively. Among the crops, pigeonpea recorded highest net returns (Rs.54050/ha) and B:C ratio (3.44) with improved practice of opening of conservation furrows (Table 135).

Table 135: Effect of *in-situ* moisture conservation on *kharif* crops yield and economics

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Improved practice	With normal practice				
Soybean	MAUS 162	1716	1580	10.86	2.69	30618	1.40
Pigeonpea	BDN 711	1395	1340	10.41	2.19	54050	3.44

Weeding/interculture increased the yield of soybean and pigeonpea by 14.7 to 26.9% compared to without weeding/interculture. Soybean variety MAUS-158 produced higher seed yield (1910 kg/ha), and RWUE (3.0 kg/ha-mm). Whereas, pigeonpea recorded higher net returns (Rs.63700/ ha) and B:C ratio (4.03) (Table 136).

Table 136: Effect of weeding/interculture on yield and economics of soybean and pigeonpea

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				
Soybean	MAUS- 158	1910	1640	16.5	3.00	36535	1.68
	MAUS- 162	1845	1608	14.7	2.90	34552	1.59
Pigeonpea	BDNS - 711	1590	1320	26.9	2.49	63700	4.03

Foliar sprays of KNO_3 @ 2% urea @ 1% and 2%, 19:19:19 @ 5%, 19:19:19 @ 5% + recommended dose of micronutrient, recommended dose of micronutrient, and kaoline (7%) at 45 DAS and 65 DAS during flowering and pod filling stage of soybean increased the yield of soybean by 16 to 28%. Among the foliar sprays, 19:19:19 @ 5% + recommended dose of micronutrient gave higher yield (1824 kg/ha), net returns (Rs.38363/ha), B:C ratio (1.76) and RWUE (3.0 kg/ha-mm) compared to other treatments (Table 137).

Table 137: Effect of foliar sprays on soybean (MAUS 162) yield and economics under mid-season drought

Crop	Seed yield (kg/ha)	% yield in-crease	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Urea @ 1%	1653	16	2.5	28836	1.33
Urea @ 2%	1682	18	2.6	29671	1.37

Crop	Seed yield (kg/ha)	% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
19:19:19 @ 5%	1739	22	2.7	31409	1.45
19:19:19 @ 5% + recommended dose of micronutrient	1824	28	3.0	38363	1.76
Recommended dose of micronutrient	1682	18	2.8	32691	1.50
Water spray	1496	5	2.3	23213	1.07
KNO3 @ 2%	1653	16	2.4	25939	1.20
Control	1425				

Situation: Terminal drought

During 2017, a dry spell of 16 days (17 September – 2 October) occurred coinciding with flowering and boll formation stage of *kharif* crops. One supplemental irrigation (5 cm) from harvested rainwater form farm pond at flowing stage in pigeonpea and boll formation stage in cotton increased the yield of cotton and pigeonpea by 17.4 to 17.9% compared to no supplemental irrigation. Among the crops, pigeonpea gave highest net returns (Rs.35600/ha) and B:C ratio (4.10) compared to cotton (Table 138).

Table 138: Effect of supplement irrigation on yield and economics of cotton and pigeonpea

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	1585	1350	17.4	2.49	35600	1.20
Pigeonpea	BDN 711	1510	1280	17.9	2.37	60700	4.10

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 south-west monsoon contributes 80 to 85%, winter rains contribute 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.

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
16	25 June - 10 July	Soybean, pigeonpea, greengram, blackgram, cotton	Early vegetative
13	26 July - 07 August	Soybean, pigeonpea, greengram, blackgram, cotton	Late vegetative
09	31 August - 08 September	Soybean, pigeonpea, greengram, blackgram, cotton	Flowering & pod formation
16	17 September - 02 October	Soybean, pigeonpea, greengram, blackgram, cotton	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Soybean, cotton, Pigeonpea, blackgram	Seedling	Dust mulching and straw mulching
Mid season drought	Cotton, pigeonpea	Vegetative	Conservation furrow after every 4 rows; Residue mulching; Foliar sprays
Terminal drought	Cotton	Square formation	Protective irrigation
	Pigeonpea	Branching	

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During *kharif* 2017, a dry spell of 16 days occurred (25 June - 10 July) at seedling stage of crops. The first weeding operation followed by hoeing or interculture was carried out at 21 to 25 days after sowing produced 12.5 to 19% higher yields compared to without weeding and hoeing. Among the soybean varieties, MAUS-71 produced higher yield (1569 kg/ha) with higher net returns (Rs 27154/ha) compared to cv. MAUS-158 (1550 kg/ha). Pigeonpea variety BDN 711 recorded higher net returns (Rs.39750/ha) and B:C ratio (3.69) compared to other crop varieties (Table 139).

Table 139: Effect of weeding/interculture on soybean and pigeonpea yields under early season drought

Farming situation/ Soil type	Crop	Variety	Yield (kg/ha)		% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With weeding/ interculture	Without weeding/ interculture				
Light to medium black soil	Soybean	MAUS 71	1569	1395	12.5	2.40	27154	1.31
		MAUS 158	1550	1302	19.0	2.43	26575	1.28
	Pigeonpea	BDN 711	1020	885	17.9	1.58	39750	3.69
		BSMR 736	940	790	18.9	1.47	28800	2.67

Situation: Mid season drought

During *kharif* 2017, a dry spell of 13 days occurred (26 July to 7 August) at vegetative and flowering stage of crops. Opening of furrow / conservation furrow between crop rows in soybean and pigeonpea at vegetative stage gave highest yields (1575 and 1040 kg/ha) when compared to farmers' practice (1410 and 905 kg/ha, respectively). Similarly, opening of conservation furrow recorded higher net returns, B:C ratio and RWUE when compared to farmers' practice (Table 140).

Table 140: Effect of opening of furrow on soybean and pigeonpea crop yields under mid season drought

Farming situation/ Soil type	Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Opening of furrow	Farmers practice				
Light to medium Black soil	Soybean	MAUS 71	1575	1410	11.7	2.47	26317	1.21
	Pigeonpea	BDN 711	1040	905	14.9	1.63	37200	2.51

One supplemental irrigation (5 cm) from harvested rainwater from farm pond at pod filling stage of soybean increased the yield of soybean MAUS 71) by 20.8% (1800 kg/ha), with higher net returns (Rs.33180/ha), B:C ratio (2.82) and RWUE (2.82 kg/ha-mm) compared to farmers' practice of no supplemental irrigation. Weeding increased the yield of both the pigeonpea varieties by 19.1 to 24.3% compared to farmers' practice of no weeding. Among the pigeonpea varieties, BDN-711 produced higher seed yield (940 kg/ha), net returns (Rs.31200/ha), B:C ratio (1.97) and RWUE (1.47 kg/ha-mm) (Table 141).

Table 141: Effect of weeding/interculture on pigeonpea yield and economics

Farming situation/ Soil type	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Light to medium deep black soil	BDN 711	940	760	19.1	1.47	31200	1.97
	BSMR 736	895	720	24.3	1.40	28950	1.83

Both KNO_3 (2%) and water spray increased the yield of soybean and pigeonpea by 3.8 to 14.6% compared to farmers' practice of no foliar spray. In both crops, foliar spray of KNO_3 (2%) gave higher yields and net returns compared to water spray (Table 142).

Table 142: Effect of foliar sprays on soybean and pigeonpea yields and economics

Farming situation/ Soil type	Crop	Intervention	Yield (kg/ha)		% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With foliar spray	Without foliar spray				
Light to medium black soil	Soybean	KNO_3	1595	1380	15.57	2.50	26927	1.23
		Water spray	1400	1360	12.94	2.20	21700	1.03
	Pigeonpea	KNO_3	930	780	19.23	1.46	31700	2.14
		Water spray	820	790	3.79	1.28	27000	1.92

Situation: Terminal drought

There was a dry spell of 16 days coinciding with maturity stage of cotton. Supplemental irrigation (5 cm) in cotton (Ajit 155) gave highest seed cotton yield (1950 kg/ha), net returns (Rs.49273/ha), B:C ratio (1.69) and WUE (3.0 kg/ha-mm) compared to farmers' practice (1560 kg/ha).

Preparedness

Rainwater management

In-situ moisture conservation in soybean (MAUS-71) with broad bed and furrow (BBF) method resulted in higher seed yield (1610 kg/ha), net returns (Rs. 27385/ha), B:C ratio (1.26) and RWUE of 2.53 kg/ha-mm compared to farmer's method (flat bed) (Table 143).

Table 143: Effect of *in-situ* moisture conservation on soybean yield and economics

Farming situation/ Soil type	Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed 2017	Mean (3 years)	Stalk				
Light to medium black soil	BBF	1610	1484	2415	21720	27385	1.26	2.53
	Farmers' practice (Flat bed)	1400	1231	2100	20210	22490	1.11	2.20

Cropping systems

Among soybean + pigeonpea (4:2) and sorghum + pigeonpea (4:2) intercropping systems, sorghum + pigeonpea (4:2) system gave higher soybean equivalent yield (SEY) (1899 kg/ha), net returns (Rs.25361 /ha), B:C ratio (2.00) and RWUE (2.98 kg/ha-mm) followed by soybean + pigeonpea (4:2) system (1794 kg/ha) when compared to farmers practice of sole soybean and sorghum (1480 and 1000 kg/ha) (Table 144).

Table 144: Effect of intercropping systems on crop yields and economics

Farming situation/ Soil type	Intervention	Yield (kg/ha)		SEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter crop				
Light to medium black soil	Soybean + pigeonpea (4:2)	975	500	1794	28737	1.10	2.82
	Sole soybean	1480		1480	24420	1.17	2.32
	Sorghum + pigeonpea (4:2)	837	425	1899	25361	2.00	2.98
	Sole sorghum	1000		1000	4750	1.31	1.57

1.2.5 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 2017-18

During 2017, the onset of monsoon was normal (25th June). A rainfall of 487.2 mm was received which was deficit by 330.3 mm (40.4%) compared to normal (817.5 mm). During *kharif*, 416.2 mm rainfall was received which was deficit by 325.5 mm than normal (742.3 mm). During north-east monsoon (October- December), 1.2 mm of rainfall was received which was deficit by 28.6 mm than normal (29.8 mm) and during summer (March-May), 43.6 mm of rainfall was received which was excess by 19.4 mm compared to normal (24.2 mm) (Fig.29).

Normal onset of monsoon	:	Third week of June (26th SMW)
Onset of monsoon during 20171	:	Third week of June (26th SMW)
Annual mean rainfall	:	817.5 mm
Annual rainfall during 2017-18	:	487.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	742 and 29.8 mm, respectively
Crop seasonal rainfall during 2017-18	:	416.2 and 1.2 mm during *kharif* and *rabi*, respectively

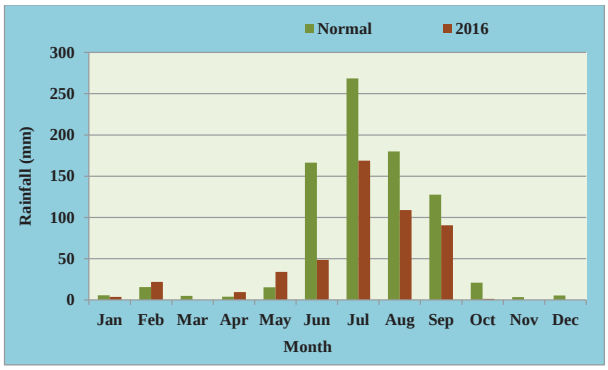


Fig. 29: Normal and actual (2017) monthly rainfall at Jhansi

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
28	30 July - 26 August	Groundnut, sorghum	Early vegetative
14	3-16 September	Groundnut	flowering
		Sorghum	Boot stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RCTP implemented
Early season drought	Groundnut, sorghum	Early vegetative	Weeding/interculture
Mid season drought	Groundnut	flowering	Foliar spray
	Sorghum	Boot stage	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

During 2017, a dry spell of 28 days occurred (30 July to 26 August) at early growth stage of groundnut and three to five leaf stage of sorghum. *In-situ* moisture conservation practices of weeding and interculture enhanced the yield of both groundnut and sorghum by 67.8 and 82.5% when compared to farmers' practice of no weeding. Among the crops, groundnut (GPBD-4) gave higher yield (498 kg/ha) and RWUE (1.2 kg/ha-mm). However, sorghum recorded higher net returns (Rs.12401/ha) and B:C ratio (2.03) (Table 145).

Table 145: Effect of *in-situ* moisture conservation on yield and economics of crops

Crop	Variety (duration)	Grain/pod yield (kg/ha)		% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding and interculture	With farmers' practice				
Groundnut	GPBD-4	498	297	67.8	1.20	7938	1.66
Sorghum	MP Chari	163	101	82.5	0.39	12401	2.03

Situation: Mid season drought

During *kharif* 2017, a dry spell of 14 days occurred (03 to 16 September) at booting stage of sorghum. Among different foliar sprays, Zinc and iron spray @ 0.5% produced higher green and dry fodder yield (16925 and 8060 kg/ha) which was at par with treatment water-soluble complex fertilizers (19: 19: 19) @ 0.5% + recommended dose (RD) of micronutrient for foliar spray (Zinc and iron @ 0.5%) (16267 and 7745kg/ha) compared to other treatments and control (10125 and 4823) (Table 146).

Table 146: Effect of foliar sprays on growth and yield of sorghum

Treatment	Growth parameters at 60 DAS			Yield (kg/ha)	
	No of plants/m	No of leaves / plant	Plant height (cm)	GFY	DFY
Main plot					
F_1: Foliar spray during dry spell	22.5	7.8	130.1	14309	6814
F_2: Foliar spray after relieving of stress/ dry spell	26.1	8.6	132.3	14038	6684
CD at 5%	NS	0.6	NS	NS	NS

Treatment	Growth parameters at 60 DAS			Yield (kg/ha)	
	No of plants/m	No of leaves / plant	Plant height (cm)	GFY	DFY
Sub plot					
S_1 : Urea 1%	23.8	8.0	132.0	13833	6587
S_2 : Urea 2%	23.0	8.3	131.2	14600	6953
S_3: Water soluble complex fertilizers (19:19:19) @ 0.5%	24.7	8.0	132.8	15175	7227
S_4: S_3 + RD of micronutrient for foliar spray: Zinc and iron @ 0.5%	32.2	8.2	139.2	16267	7745
S_5: RD of micronutrient for foliar spray: Zinc, boron, iron, Mn @ 0.5%	28.8	10.8	147.3	16925	8060
S_6:Water spray	19.3	6.8	118.5	12292	5853
S_7:Control	18.3	7.2	117.5	10125	4823
CD at 5%	7.7	1.2	14.7	939	447

GFY: Green fodder yield; DFY: Dry fodder yield

Similarly, in groundnt, RD of micronutrient for foliar spray (Zinc and iron, @ 0.5%) and water soluble complex fertilizers (19: 19: 19) @ 0.5% + RD of micronutrient for foliar spray (Zinc and iron @ 0.5 %) were at par with each other and recorded significantly higher plant height (31.2 and 35.3 cm), no of branches/plant (18.3 and 21.2), pod yield (498 and 497 kg/ha) and haulm yield (982 and 979 kg/ha) respectively over all other treatments. Whereas, significantly the lowest pod and haulm yield (297 and 585 kg/ha) was obtained with control (Table 147).

Table 147: Effect of different foliar sprays on growth and yield of groundnut in *Alfisols*

Treatment	Growth parameters at 60 DAS				Yield (kg/ha)	
	No. of plants/m	No. of leaves/ plant	Plant height (cm)	No. of Branches/ plant	Pod	Haulm
Main plot						
F1: Foliar spray during dry spell	5.71	67.57	29.28	16.04	429	845
F2: Foliar spray after relieving of stress/ dry spell	5.66	64.85	26.66	17.00	436	859
CD at 5%	NS	NS	1.62	NS	NS	NS
Sub plot						
S1 : Urea 1%	6.17	66.67	27.67	16.33	449	885
S2 : Urea 2%	6.17	65.33	26.50	16.00	471	928
S3: Water soluble complex fertilizers (19:19:19)@ 0.5%	5.83	65.50	30.17	16.50	482	949
S4: S3 + RD of micronutrient for foliar spray: Zinc and iron @ 0.5%	5.83	79.17	35.33	21.17	497	979
S5: RD of micronutrient for foliar spray: Zinc, boron, iron, Mn @ 0.5%	5.67	70.67	31.17	18.33	498	982
S6: Water spray	5.33	56.17	23.50	14.67	334	658
S7: Control	4.83	60.00	21.50	12.67	297	585
CD at 5%	NS	NS	3.03	3.25	23.4	46.1

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. 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 pump set 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 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 2017-18

The onset of monsoon was advanced by 9 days (17th June). During 2017, in Kadesara kalan village, a rainfall of 1154.9 mm was received which was excess by 337.4 mm compared to normal of 817.5 mm. During south-west monsoon (*kharif*), 1100 mm rainfall was received which was 357.7 mm excess compared to normal of 742.3 mm and during north-east monsoon (October to December), there was 10.5 mm rainfall as against normal of 29.8 mm. During summer, 34.9 mm rainfall was received which was 10.7 mm excess against normal of 24.2 mm (Fig.30).

Normal onset of monsoon	:	25 June
Onset of monsoon during 2017	:	17 June
Annual mean rainfall	:	817.5 mm
Annual rainfall during 2017-18	:	1154.9 mm
Mean crop seasonal rainfall during	:	742.3 and 29.8 mm, during *kharif* and *rabi,* respectively
Crop seasonal rainfall during 2017-18	:	1100 and 10.5 mm, during *kharif* and *rabi,* respectively

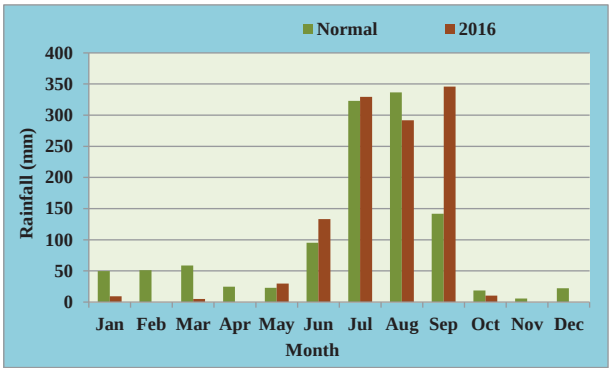


Fig. 30: Normal and actual (2017) monthly rainfall at Kadesara Kalan village

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
14	28 August - 10 September	Blackgram, sesame, groundnut	Flowering and pod formation

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of the crop	RTCP implemented
Mid season drought	Blackgram	Flowering and pod formation	Life saving irrigation
	Groundnut	Flowering and pod formation	Weeding/inerculture

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

During 2017, a dry spell of 14 days occurred (August 28 to September 10) at pod and seed development in groundnut. *In-situ* moisture conservation practices of weeding and interculture increased groundnut pod yield by 31.8% (1098 kg/ha) with higher net returns (Rs.34096/ha) and B:C ratio (3.5) compared to farmers' practice of no weeding (833 kg/ha).

Supplemental irrigation (40 mm) from harvested rainwater increased the seed yield of blackgram by 42.4% (491 kg/ha) with higher net returns (Rs.6702/ha) and B:C ratio (1.44) compared to without supplemental irrigation (345 kg/ha).

1.2.6 RAKH DHIANSAR

a. Agro-ecological setting

Rakh Dhiansar is situated at a latitude of 32°39' North and longitude of 74°53' East and at an elevation of 332 meters above mean sea level. The depth of the soil varies from 70 cm to 130 cm. Soil organic carbon varies from 0.22 to 0.50% and available nitrogen ranges from 144 to 207 kg/ha. The soils are low to very low in moisture retention.

b. On-station experiments

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was early by 5 days (22 June). The annual rainfall recorded during 2017 was 890.5 mm which was deficit by 257.5 mm than the normal (1148 mm). Out of the total rainfall received, 664.6 mm was received during the *kharif* season (June to September) which was deficit by 221.2 mm (24.97%) as against normal of 885.8 mm. In *rabi,* 44.8 mm rainfall was received which was deficit by 2.8 mm (5.9%) than normal of 47.6 mm. In summer season, 51.9 mm rainfall was received which was deficit by 62.2 mm as against normal of 114.1 mm (Fig.31).

Normal onset of monsoon	:	27 June
Onset of monsoon during 2017	:	22 June
Annual mean rainfall	:	1150.9 mm
Annual rainfall during 2017-18	:	890.5 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	885.8 and 47.6 mm
Crop seasonal rainfall during 2017-18 (*kharif & rabi)*	:	664.6 and 44.8 mm

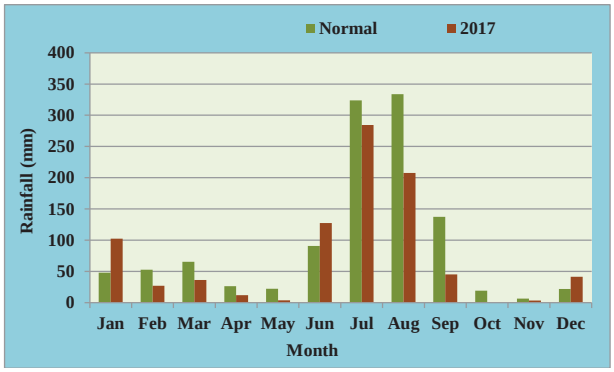


Fig.31: Normal and actual (2017) monthly rainfall at Rakh Dhiansar

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
41	04 September - 14 October	Maize, green-gram, black-gram, sesame	Grain filling

Real time contingency plan (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Maize	Grain filling	Removal of less vigorous plants up to 15-20% and use them as mulch Supplemental irrigation, Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

There was a dry spell during 4th September to 14th October coinciding with grain filling and maturity stage of maize. To overcome the effect of

drought, contingency measures like removal of less vigorous plants up to 15-20% was done and used as mulch coupled with supplemental irrigation from harvested water. Among the four hybrids of maize, Double Dekalb performed well with supplemental irrigation during terminal drought and produced maximum grain yield (3639 kg/ha) with higher net returns (Rs 53046/ha), B:C ratio (3.66) and WUE (7.08 kg/ha-mm) followed by K-517, PMH 2 and lowest yield was obtained with Local cv. Mansar (2424 kg/ha) (Table 148).

Table 148: Effect of supplemental irrigation on yield and economics of different maize hybrids

Variety	Grain yield (kg/ha)		% increase in yield	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With irrigation	Without irrigation				
Double dekalb	3639	3289	10.6	7.08	53046	3.66
TIP TOP	3215	2819	14.0	6.25	44741	3.29
PMH 2	2771	2347	18.0	5.39	34245	2.63
K-517	3292	2889	13.9	6.40	47139	3.51
Local (Mansar)	2424	2181	11.1	4.71	30064	2.64

Among different foliar sprays of chemicals with different concentrations applied to maize (variety Double dekalb) to cope with the terminal drought during the grain filling stage, foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of zinc recorded highest grain yield of 3130 kg/ha with 25% increase over control (without foliar spray), with highest RWUE (6.08 kg/ha-mm), net returns (41918/ha) and B:C ratio (3.0) (Table 149).

Table 149: Effect of foliar sprays on yield and economics of maize

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Urea 1%	2790	5.42	35527	2.75
Urea 2%	2830	5.50	36315	2.79
Water soluble complex fertilizer (19:19:19) @ 0.5%	2950	5.73	38390	2.85
Water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of zinc	3130	6.08	41918	3.0
Recommended dose of zinc	2650	5.15	32438	2.59
Water spray	2610	5.07	32206	2.60
Control	2500	4.86	29950	2.50

Preparedness

Rainwater management

Among different *in-situ* moisture conservation techniques *viz*. circular pit, strip trenching, continuous trenching, off-season tillage and deep tillage in maize, the highest grain yield of 2360 kg/ha was recorded with continuous trenching method followed by strip trenching method (2150kg/ha). The maximum and minimum B:C ratio of 2.69 and 1.86 was recorded with continuous trenching and off season tillage, respectively (Table 150). The highest RWUE (4.59) and minimum (3.35) was also recorded with continuous trenching compared to other treatments.

Table 150: Yield and economics of maize as influenced by *in-situ* moisture conservation

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Circular pit	2020	3.93	22640	2.27
Strip trenching	2150	4.18	25111	2.41
Continuous trenching	2360	4.59	30006	2.69
Off-season tillage	1720	3.35	15293	1.86
Deep tillage	1970	3.83	21619	2.22
Control	1840	-	-	-

Energy management

Sowing of maize with maize planter gave higher grain yield (2450 kg/ha), net returns (30995/ha) and B:C ratio (2.75), followed by sowing with liner (2120 kg/ha) compared to broadcasting (1840 kg/ha). Among the three planting methods, the maize planter recorded the maximum energy output of 7008 MJ/ha and energy use efficiency of 15.41 (Table 151).

Table 151: Comparative performance of maize under different methods of sowing

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	Energy (MJ/ha)		Energy Use efficiency
					Input	Output	
Sowing with maize planter	2450	4.76	30995	2.75	107984	7008	15.41
Broadcasting	1840	3.58	17168	1.93	75173	6650	11.30
Sowing with liner	2120	4.12	21517	2.08	88934	6950	12.80

c. On-farm demonstrations

Village profile

The programme is being implemented in Khaner village, Purmundal block, Tensil and district Samba, Jammu and Kashmir. The total cultivated area is 55 ha and 100 area is rainfed. The mean annual rainfall is 1150.9 mm with seasonal rainfall of 514.2 mm. The major soil types are sandy loam. The major rainfed crops during *kharif* are maize, blackgram, greengram, sesame, fodder pearl millet, fodder sorghum and during *rabi* season are wheat, chickpea and mustard. The number of small, marginal and medium farmers are 40, 18 and 32 respectively. The ground water table is 150-200 meters. There is no source of irrigation in the village.

Climatic vulnerability in general

In general, the climate in this agro-climatic zone is sub-humid. The rainfall is received through south-west monsoon, western disturbances (winter season) and summer (pre monsoon) and contributes about 75, 13 and 12 % of the annual rainfall. The historical rainfall data 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 monsoon was during 26th SMW. The chances of occurrence of normal and moderate drought were 7 and 12% during *kharif* season and 8 and 8% during *rabi* season respectively.

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was normal (30th June). The annual rainfall recorded during the year was 890.5 mm, which was deficit by 260 mm than the normal rainfall of 1151.1 mm. Out of total rainfall, 514.2 mm was received during the *kharif* season (June to September) as against normal of 896.9 mm. In *rabi*, no rainfall received which was 46.6 mm deficit than normal of 46.6 mm (Fig).

Normal onset of monsoon	:	27 June
Onset of monsoon during 2017	:	30 June
Annual mean rainfall	:	1150.9 mm
Annual rainfall during 2017-18	:	890.5 mm
Mean crop seasonal rainfall (mm) during *kharif* and *rabi*	:	668.5 mm and 108.7 mm, respectively
Crop seasonal rainfall during 2017 (*kharif*)	:	514.2 mm

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
41	04 September - 14 October	Maize, greengram, blackgram, sesame	Grain filling to maturity

Real time contingency plan (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Maize	Grain filling	Removal of less vigorous plants up to 15-20% and use them as mulch Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

There was a dry spell during 4th September to 14th October due to early cessation of monsoon resulting in terminal drought coinciding with grain filling stage of maize. One supplemental irrigation to maize from the harvested water in farm pond gave 11.3% higher grain yield (2516 kg/ha) with net returns of Rs 29167/ha, B:C ratio of 2.39 and WUE of 4.89 kg/ha-mm compared to without supplemental irrigation (2260 kg/ha).

Maize with supplemental irrigation

Preparedness

Rainwater management

Sowing across the slope gave maize grain yield of 2390 kg/ha with RWUE of 4.65 kg/ha-mm, net returns of Rs. 27419/ha and B:C ratio of2.37 compared to farmers' practice (2092 kg/ha).

Cropping systems

Maize + blackgram intercropping in 1:1 ratio (additive series) gave 26% higher maize equivalent yield (2892 kg/ha), with RWUE of 5.62 kg/ha-mm, net returns of Rs. 32593/ha and B:C ratio of 2.46 compared to farmers' practice of sole maize (2290 kg/ha).

Energy management

Sowing of maize with maize planter gave 27 and 26% increase in grain yield over farmers' practice in NICRA villages Khaner and Madana, respectively with net returns of Rs 24278 to 25122/ha and B:C ratio of 2.31 to 2.35. The energy input ranged from 6893 to 6905 MJ/ha and energy output ranged from 89903 to 94623 MJ/ha (Table 152).

Maize without supplemental irrigation

Sowing with maize planter in Khaner village

Table 152: Effect of sowing methods on yield and economics of maize

Farming situation/ soil type	Village	Yield Kg/ha		Increase in yield (%)	RWUE (kg/ha-mm)	Net returns (Rs./ha)	B:C ratio	Energy (MJ/ha)	
		Maize planter	Farmers' practice					Input	Output
Medium deep soils	Khaner	2217	1624	26.8	4.31	25122	2.35	6905	94623
	Madana	2210	1624	26.3	4.30	24278	2.31	6893	89903

Alternate land use

The yield of mixed fodder on farmers' fields under aonla + mixed fodder system ranged from 23000 to 24800 kg/ha with mean yield of 23900 kg/ha. RWUE ranged from 45.7 to 49.3 kg/ha-mm with mean RWUE of 47.5 kg/ha-mm. The net returns ranged from Rs 15634/ha to Rs 17794/ha with B:C ratio of 2.31 to 2.49, respectively (Table 153).

Table 153: Yield and economics of mixed fodder system

Farming situation/ soil type	Intervention	Fodder crop	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Mixed fodder	Farmers' practice (sole pearlmillet)				
Shallow soils	Mixed fodder with recommended fertilization-I	Maize + sorghum + pearlmillet	24800	19200	29.2	49.3	17794	2.49
	Mixed fodder with recommended fertilization- II	Maize + sorghum + pearlmillet	23000		19.8	45.7	15634	2.31

Aonla + mixed fodder (maize + sorghum + pearlmillet)

1.3 Dry Sub-humid Zone (1000-1250 mm)

1.3.1 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 2017-18

During 2017, the onset of monsoon was normal. The annual rainfall recorded during the year was 1161.4 mm, which was excess by 67.1 mm than the normal annual rainfall of 1094.3 mm. Out of the total rainfall, 887 mm was received during the *kharif* season (June to September) which was excess by 25 mm (2.9%) as against normal of 862 mm. In *rabi*, 45.1 mm rainfall was received which was 145.4 mm deficit (76.3%) than normal of 190.5 mm. In summer season, 108.4 mm rainfall was received which was excess by 26.3 mm as against normal of 82.1 mm (Fig.32).

Normal onset of monsoon	:	1 July
Onset of monsoon during 2017	:	28 June
Annual mean rainfall	:	1094.3 mm
Annual rainfall during 2017-18	:	1161.4 mm
Mean crop seasonal rainfall	:	862 and 190.5 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	887 and 45.1 mm during *kharif* and *rabi*, respectively

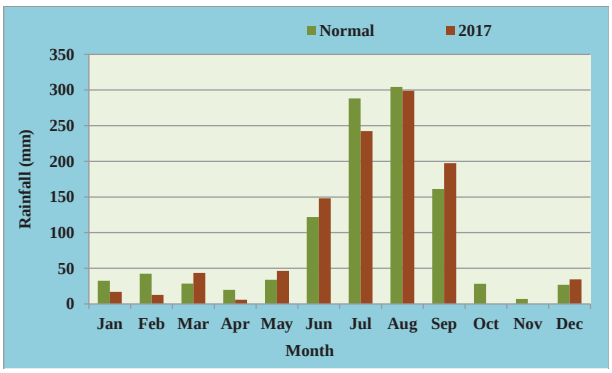


Fig.32: Normal and actual (2017) monthly rainfall at Ballowal Saunkhri

Dry spells during crop growing season (2017-18):

There were no dry spells during the crop growing season.

Real time contingency practices (RTCP) implemented:

No RTCPs were implemented

Salient achievements of on-station experiments

Preparedness

Rainwater management

During 2017, application of irrigation using harvested rainwater through micro-irrigation system (MIS)/ drip @ 50% of ET, 75% of ET and 100% of ET resulted in corresponding increase in yield of maize from 15, 22 and 25% as compared to rainfed crop. The WUE was also higher with drip irrigation but net returns and B:C ratio was higher in rainfed maize due to the higher initial investment in the installation of drip irrigation (Table 154).

Table 154: Effect of drip irrigation on yield and economics of maize

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Rainfed	3310	6918	30260	26308	1.87	4.48
50% ET	3896	7587	50260	15770	1.31	4.93
75 % ET	4245	7959	50260	21374	1.43	5.20
100 % ET	4390	8033	50260	23623	1.47	5.56

Drip irrigated maize

Rainfed maize

Cropping systems

During 2017, no long dry spell was observed and the foliar application of 19:19:19 fertilizers (1%) along with zinc sulphate (0.5%) at 35 days after sowing resulted in higher grain yield of maize (2888 kg/ha) which was statistically at par with treatment T_5- KCl (2%), T_6-19:19:19 (1%) and T_8-$ZnSO_4$ (0.5%). The increase in grain yield among these treatments was 17-23% compared to control. Foliar spray of 19:19:19 fertilizers (1%) along with zinc sulphate (0.5%) also recorded higher net returns (Rs 20813/ha), B:C ratio (1.69) and RWUE (3.66 kg/ha-mm) compared to other treatments (Table 155).

Table 155: Effect of foliar sprays on maize yield and economics

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
T_1- No spray	2353	4118	2.98	12776	1.45
T_2-Water spray	2443	4275	3.09	14098	1.49
T_3-Urea (1%)	2574	4505	3.26	16300	1.56
T_4-Urea (2%)	2602	4554	3.29	16452	1.56
T_5-KCl (2%)	2788	4879	3.53	19580	1.66
T_6-19:19:19 (1%)	2863	5010	3.62	20443	1.68
T_7-T_6 + $ZnSO_4$ (0.5%)	2888	5054	3.66	20813	1.69
T_8-$ZnSO_4$ (0.5%)	2755	4821	3.49	18989	1.64
CD at 5%	226				

c. On-farm demonstrations

Village profile

The program is being implemented by AICRPDA centre, Ballowal-Saunkhri in Achalpur, Nainwan and Bhawanipur (new) 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. (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 2017-18

During 2017, the onset of monsoon was normal. The annual rainfall recorded during the year 2017 was 983.6 mm, which was 110.7 mm deficit than the normal annual rainfall of 1094.3 mm. Out of total rainfall, 745.2 mm was received during the *kharif* season (June to September) which was deficit by 130.4 mm (14.8%) as against normal of 875.6 mm. In *rabi*, 34.0 mm rainfall was received which was 27.9 mm deficit than normal of 61.9 mm and in summer season, it was 67.2 mm which was deficit by 14.9 mm as against normal of 82.1 mm (Fig.33)

Normal onset of monsoon	:	1 July
Onset of monsoon during 2017	:	28 June
Annual mean rainfall	:	1094.3 mm
Annual mean rainfall during 2017-18	:	949.6
Mean crop seasonal rainfall during *kharif* and *rabi*	:	862 and 61.9 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	745.2 and 34.0 mm, respectively

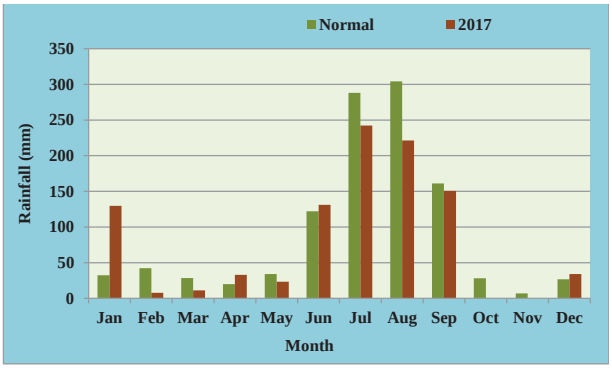


Fig.33: Normal and actual (2017) monthly rainfall at Achalpur

Dry spells during crop growing season (2017-18):

No dry spells experienced during the crop growing season.

Real time contingency practices (RTCP) implemented:

No RTCPs were implemented NICRA village.

Salient achievements of on-farm demonstrations

Preparedness

Rainwater management

Sowing of maize on ridges produced highest grain and stover yield (3646 and 7218 kg/ha) followed by bed sowing (3482 kg/ha). The increase in grain yield of maize in ridge and bed sowing was 11.7 and 6.2%, respectively over flat sowing (3263 kg/ha). The net returns (Rs. 28971/ha), B:C ratio (1.88) and RWUE (9.4 kg/ha-mm) were also highest under ridge method of sowing followed by bed sowing (Table 156).

Ridge planting **Flat sowing**

Table 156: Effect of planting methods on yield and economics of maize

Farming situation/ soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain	Stover				
Deep alluvial soil	Ridge planting	3646	7218	32937	28971	1.88	5.94
	Bed planting	3482	6861	32796	26040	1.79	5.67
	Flat sowing (Farmers' practice)	3263	6460	30771	24634	1.80	5.31

Cropping systems

Maize hybrid PMH 1 gave 47% higher grain yield of 3880 kg/ha compared to local variety (2640 kg/ha), with higher net returns (Rs 33888/ha) and B:C (1.99) (Table 157).

Table 157: Performance of improved variety of maize

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain	Stover				
Deep alluvial soil	PMH-1	3880	6580	34182	33,888	1.99	6.32
	Local variety	2640	5420	29576	15,543	1.53	4.30

1. 3.2 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.

b. On-station experiments

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was delayed by 11 days (21st June). The annual rainfall of 1017.8 mm was received which was deficit by 162.2 mm compared to normal (1180 mm) (Fig.34). During *kharif* (June–September), 937.2 mm of rainfall was received which was deficit by 100.8 mm compared to normal (1038 mm). During *rabi* season, 42.0 mm rainfall was received which was deficit by 23.9 mm compared to normal (65.9 mm) and in summer, rainfall was 6.2 mm which was deficit by 36.5 mm as against normal (42.7 mm).

Normal onset of monsoon	:	4-10 June
Onset of monsoon during 2017	:	21 June
Annual mean rainfall	:	1180 mm
Annual rainfall during 2017-18	:	1017.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	1038 and 65.9 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	937.2 and 42 mm, respectively

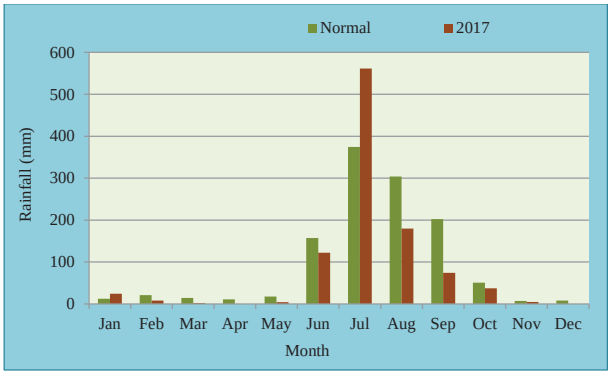


Fig.34: Normal and actual (2017) monthly rainfall at Chianki

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
13	19 - 31 August	Rice, maize, sesame, pigeonpea	Vegetative
11	10 - 20 September	Rice, maize, sesame, pigeonpea	Flowering; vegetative stage in pigeonpea
13	8 - 20 October	Rice, maize, sesame, pigeonpea	Maturity in rice, maize and sesame; flowering in pigeonpea
161	22 October to 31 March 2018	Wheat, chickpea, lentil, mustard	Entire crop season

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Rice	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2017, two dry spells of 11 and 13 days occurred coinciding with the flowering and milking stage of rice. Foliar spray during dry spell and after relieving of dry spell significantly influenced the yield of rice. Among the treatments, spraying of water soluble complex fertilizer having N, P and K (12:32:16) @ 0.5% + foliar spray of Zn during dry spell and after relieving of dry spell recorded significantly higher grain yield (3230 and 3490 kg/ha) than all other treatments except foliar spray of Zn alone (3110 and 3320 kg/ha) (Table 158).

Table 158: Effect of foliar spray on yield of rice (Sahbhagi dhan)

Treatment	Grain yield (kg/ha)
M_1 :Foliar spray during dry spell	
M_1S_1: Urea @1%	2690
M_1S_2: Urea @2%	2710
M_1S_3: Water soluble complex fertilizer (12:32:16) @ 0.5%	2800
M_1S_4 :Water soluble complex fertilizer (12:32:16) @ 0.5%+ foliar spray of Zn	3230
M_1S_5: Foliar spray of Zn @ 0.5%	3110
M_1S_6 :Water spray	2760
M_1S_7 : Control (No spray)	2660
CD at 5%	224
M_2 Foliar spray after relieving of dry spell	
M_2S_1: Urea @1%	2780
M_2S_2:Urea @2%	2830
M_2S_3 :Water soluble complex fertilizer (12:32:16) @ 0.5%	2980
M_2S_4: Water soluble complex fertilizer @ (12:32:16) 0.5%+ foliar spray of Zn @ 0.5%	3490
M_2S_5 :Foliar spray of Zn @ 0.5%	3320
M_2S_6 :Water spray	2800
M_2S_7: Control (No spray)	2720
CD at 5%	226

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 2017-18

During the year 2017, the onset of monsoon was delayed by 14 days (22nd June). A rainfall of 964.1 mm was received which was deficit by 188.3 mm compared to normal of 1152.4 mm (Fig.35). During *kharif* (June - September), 883.4 mm rainfall was received which was deficit by 109.1 mm (10.9%) compared to normal (992.5 mm). During *rabi* season, 42.0 mm rainfall was received which was deficit by 35.6 mm (45.8%) compared to normal (77.6 mm) and during summer (March - May), 10.2 mm rainfall was received which was deficit by 37.8 mm compared to normal (48 mm).

Normal onset of monsoon	:	4 - 10 June
Onset of monsoon during 2017	:	24 June
Annual mean rainfall	:	1152 mm
Annual rainfall during 2017-18	:	964.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	993 and 77.6 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	883.4 and 42.0 mm, respectively

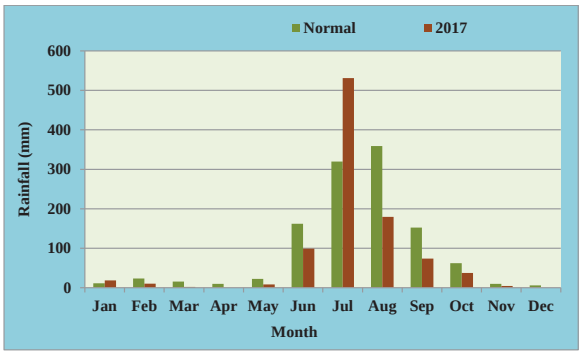


Fig.35: Normal and actual (2017) monthly rainfall at Kumbhi Bankheta

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
15	19 August to 2 September	Rice, maize, sesame, pigeonpea	Flowering; vegetative in pigeonpea
13	10 - 20 September	Rice, maize, sesame, pigeonpea	Grain formation; vegetative in pigeonpea
13	8 - 20 October	Rice, maize, sesame, pigeonpea	Maturity; flowering in pigeonpea
161	22 October to 31 March 2018	Wheat, chickpea, lentil, mustard	Entire crop season

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2017, the onset of monsoon was delayed by 14 days. Drought tolerant varieties of medium land rice (Arize Tej/PAC-801) recorded higher grain yield (3168 kg/ha), net returns (Rs.35071/ha), B:C ratio (2.69) and RWUE (4.93 kg/ha-mm) as compared to local variety (1534 kg/ha) (Table 159).

Performance of medium duration hybrid rice (Arize Tej/PAC-801)

Table 159: Performance of drought tolerant varieties of rice under medium land situation

Variety	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Arize Tej	4311	4.93	50283	2.69
Local	3168	-	-	-

Similarly, in an on-farm demonstrations on 80 farmers' fields, Sahbhagi Dhan recorded higher grain yield (4194 kg/ha) as compared to local variety (2989 kg/ha) with higher net returns (Rs.49509/ha), B:C ratio (2.81) and RWUE of 4.15 kg/ha-mm (Table 160).

Table 160: Yield, RWUE and economics of the medium land rice varieties

Variety	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sahbhagi	4194	4.80	49509	2.81
Local	2989	-	-	-

High yielding short duration hybrid of maize (Kanchan) recorded higher grain yield (2786 kg/ha) by 35% with higher net returns (Rs.15803/ha), B:C ratio (1.03) and RWUE (3.19 kg/ha-mm) compared to farmers' variety (1802 kg/ha) (Table 161).

Table 161: Yield and economics of the hybrid maize

Variety	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Maize (Kanchan)	2786	3.19	15803	1.03
Local	1802	-	-	-

1.3.3 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 2017-18

During 2017, the onset of monsoon was delayed by 11 days (2 July). A rainfall of 882.5 mm was received which was deficit by 157.6 mm (15.2%) compared to normal rainfall (1040.1 mm). During south-west monsoon (*kharif*), 855.1 mm rainfall was received which was deficit by 59.8 mm (6.54%) compared to normal of 914.9 mm. During *rabi*, no rainfall was received against the normal rainfall of 65.6 mm. During summer, 10.6 mm of rainfall was received which was deficit by 22.6 mm compared to normal rainfall (33.2 mm) (Fig.36).

Normal onset of monsoon	:	21 June
Onset of monsoon during 2017	:	2 July
Annual mean rainfall	:	1040.1 mm
Annual rainfall during 2017-18	:	882.5 mm
Mean crop seasonal rainfall	:	914.9 mm (*kharif*) & 65.6 mm (*rabi*)
Crop seasonal rainfall during 2017-18	:	855.1 mm (*kharif*) & 0 mm (*rabi*)

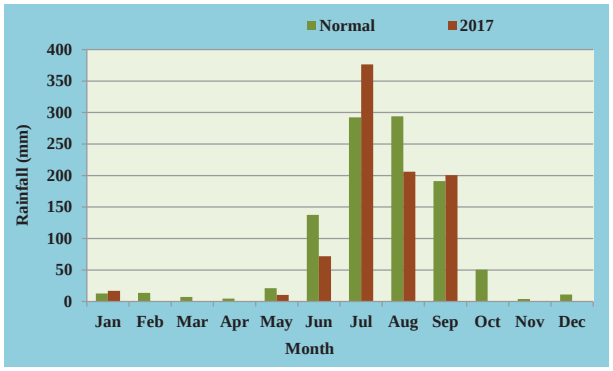


Fig.36: Normal and actual (2017) monthly rainfall at Faizab1ad

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
15	06- 19 September	Paddy, maize	Grain filling
		Pigeonpea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Pigeonpea	-	Improved varieties
Terminal drought	Maize	Grain filling	Foliar spray

Situation: Delayed onset of monsoon

During 2017, the onset of monsoon was delayed by 11 days (2 July). Short duration varieties of pigeonpea were evaluated for suitability under delayed onset of monsoon. Among the varieties of pigeonpea, NDA-1 performed better and gave highest seed yield (1956 kg/ha), net returns (Rs. 98310/ha), B:C ratio (6.16) and RWUE of 2.95 kg/ha-mm and the lowest yield was recorded by MA-13 (Table 162).

Table 162: Performance of short duration pigeonpea varieties under delayed onset of monsoon

Varieties	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B: C ratio
NDA-1	1956	2.95	98310	6.16
NDA-2	1812	2.73	89670	5.71
Bahar	1832	2.76	90870	5.77
MA-13	1570	2.37	75150	4.94
CD at 5%	67	-	-	-

Among different foliar sprays in maize, foliar spray during dry spell recorded higher grain yield (1636 kg/ha), net returns (Rs.5296/ha), B:C ratio (1.28) and RWUE of 2.47 kg/ha-mm compared to foliar spray after relieving of stress/dry spell (1340 kg/ ha). Among the different sources of foliar sprays, water soluble complex fertilizer (19: 19: 19) @ 5% & zinc sulphate @ 0.5% spray recorded the highest grain yield (1786 kg/ha), net returns (Rs.6910/ ha), B:C ratio (1.35) and RWUE of 2.7 kg/ha-mm compared to other treatments (Table 163).

Table 163: Effect of foliar spray of various nutrients on yield of maize

Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Main plot					
F1- Foliar spray during dry spell	1636	19244	5296	1.28	2.47
F2- Foliar spray after relieving of stress (with favourable soil moisture)	1340	18865	1235	1.07	2.02
Sub plot					
N1- Urea @ 2%	1529	19170	3765	1.20	2.31
N2- Urea @ 1%	911	19350	-5685	0.71	1.37
N3- Water soluble complex fertilizer (19:19:19) @ 5%	1643	19500	5145	1.26	2.48
N4- N3 + zinc sulphate @ 5%	1786	19880	6910	1.35	2.70
N5- Zinc sulphate @ 5%	1635	19525	5000	1.26	2.47
N6- water spray	1513	18885	3810	1.20	2.28
N7- Control (no spray)	1399	18400	2585	1.14	2.11

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% of the total annual average rainfall of 1041.1 mm. The historical rainfall data (30 years) indicated that the variability in rainfall during southwest 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.

Experienced weather conditions during 2017-18

The rainfall data of Faizabad centre was taken.

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
15	06- 19 September	Paddy, maize, sorghum	Grain filling
		Pigeonpea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Maize, paddy, pigeonpea	Grain filling	Foliar spray, mulching, weeding/inter-culture

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

During 2017, sufficient moisture was available in the soil at the time of sowing. But about 60 days after sowing (7th September) at the growth/ maturity stage of crops, moisture stress was observed. Mulching with green leaves of subabool @ 10 t/ ha in paddy, pigeonpea, maize and sorghum on 10th September, improved yields of all crops by 16-33% over without mulching. Among different crops, pigeonpea (NDA-1) recorded higher net returns (Rs.91950/ha) and B:C ratio (5.83) while maize (Naveen) recorded higher RWUE of 3.32 kg/ha-mm (Table 164).

Table 164: Effect of mulching on the yield and economics of *kharif* crops

Farming situation/ soil type	Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With mulching	Without mulching				
Medium lands	Paddy	NDR-97	1200	950	26.3	1.81	(-) 2280	0.89
	Maize	Naveen	2200	1650	33.3	3.32	12846	1.64
	Sorghum	CSV-10	1510	1300	16.2	2.28	3996	1.21
	Pigeonpea	NDA-1	1850	1450	27.6	2.79	91950	5.83

Two weedings followed by interculture at 25 and 45 days after sowing improved the crops yields by 10.3 to 34.6% over without weeding/ interculture (Table). Among different crops, pigeonpea (NDA-1) recorded higher net returns (Rs.94950/ha) and B:C ratio (5.98) while maize (Naveen) recorded higher RWUE of 3.40 kg/ha-mm (Table 165).

Table 165: Effect of weeding/ interculture on the yield and economics of *kharif* crops

Farming situation/ soil type	Normal crop	Normal variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With weeding/ interculture	Without weeding/ interculture				
Medium lands	Paddy	NDR-97	1225	910	34.6	1.85	(-) 1905	0.91
	Maize	Naveen	2250	1700	32.4	3.40	13596	1.67
	Sorghum	CSV-10	1600	1450	10.3	2.41	5346	1.29
	Pigeonpea	NDA-1	1900	1580	20.3	2.87	94950	5.98
	Sesame	T-12	575	500	15.0	0.87	9700	1.51
	Blackgram	NDU-1	625	530	17.9	0.94	30950	2.62

Foliar spray of 2% urea on 12th September (60 DAS) in different crops improved yields by 14.3 to 42.4% over without foliar spray. Among the crops, pigeonpea (NDA-1) recorded the highest net returns (Rs. 99450/ha) and B:C ratio(6.22) followed by maize (Naveen) with net returns of Rs.15096/ha and B:C ratio of 1.75 (Table 166).

Table 166: Effect of foliar spray of 2% urea on yield and economics *kharif* crops

Farming situation/ soil type	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				
Medium lands	Paddy	NDR-97	1240	960	29.2	1.87	(-) 1680	0.92
	Maize	Naveen	2350	1650	42.4	3.55	15096	1.75
	Sorghum	CSV-10	1600	1400	14.3	2.41	5346	1.29
	Pigeonpea	NDA-1	1975	1675	17.9	2.98	99450	6.22

Preparedness

Cropping systems

Among different intercropping systems, pigeonpea + sesame (1:1) recorded higher maize grain equivalent yield (9633 kg/ha) closely followed by pigeonpea + maize (1:1) and pigeonpea + sorghum (1:1) with maize grain equivalent yields of 9560 and 8985 kg/ha, respectively whereas maize + sesame (1:1) recorded lower maize grain equivalent yield (3642kg/ha). The net returns and B:C ratio also showed similar trend (Table 167).

Table 167: Performance of different intercropping systems

Farming situation/ soil type	Cropping system	Yield (kg/ha)		MEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Main crop	Inter-crop				
Medium lands	Pigeonpea + maize (1:1)	1865	2100	9560	25927	117473	5.53
	Pigeonpea + sorghum (1:1)	1875	1485	8985	25177	109598	5.35
	Pigeonpea + sesame (1:1)	1975	520	9633	24877	119623	5.81
	Maize + blackgram (1:1)	2075	525	4875	20600	52525	3.55
	Maize + sesame (1:1)	1975	500	3642	19100	35525	2.86

Among different double/ relay cropping systems, maize-chickpea system gave highest paddy equivalent yield of 5167 kg/ha, net returns (Rs.36300/ha), B:C ratio (1:88) and RWUE of 4.45 kg/ha-mm while paddy-mustard/ paddy-lentil systems gave lowest paddy equivalent yields (2052-2477 kg/ha) with negative net returns (Rs.-5025 to -2550/ha) (Table 168).

Table 168: Performance of different double/relay cropping systems

Farming situation/ soil type	Treatment	Yield (kg/ha)		PEY	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		kharif	*rabi*					
Medium lands	Maize- chickpea	2000	950	5167	41200	36300	1.88	4.45
	Maize- lentil	2135	600	4135	39400	22625	1.57	4.12
	Maize- mustard	2065	585	3625	35100	19275	1.55	3.99
	Paddy-lentil	1210	380	2477	39700	(-) 2550	0.94	2.40
	Paddy-mustard	1225	310	2052	35800	(-) 5025	0.86	2.31

PEY: Paddy equivalent yield

1.3.4 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

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was timely (20 June). A rainfall of 632.8 mm was received which was deficit by 448.9 mm (41.5%) compared to normal (1081.7 mm). During south-west monsoon (*kharif*), 629.6 mm of rainfall was received which was deficit by 314.9 mm compared to normal (1067.3 mm), During rabi, no rainfall was received against the normal rainfall of 60.9 mm (Fig.37).

Normal onset of monsoon	:	22 June
Onset of monsoon during 2017	:	20 June
Annual mean rainfall	:	1081.7 mm
Annual mean rainfall during 2017-18	:	664.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	944.5 mm and 60.9 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* & *rabi*)	:	629.6 mm and 0 mm, respectively

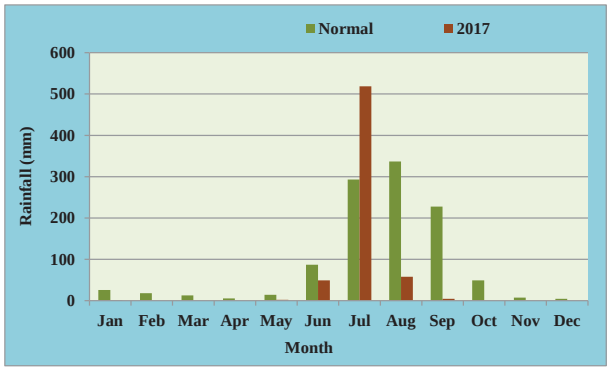


Fig.37: Normal and actual (2017) monthly rainfall at Varanasi

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
11	7- 17 August	Rice	Vegetative
		Maize	Seedling
19	30 August - 17 September	Rice	Panicle initiation
		Maize	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Rice	Weeding, foliar spray
	Maize	Weeding, foliar spray
Terminal drought	Rice, maize	Supplemental irrigation

Salient achievements of on-station experiments

Real time contingency plan implementation

Situation: Mid season drought

There was a dry spell of 11 days (7-17 August). Weeding with dryland weeder in line sown rice (NDR-97) increased grain yield by 17.3% (2130 kg/ha), net returns (Rs.19015/ha), B:C ratio (2.3) and RWUE (3.3 kg/ha-mm) when compared to without weeding (1760 kg/ha). Similarly, foliar spray of 2% thiourea with micronutrients 0.5% (Zn + Bo) recorded the highest rice (NDR-97) yield (2320 kg/ha), net returns (Rs.21960/ha), B:C ratio (2.5) and RWUE (4.0) followed by maize (Malaviya makka-2) (2180 kg/ha), net returns (Rs.16065/ha), B:C ratio (2.0) and RWUE (3.3) when compared to without foliar spray (Table 169).

Table 169: 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 (90 days)	2320	2050	11.6	4.0	21960	2.5
Maize	Malviya Makka-2 (80 days)	2180	1650	24.3	3.3	16065	2.0

c. On-farm interventions

Village profile

The program is being implemented in Terha Saraya Village, Mirzapur District, 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. New village adopted is Patharaha (Hinauti), Mirzapur Dist., Uttar Pradesh.

Experienced weather conditions during 2017-18

During 2017, at Terha Saraya village, the onset of monsoon was timely (21st June). A rainfall of 661.2 mm was received which was deficit by 420.5 mm (38.8%) compared to normal (1081.7 mm). During south-west monsoon (*kharif*), 661.2 mm of rainfall was received which was deficit by 420.5 mm compared to normal (948.0 mm) (Fig.38).

Normal onset of monsoon	:	25 June
Onset of monsoon during 2017	:	21 June
Annual mean rainfall	:	836.7 mm
Annual mean rainfall during 2017-18	:	649.0 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	699.5 mm and 60.9 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi)*	:	649.0 mm and 0.0 mm, respectively

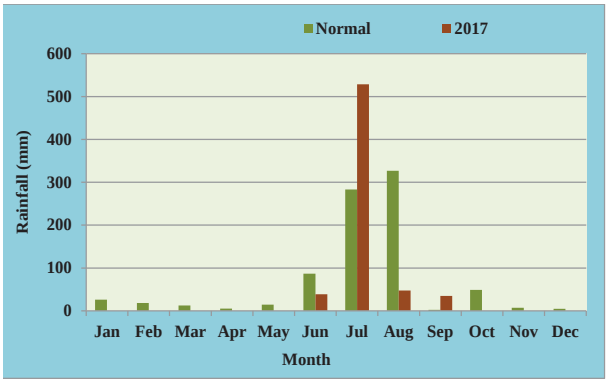


Fig.38 : Normal and actual (2017) monthly rainfall at Terha

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
17	4 - 22 August	Rice	Tillering
		Maize, sesame, pigeonpea, greengram	Early vegetative
20	27 August - 15 September	Rice	Panicler initiation
		Maize	Late vegetative
		Pigeon pea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	RTCP implemented	
	Crop	RTCP implemented
Mid season drought	Rice	Weeding/interculture and life saving irrigation
	Maize	Soil mulcting and life saving irrigation
	Pearlmillet	Weeding/interculture
Terminal drought	Rice	Supplemental irrigation
	Maize	Green cobs harvested and stalk used for fodder
	Pigeonpea	Weeding/interculture
	Pearlmillet	Crop harvested for fodder

Salient achievements of on-farm demonstrations

Real time contingency plan implementation

Situation: Mid season drought

There was a dry spell of 17 days (4-22August). *In-situ* moisture conservation through soil mulching and weeding with dryland weeder gave highest grain yield of rice (2070 kg/ha), net returns (Rs. 18085/ha), RWUE (3.2 kg-ha-mm) and B:C ratio (2.3) when compared to farmers' practice (1460 kg/ha). Two supplemental irrigations recorded higher grain yield of rice (1840 kg/ha), net returns (Rs. 14520/ha), B:C ratio (2.0) and RWUE (2.8 kg/ha-mm) followed by maize (1670 kg/ha), sesame (3650 kg/ha), greengram (3410 kg/ha) and pearlmillet (2785 kg/ha) compared to farmers' practice (Table 170).

Table 170: Performance of different crops under supplemental irrigation

Farming situation/ Soil type	Crop	Variety (duration)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With irrigation	Without irrigation*			
Shallow and medium alluvial soil	Rice	HUR3022 (105 days)	1840	-	2.8	14520	2.0
	Maize	Malviya Makka-2 (80 days)	1670	-	2.6	87970	1.5
	Sesame	Shekhar (115days)	370	-	0.6	13900	2.1
	Greengram	HUM-16 (60DAS)	800	-	1.2	18200	1.7
	Pearlmillet	Pusa -322 (79 days)	1130	-	1.5	1560	1.1

*Crop failed due to dry spell

Weeding with dryland weeder in line sown rice and pearlmillet increased yields by 30 and 25%, respectively as compared to broadcasting method without weeding. Rice (NDR-97) recorded highest yield (1970 kg/ha), net returns (Rs.16535/ha), B:C ratio (2.1) and RWUE (2.6 kg/ha-mm) and pearlmillet recorded yield of 1130 kg/ha compared to without weeding (1360 and 840 kg/ha, respectively) (Table 171).

Table 171: Performance of rice and pearlmillet as influenced by weeding/interculture

Farming situation/ Soil type	Crop	Variety (duration)	Grain yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With weeding/ interculture	Without weeding/ interculture			
Shallow and medium alluvial soil	Rice	NDR 97 (90 days)	1970	1360	2.6	16535	2.1
	Pearlmillet	Pusa -322 (79 days)	1130	840	1.5	1560	1.1

Preparedness

Cropping systems

Rice var. NDR 97 gave highest grain yield (2070 kg/ha), net returns (Rs.18085/ha), B:C ratio (2.3) and RWUE (3.2 kg/ha-mm) followed by maize var. Malviya makka-2 (1670 kg/ha) compared to farmers' practice of local variety (1400 kg/ha in rice while maize crop failed) (Table 172).

Table 172: Performance of improved varieties of rice and maize

Farming situation/ Soil type	Crop	Variety	Grain yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Shallow and medium alluvial soil	Rice	NDR-97	2070	18085	2.3	3.2
		Local	1400	9700	1.8	2.2
	Maize	Malviya makka-2	1670	8797	1.5	2.6
		Local	Crop failed due to long and continues dryspell			

Maize cv. Malviya makka-2

Maize - local cultivar

1.4 Moist Sub-humid zone (1250-1500 mm)

1.4.1 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 2017-18

During 2017, the onset of monsoon was delayed by two days (7 June). A total rainfall of 1677 mm was received which was excess by 497 mm compared to normal of 1180 mm. During south-west monsoon (*kharif*), there was 1365.8 mm rainfall which was excess of 244.3 mm (21.8%) as against normal rainfall of 1122 mm. During north-east monsoon (October - December), 235.9 mm of rainfall was received which was excess 121.1 mm as that of normal (115.0 mm). During summer, 75.0 mm of rainfall was received which was deficit by 70.8 mm (48.5%) compared to normal rainfall of 146.1 mm (Fig.39).

Normal onset of monsoon	:	5 June
Onset of monsoon during 2017	:	7 June
Annual mean rainfall	:	1404 mm
Annual rainfall during 2017-18	:	1677 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	1122 and 115 mm, respectively
Crop seasonal rainfall during 2017-18 (*kharif* and *rabi*)	:	1365.8 and 235.9 mm, respectively

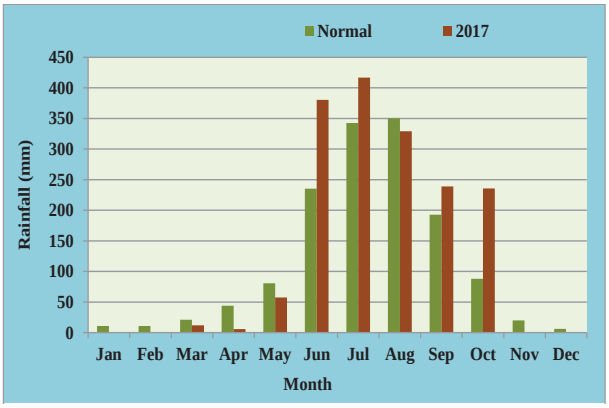


Fig.39: Normal and actual (2017) monthly rainfall at Jagdalpur

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
8	24-31 October	Rice, horsegram	Flowering
30	1-30 November	Rice, maize	Grain filling
30	1-30 December	Rice, maize, niger	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Rice	Vegetative stage	Furrow opening at 2 m interval by country plough
	Rice	Late jointing	2% nitrogen foliar spray
Terminal drought	Maize	Tasseling & silking	Supplemental irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During 2017, a dry spell of 8 days occurred during 24-31 October coinciding with the flowering stage of rice. Foliar spray of 2% nitrogen gave higher grain yield (1972 kg/ha), net returns (Rs.7043/ ha), RWUE (2.87 kg/ha-mm) and B:C ratio (1.31) compared to farmers' practice of no spray (1720 kg/ ha).

Situation: Terminal drought

During 2017, a dry spell of 30 days occurred during 1-30 November coinciding with the grain filling and maturity stage of rice. Foliar spray during the stress condition (dry spell) resulted in significantly higher grain yield (1760 kg/ha) than sprays after relieving of stress (1340 kg/ha). Among the spraying treatments, foliar spray of water soluble fertilizer (19:19:19) along with 0.5% $ZnSO_4$ recorded significantly higher grain and straw yield (2160 and 2480 kg/ha), net returns (Rs.12430/ ha), B:C ratio 2.54) and RWUE (2.09 kg/ha-mm) compared to other treatments (Table 173).

Table 173: Effect of foliar sprays on yield and economics of rice

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Main plot					
Foliar spray during dry spell	1760	2420	1.31	9610	2.31
Foliar spray after relieving of stress / dry spell	1340	1830	1.97	7316	1.93
CD @ 5%	32.2	43.7	-	-	-
Sub plot					
Urea @ 1%	1780	1970	1.29	9876	2.01
Urea @ 2%	1860	2040	1.21	12342	2.09
19:19:19 @ 0.5%	2120	2500	2.01	11272	2.45
19:19:19 @ 0.5% + $ZnSO_4$ @ 0.5%	2160	2480	2.09	12430	2.54
$ZnSO_4$ @ 0.5%	1280	1720	1.45	6784	1.97
Water spray	1130	1730	1.15	6537	1.87
Control	510	1380	1.23	2432	0.75
CD @ 5%	28.6	39.7	-	-	-

Situation: Excess rainfall event

Heavy rainfall, excess by 61.2% in June 2017 compared to normal (235 mm in June), vitiated rice nursery due to inundation of rainwater. Under these conditions the multi storied nursery raising system was taken in rice (MTU 1010). Seedlings of 10, 15, 20 and 25 days old were transplanted to escape the loss from heavy rain during transplanting. Higher grain yield (6757 kg/ha), net returns (Rs.57459/ ha), B:C ratio (2.74) and RWUE (3.72 ka/ha-mm) was recorded when seedlings of 20 days were transplanted compared to other treatments (Table 174).

Table 174: Effect of age of seedlings on yield and economics of rice

Treatment (seedling age)	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
10 days	3733	3.35	21169	1.79
15 days	5009	3.18	36479	2.40
20 days	6757	3.72	57459	2.74
25 days	6048	3.76	48954	2.70

Multi-storey nursery technique

Preparedness

Rainwater management

In-situ moisture conservation practice of scooping by spading out soil in between crop rows in maize increased the grain yield by 44.5% (1731 kg/ha) compared to farmers' practice (960 kg/ha) with higher net returns (Rs.6346.80/ha), B:C ratio (1.15) and RWUE (2.06 kg/ha-mm) (Table).

Scooping in between rows of maize

Cropping systems

Thirty one drought tolerant upland and 25 drought tolerant midland rice varieties were evaluated. Among the varieties, shyamjeera gave higher grain yield of 3183 kg/ha followed by Kapursar variety (3065 kg/ha). Among midland varieties, R-RF-65 recorded higher grain yield (2731 kg/ha) followed by D X D (124)-7 variety (2496 kg/ha).

During 2017, the rainfall was excess in June (196.2%) and transplanted rice seedlings were washed away and resowing was taken up with drum seeder using sprouted seed. Sowing sprouted rice with drum seeder recorded higher grain yield (3148 kg/ha), net returns (Rs.7668/ha), B:C ratio (1.42) and RWUE (3.09 kg/ha-mm) compared to traditional *Lehi* system (2872 kg/ha) (Table 175).

Table 175: Effect of establishment methods on yield and economics of rice

Establishment method	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With sprouted seed	Without sprouted seed				
Drum seeding	3148	2872	11.6	3.09	7668	1.42
Traditional *Lehi* method	2914	2576	8.7	2.77	4873	1.28

c. On-farm interventions

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 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 large farmers are 61, 269, 86 and 20, respectively. 24th to 25th SMW. 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 moist sub-humid. The south-west monsoon contributes 80% 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.

Experienced weather conditions during 2017-18

During 2017, in Tahkapal village, onset of monsoon was delayed by 3 days (8th June). A rainfall of 1740.8 mm was received which was excess by 336.4 mm compared to normal rainfall of 1404.4 mm. During South-west monsoon (*kharif*), 1421.9 mm rainfall was received which was 300.4 mm excess compared to normal rainfall of 1122 mm; during North-east monsoon, 182.7 mm of rainfall was received which was excess by 67.7 mm compared to normal (115 mm). During summer, 125.7 mm of rainfall was received which was deficit by 20.4 mm compared to normal (146.1 mm) (Fig.40).

Normal onset of monsoon	:	5 June
Onset of monsoon during 2017	:	8 June
Annual mean rainfall	:	1404 mm
Annual rainfall during 2017-18	:	1740.8 mm
Mean crop seasonal rainfall	:	1122 and 115 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	1421.9 and 182.6 mm during *kharif* and *rabi*, respectively

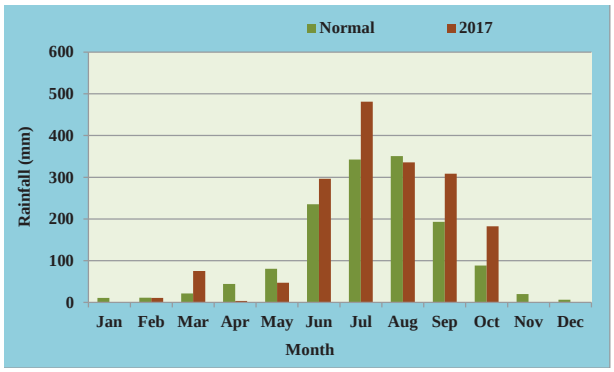


Fig.40: Normal and actual (2017) monthly rainfall at Tahkapal village

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
8	24-31 October	Rice, horsegram	Flowering, grain filling
30	1-30 November	Rice and maize	Grain filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Rice	Flowering	Life saving irrigation, foliar spray
Terminal drought	Rice	Grain filling and maturity	Supplemental irrigation from harvested rainwater

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

A dry spell of 8 days occurred during 24-31 October coinciding with tillering and flowering stage of rice. Life saving irrigation of 2 cm from harvested rainwater given at tillering stage gave highest grain yield (1503 kg/ha), net returns (Rs.41463/ha), B:C ratio (3.16) and WUE (1.10 kg/ha-mm) compared to other treatments and control (406 kg/ha) (Table 176).

Table 176: Effect of supplemental irrigation on rice yield and economics

Farming situation/soil type	Stage of supplemental irrigation	Grain yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Midland	Control	406	1.47	5640	1.31
	Tillering	1503	1.10	41463	3.16
	Jointing	1083	0.79	23672	2.16
	Flower initiation	997	0.73	21223	2.10

Harvested rainwater in farm pond

Rice with supplemental irrigation at tillering

Foliar spray of nitrogen @ 2% at flowering initiation stage increased the grain yield of rice (2098 kg/ha in cv. MTU 1010 and 1870 kg/ha in cv. MTU 1001) compared to control. Among the rice varieties, MTU 1010 gave higher grain yield (2099 kg/ha), net returns (Rs.7493.33/ha), B:C ratio (1.39) and RWUE (3.02 kg/ha-mm) (Table 177).

Table 177: Effect of foliar spray on rice yield and economics

Farming situation/ soil type	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray			
Midland	MTU 1010	2098	1830	3.02	7493	1.39
	MTU 1001	1870	1540	2.71	4762	1.25

Preparedness

Cropping systems

Among different rice varieties demonstrated, Sahbhagi recorded higher grain yield (1730 kg/ha), net returns (Rs 6328/ha) and B:C ratio (1.71) followed by variety CR 40 (1682 kg/ha) compared to other varieties. Fingermillet variety GPU 28 gave higher grain yield (1466 kg/ha), net returns (Rs 9220/ha) and B:C ratio (1.72) compared to variety CR 1 (1198 kg/ha). Yam variety A-1 recorded higher yield (15104 kg/ha) and net returns (Rs 45474/ha) (Table 178).

Table 178: Performance of drought tolerant rice varieties

Farming situation/ soil type	Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Midland	Rice	Sahbhagi	1730	1.72	6328	1.71
		CR 40	1682	1.68	5752	1.67
		Indira Barani dhan	1636	1.64	5193	1.62
		Neem chudi	1590	1.59	4649	1.57
	Fingermillet	GPU 28	1466	1.46	9220	1.72
		CR-1	1198	1.20	6009	1.34
	Yam	A-1 (Arabi)	15104	3.07	45474	1.46
		Gajendra (EFY)	9517	2.50	26906	3.23

1.4.2 PHULBANI

a. Agro-ecological setting

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

b. On-station experiments

Experienced weather conditions during 2017-18

During 2017, the onset of monsoon was on time (10th June). A rainfall of 1265.9 mm was received during the year which was deficit by 141.1 mm than normal (1407.0 mm). Out of total rainfall, 894.6 mm was received during *kharif* (June- September) and was deficit by 141.4 mm (10.1%) than normal (1150.5 mm). In *rabi*, 285.5 mm rainfall was received which was 128 % higher than the normal (124.7 mm). In summer 85.8 mm rainfall was received against 108.4 mm (Fig.41).

Normal onset of monsoon	:	10 June
Onset of monsoon during 2017	:	10 June
Annual mean rainfall	:	1407.0 mm
Annual rainfall during 2017-18	:	1265.9 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:	1150.5 and 124.7 mm, respectively
Crop seasonal rainfall during *kharif* and *rabi* (2017-18)	:	894.6 and 285.5 mm, respectively

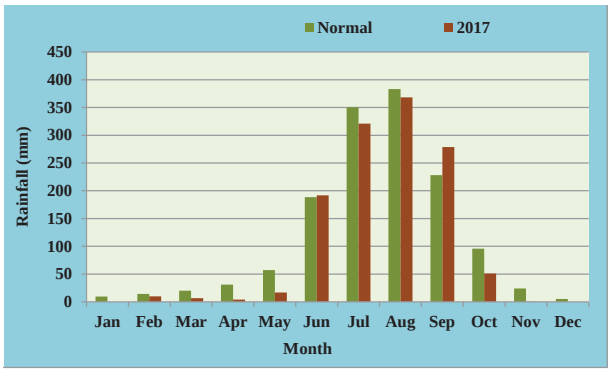


Fig.41: Normal and actual (2017) monthly rainfall at Phulbani

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
7	10 - 16 August	Rice, maize, cowpea, pigeonpea	Vegetative
8	23 September – 1 October	Rice, maize, cowpea, pigeonpea, greengram, blackgram, sesame	Grain filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Early season drought	Rice, maize, pigeonpea	Hoeing/weeding, and gap filling
Terminal drought	Maize, pigeonpea, greengram, blackgram and sesame	Life saving irrigation

Salient achievements of on-station experiments

Real time contingency crop planning

Situation: Early season drought

During 2017-18, the onset of monsoon was normal (10th June). Rice variety Sahabhagi gave higher yield (2520 kg/ha), RUWE (2.53 kg/ha-mm), net returns (Rs. 10680/ha) with B:C ratio of 1.4 with *in-situ* moisture conservation (summer ploughing and raising bund height) as compared to normal practice of no *in-situ* moisture conservation (1960 kg/ha). Maize (Hybrid-SA701) and pigeonpea (NTL 724) also gave 46 and 49% higher yield with *in-situ* moisture conservation compared to normal practice (Table 179).

Table 179: Performance of different crops under *in-situ* moisture conservation

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	Farmer's practice				
Rice	Sahabhagi	2520	1960	29	2.53	10680	1.40
Maize	Hybrid -SA 701	2950	2020	46	4.55	14088	1.56
Pigeonpea	NTL 724	1060	710	49	1.13	21905	1.88

Situation: Terminal drought

During 2017, a dry spell of 8 days from 23rd September to 1st October and no rainfall from 21st October till crop harvest affected all rainfed crops. Life saving irrigation, from harvested rainwater, during flowering and pod formation stage of pigeonpea, sesame, greengram and blackgram revealed that pigeonpea with supplemental irrigation gave highest seed yield of 1060 kg/ha, net returns of Rs. 21905/ha, B:C ratio of 1.88 and WUE of 1.13 kg/ha-mm. Late sown pigeonpea (NTL 724), greengram (OUM 11-5) and blackgram (B-3-8-8) with supplemental irrigation gave 49.3, 70.3 and 63.2% higher yield as compared to farmers practice of without irrigation, respectively (Table 180).

Table 180: Performance of different crops under supplemental irrigation

Crop	Variety	Yield (kg/ha)		% increase in yield	WUE (kg/ha-mm)	NMR (Rs/ha)	B:C ratio
		With supplemental irrigation	Without supplemental irrigation				
Pigeonpea	NTL 724	1060	710	49.3	1.13	21905	1.88
Greengram	OUM 11-5 (Kamadev)	630	370	70.3	1.08	14295	1.95
Blackgram	B-3-8-8 (Prasad)	620	380	63.2	1.06	12435	1.83

Preparedness

Cropping systems

Among the maize based intercropping systems, maize + pigeonpea (2:2) gave higher maize equivalent yield (4375 kg/ha) with higher net returns (Rs.27969/ha), B:C ratio (1.93) and RWUE (3.96 kg/ha-mm) compared to sole maize (2180 kg/ha) (Table). Similarly, pigeonpea + radish intercropping system (2:2) gave higher pigeonpea equivalent yield (1687 kg/ha) and net returns (Rs.42650/ha) compared to sole pigeonpea (Table 181).

Table 181: Performance of maize and pigeonpea based intercropping systems

Intercropping system	Yield (kg/ha)		RWUE (kg/ha-mm) for inter-cropping	Net returns (Rs/ha)	B:C ratio
	With intercrop-ping system	Sole crop			
Maize (SA 701) + cowpea (Gomti) (2:2)	MEY-4375	Sole maize 2180	3.96	27969	1.93
Pigeonpea (NTL 724) + radish (Pusa Chetki) (2:2)	PEY-1687	Sole pigeonpea 810	1.37	42650	2.33

MEY: Maize equivalent yield; PEY: Pigeonpea equivalent yield

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 new village adopted during 2017-18 is Gunjidraga village, Phulbani block in Kandhamal district of Odisha.

Climate vulnerability in general

The climate 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.

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
7	10 - 16 August	Rice, maize, cowpea and pigeonpea	Germination / seedling
8	23 September - 1 October	Rice, maize, cowpea, pigeonpea, green-gram and blackgram	Grain filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought	Rice, pigeonpea	Life saving irrigation

Situation: Terminal drought

During 2017, a dry spell of 8 days from 23rd September to 1st October coincided with maturity stage of rice and pigeonpea. Life saving irrigation from nearby water stream in two rice varieties revealed that var. Naveen gave the highest grain yield (2540 kg/ha), net returns (Rs.14370/ha) and B:C ratio (1.57) followed by var. Sahabhagi (2420 kg/ha) compared to farmers' practice of no supplemental irrigation (1980 and 1920 kg/ha in Naveen and Sahabhagi, respectively). Pigeonpea with life saving irrigation gave 44% higher seed yield (880 kg/ha), net returns (Rs.14940/ha) and B:C ratio (1.62) compared to farmers' practice of no supplemental irrigation (610 kg/ha) (Table 182).

Table 182: Performance of different crops under supplemental irrigation

Farming situation/ soil type	Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With supplemental irrigation	Without supplemental irrigation				
Midlands	Rice	Sahabhagi	2420	1920	26.0	2.43	12510	1.50
		Naveen	2540	1980	28.3	2.55	14370	1.57
	Pigeopea	NTL 724	880	610	44.3	0.88	14940	1.62

Preparedness

Rainwater management

In-situ moisture conservation with deep summer tillage and raising of bund height in rice (var. Sahabhagi) gave 26% higher grain yield (2420 kg/ha), net returns (Rs.12510/ha), B:C ratio (1.50) and RWUE (2.43 kg/ha-mm), whereas rice variety Naveen gave 28.3% higher grain yield (2540 kg/ha), net returns (Rs.14370/ha), B:C ratio (1.57) and RWUE (2.55 kg/ha-mm) compared to farmers' practice of no *in-situ* moisture conservation (2040 kg/ha) (Table 183).

Table 183: Performance of rice varieties under *in-situ* moisture conservation

Farming situation/ soil type	Crop	Variety (duration)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With *in-situ* moisture conservation	Without *in-situ* moisture conservation			
Midlands	Rice	Sahabhagi (110 days)	2420	1920	2.43	12510	1.50
		Naveen (110 days)	2540	1980	2.55	14370	1.57

1.5. Per-humid Zone

1.5.1 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 drought and flooding is common which demands special selection for normal crop husbandry.

b. On-station experiments: Nil

Experienced weather condition during 2017-18

During the year 2017, the onset of monsoon was normal (1st June). A rainfall of 2202.1 mm was received which was excess by 337.3 mm compared to normal (1864.8 mm). During south-west monsoon (*kharif*), a rainfall of 1414.6 mm was received against a normal rainfall of 1182.2 mm. The rainfall during *rabi* was excess by 33.8 mm compared to normal rainfall of 120 mm (Fig.42).

Normal onset of monsoon	:	1st week of June
Onset of monsoon during 2017	:	1st week of June
Annual mean rainfall	:	1864.8 mm
Annual rainfall during 2017-18	:	2202.1 mm
Mean crop seasonal rainfall	:	1182 and 120 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	1414.6 and 153.8 mm during *kharif* and *rabi*, respectively

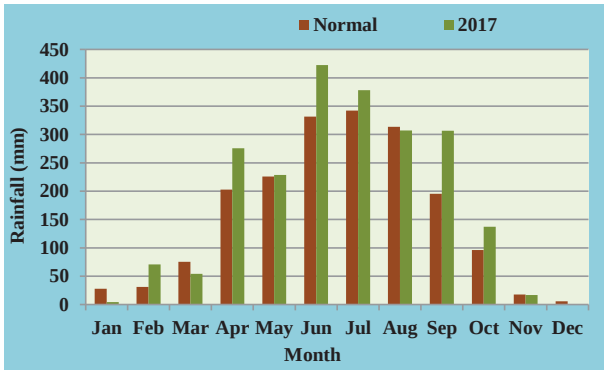


Fig.42: Normal and actual (2017) monthly rainfall at Biswanath Chariali

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 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.

Chamua village

The NICRA programme is being implemented in Chamua village which is situated in the Narayanpur block of Lakhimpur district, Assam. The total cultivated area of the village is 133 ha which is entirely rainfed. The mean annual rainfall 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 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 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, blackgram, greengram, 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 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 weather related problems in the village are 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

Gankdoloni village is 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. The village is affected by 3-5 flash floods of 7 to 15 days duration during *kharif* season. 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 suffers 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 0.0060C/year and minimum by 0.01940C/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 and hail storm.

Experienced weather conditions during 2017-18

During 2017, in Chamua Narayanpur village, the onset of monsoon was normal (1st week of June). A rainfall of 2780.2 mm was received which was excess by 801.6 mm compared to normal (1978.6 mm). During south-west monsoon (*kharif*), a rainfall of 1752.4 mm was received against a normal rainfall of 1280.1 mm. The rainfall during *rabi* was excess by 37.9 mm compared to normal rainfall of 161.1 mm (Fig.43).

Normal onset of monsoon	:	1st week of June
Onset of monsoon during 2017	:	1st week of June
Normal annual rainfall	:	1978.6 mm
Annual rainfall during 2017-18	:	2780.2 mm
Normal crop seasonal rainfall	:	1280.1 and 161.0 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2017-18	:	1752.4 and 199.0 mm during *kharif* and *rabi*, respectively

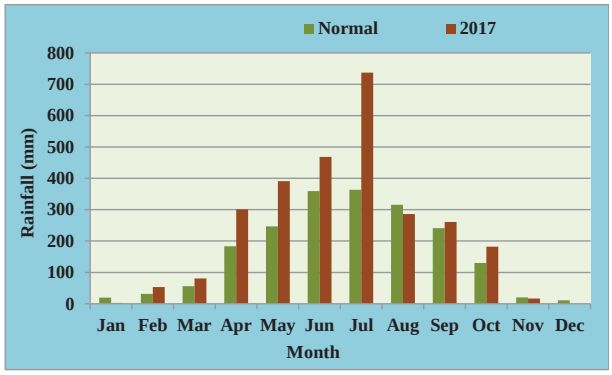


Fig.43: Normal and actual (2017) monthly rainfall at Chamua village

Dry spells during crop growing season (2017-18)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
27	1 -27 November	Potato, toria, *rabi* vegetables	Vegetative
33	29 November - 31 December	Potato, toria	Vegetative
37	1 - 6 February	Potato, toria, *rabi* vegetables	Tuber/siliqua formation, vegetative (vegetables)
7	8 - 14 February	Potato, toria, *rabi* vegetables	Tuber/siliqua formation, vegetative (vegetables)

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought (*kharif*)	Rice	Short duration varieties
Mid season drought (*rabi*)	Potato	Supplemental irrigation
Intermittent flash flood	Rice	Direct seeding

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

Chamua village experienced two dry spells, a dry spell of 9 days (4-12 October) and a long dry spell (1-27 November), which affected the grain filling stages of long and medium duration varieties of *Sali* rice. Short duration cultivars Disang and medium duration cultivars –TTB-404 produced 14 to 31% higher yields compared to long-duration cultivars (Table 184).

Table 184: Terminal drought management through short and medium duration rice cultivars

Duration (days)	Variety	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
		With improved practice*	With farmers practice**			
Short (100-120)	Disang	2705	2329	13.9	17050	1.71
Medium (135 to 140)	TTB-404	4100	2826	31.1	29000	2.42
Long	Ranjit	5278	3533	33.1	37780	2.52

*Improved practice: Short, medium or long duration high yielding varieties; ** Farmers' practice: Same variety was grown in the uplands/medium lands

Rice cv. TTB-404

In Chamua village, supplemental irrigation from the harvested rainwater in farm pond during dry spell increased the yield of potato by 43.8 to 58.1%. The net returns (Rs.162500/ha) and B:C ratio (3.61) was higher with potato variety Kufri Pokhraj compared to small seeded local variety (Table 185).

Table 185: Performance of potato with supplemental irrigation from the harvested rainwater

Variety	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
	With irrigation	Without irrigation			
Kufri Pokhraj	20750	11656	43.8	162500	3.61
Local (small seeded)	9853	4125	58.1	137060	2.28

Situation: Intermittent flash flood

In Ganakdoliloni village, due to occurrence flash floods, field preparations as well as transplanting of rice varieties was hampered. Direct seeding of rice varieties (Bakul bora, Chakowa and Kon joha rice) was demonstrated. Performance of the directly seeded cultivars was almost at par with normal transplanted crop but with an added advantage of no additional cost in land preparation and transplanting. Among the cultivars, Chakowa gave higher yield (2216 kg/ha), net returns (17160/ha) and B:C ratio (3.43) (Table 186).

Table 186: Performance of direct seeded traditional rice varieties at Ganakdoloni village

Cultivar	Grain yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Bakul bora	2140	16400	3.28
Chakowa 2216		17160	3.43
Konjoha	1935	14350	2.87

Rapeseed sown in October

Crop diversification with high value crops like ginger, turmeric, sesame, balckgram, greengram, summer vegetables, winter vegetables etc was demonstrated. All the farmers earned much higher income from the same soil type and same amount of rainfall from the diversified cropping as compared to mono-cropping of *Sali* rice (Table 188).

Preparedness

Cropping systems

Farmers of Chamua were encouraged for early sowing of rapeseed for effective utilization of the residual soil moisture. The village experienced long dry-spells in the entire *rabi* season (from 1st week of November, 2017 to Mid of February, 2018) adversely affecting the crop. However, crop sown within October (early sown) was less affected as compared to the crop sown on November. Early sown rapeseed gave higher seed yields compared to late sown rapeseed (Table 187).

Table 187: Performance of rapeseed varieties under different sowing dates in Chauma

Variety	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio
	Early sowing	Late sowing		
TS-36	1025	559	14250	0.86
TS-38	1085	685	16050	0.97

Rapeseed sown in November

Table 188: Economics of crop diversification

Name of the farmer	Crop (variety)	Area (ha)	Net returns (Rs/ha)	B:C ratio
Mr. Harendra Neog	Rice (Var. Disang, Ranjit) Potato (var. Pokhraj) Rapeseed (var. TS-38) Pumpkin, pea, cabbage/cauliflower	1.0	365250	2.15
Mr. Balindra Neog	Rice (Var.Mahsuri, Punjasali, Nania) Potato (Kufri Pokhraj) Rapeseed (var. TS-38)	0.5	55875	1.23
Mr Kamal Saikia	Colocasia (var. Ahinakachu) Ridge gourd (var. Hybrid) Cucumber (var. Hybrid) Sesame (var. Local) Brinjal (var. JC-1) Tomato (var. Hybrid) Potato (Kufri Jyoti) Cabbage (var. Rear Ball)	0.5	250857	2.01

Potential of organic crop production as a climate change adaptation and mitigation strategy in rainfed agriculture

A field experiment was conducted during *kharif* 2016 at GRF-CRIDA to evaluate the performance of sunflower, greengram 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 (20:50 kg N & P_2O_5/ha for pigeonpea and greengram; 60:60:30 kg N, P_2O_5 & K_2O/ha for sunflower).

In general, the seed yield of all three crops was less across different treatments due to poor rainfall distribution during crop season with 2 dry spells of 18 days in July and 9 days in September. There was no rainfall from 24 October till harvest of pigeonpea. The seed yield of sunflower was 14 and 7% higher in the plots under integrated management (1374 kg/ha) than that under inorganic and organic management, respectively. However, plots under organic management gave marginally higher seed yield of greengram (706 kg/ha) compared to integrated (673 kg/ha) and inorganic management (664 kg/ha). Similarly, pigeonpea seed yield was similar in the plots under organic and inorganic management (898-911 kg/ha) and the plots under organic management produced 9% higher seed yield compared to inorganic management (836 kg/ha) (Fig.44).

Different production systems had no significant on soil pH, available N and Mn. However, plots under organic management recorded significantly higher

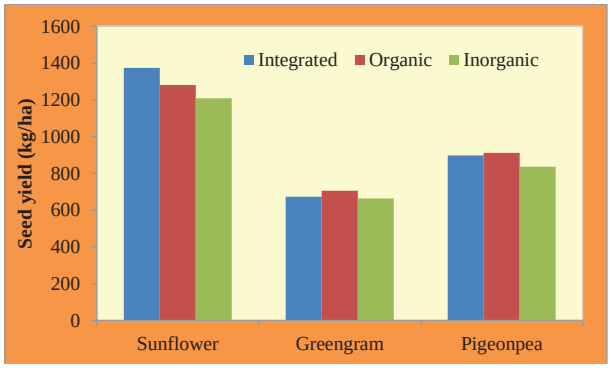


Fig.44: Performance of crops under different production systems

soil organic C (0.67%), compared to inorganic and integrated production systems. Plots under organic management being on par with integrated production systems also recorded significantly higher available K (263.1 kg/ha), Cu (2.54 ppm), Fe (7.92 ppm) and Zn (0.57 ppm) compared to inorganic production system. However, integrated production system recorded significantly higher available P (28.2 kg/ha) compared to other production systems. The bacteria, fungal and actinomycetes counts (6, 3.22 and 5.51 log10 CFU/g soil, respectively) were highest in plots under organic management compared to other treatments in greengram. Similarly in sunflower, bacterial and fungal counts (6.73 and 3.56 log10 CFU/g soil, respectively) were higher in plots under organic management compared to other treatments. In case of pigeonpea, bacterial counts (6.00 log10 CFU/g soil) were higher in plots under organic management than other treatments (Table 189).

Table 189: Effect of different treatments on soil microorganisms

Crop	Treatment	Bacteria (Log10 CFU/g soil)	Fungi (Log10 CFU/g soil)	Actinomy-cetes (Log10 CFU/g soil)	PSB (Log10 CFU/g soil)	Azotobac-ter sp. (Log10 CFU/g soil)	Pseudomonas sp. (Log10 CFU/g soil)
Sunflower	Organic	6.73	3.56	5.21	5.00	5.43	5.64
	Integrated	6.60	3.43	5.36	5.00	5.85	5.60
	Inorganic	6.00	3.12	5.42	5.48	5.56	5.99
Greengram	Organic	6.00	3.22	5.51	5.64	5.22	5.52
	Integrated	6.00	3.12	5.41	4.82	5.30	5.43
	Inorganic	5.52	2.82	4.88	5.00	5.12	5.48
Pigeonpea	Organic	6.00	3.22	5.01	5.12	5.60	5.78
	Integrated	5.82	3.30	5.00	5.78	5.97	5.52
	Inorganic	5.82	3.48	4.88	5.30	5.67	5.52

3. NICRA - Other Activities

3.1 Collaboration

Collaboration with AICRPAM-NICRA: Agromet advisories from common centres of AICRPDA-AICRPAM viz. Akola, Anantapuramu, Bengaluru, Vijayapura, Parbhani and Solapur were issued by AICRPAM centres in AICRPDA NICRA villages. Successful RTCPs from AICRPDA-NICRA villages will be up-scaled in AICRPAM-NICRA villages by the AICRPAM.

Collaboration with NICRA-TDC-KVKs: NICRA-KVKs in the domain districts of AICRPDA centres (Akola, Anantapuramu, Bengaluru, Biswanath Chariali, Chianki, Hisar, Indore, Jagdalpur, Jhansi, Kovilpatti, Parbhani, Rajkot, Rakh Dhiansar, SK Nagar, Solapur, Varanasi and Vijayapura) were given technical inputs on real time contingency planning and doable technologies.

3.2 Village Institutions

3.2.1 Village Climate Risk Management Committee (VCRMC)

VCRMCs have been established in each NICRA village and actively involved in various activities of the project. During 2017-18 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
Budhadani village (old), Kandhamal district, Odisha	05.06.2017	Interventions for *kharif* 2017 discussed
	08.07.2017	Beneficiary selection and activities of NICRA programme
Gunjidraga village (New), Kandhamal district, Odisha (Phulbani)	02.08.2017	Custom hiring center management
	28.08.2017	Pest and disease management
Vannedoddi village, Ananthapuramu district, Andhra Pradesh, (Anantapuramu)	24.07.2017	Formation of conservation furrows, and implementation of *kharif* interventions
Achalpur & Nainwan (Old villages) Bhawanipur (New village), Hoshiarpur district, Punjab (Ballowal Saunkhri)	17.06.2017	Revise the rate of custom hiring centre
	12.10.2017	Supplemental irrigations from harvested rainwater at village Nainwan
Warkhed and Kajleshwar village Akola district, Maharashtr (Akola)	29.07.2017	Opening of furrows by tying a rope to hoe in soybean and cotton for *in-situ* moisture conservation
	19.08.2017	Foliar spray of 2% urea and 2% DAP at the time of flowering and boll development stage in cotton
	07.10.2017	
Babhulgaon village, Parbhani district, Maharashtra (Parbhani)	17.06.2017	Early and drought tolerant varieties should be sown
	4.08.2017	Hoeing and weeding operations should be carried out Straw mulching and spraying of KNO_3 Opening of furrow should be undertaken after every 4 rows in soybean and 2 rows in pigeonpea and cotton
	17.10.2017	Supplemental irrigation to cotton and pigeonpea

NICRA village	VCRMC meeting	Outcome of VCRMC meetings
Nignoti village, Indore district, Madhya Pradesh (Indore)	01.07.2017	Ensure proper germination/gap filling of crops
	11.07.2017	Interculture and foliar sprays
	09.08.2017	Pesticide use as required
	30.08.2017	Pest management
	01.09.2017	Take up plant protection in pigeonpea
	07.09.2017	*Rabi* planning for chickpea, suggested new varieties, use of harvested rainwater
	12.10.2017	Sowing of *rabi* crops on residual moisture
	27.02.2018	Construction of WHT suggested
Kavalagi village, Vijayapura district, Karnataka (Vijayapura)	12.09.2017	Take up *rabi* sowings and seed treatment before sowing of crop
	07.11.2017	Thinning and gap filling
	14.11.2017	Suggested intercultivation practices
	21.11.2017	Plant protection measures in pigeonpea
	28.11.2017	Weed control and repeated intercultivation in *rabi* crops
	05.12.2017	Harvesting of pigeonpea at right time
	12.12.2017	Plant protection in chickpea
	19.12.2017	Plant protection in safflower and chickpea
	26.12.2017	Proper bagging and marketing of pigeonpea seed
Chikkamaranahalli village, Bengaluru Rural district, Karnataka (Bengaluru)	22.07.2017	Opening of ridges and furrow between paired of pigeonpea in pulse based cropping system
	29.08.2017	Weeding and intercultivation in fingermillet
		Opening of moisture conservation furrow between paired rows of pigeonpea
	30.09.2017	Plant protection measures in pigeonpea
	04.11.2017	

Interaction meeting with farmers, Pata meghapur village, Rajkot district, Gujarat

NICRA village	VCRMC meeting	Outcome of VCRMC meetings
Patameghpar, Jamnagar district, Gujarat. (Rajkot)	21.05.2017	Control of pink bollworm in cotton
	15.06.2017	Contingency crop planning for *Kharif* 2017
	28.10.2017	Contingency crop planning for *rabi* (2017-18)
Dharmathanpatti (Kovilpatti)	21.12.2017	Contingent crop management
Muthukrishnapuram, (Kovilpatti)	28.12.2017	Spray PPFM @ 500 ml/ha
Nagla Dulhe Khan (Agra)	20.06.2017	Adopt *in-situ* moisture conservation practices
	14.09.2017	Avoid the application of chemical fertilizers during dry spell
Kalimati/Dholia, Banaskantha (SK Nagar)	11.06.2017	*Kharif* planning
	22.06.2017	Selection of beneficiaries
	11.07.2017	Application of recommended dose of fertilizers
	09.08.2017	Split application of urea
Khaner village, Samba district (Rakh Dhiansar)	29.06.2017	Selection of beneficiaries of newly adopted NICRA village Crops and their varieties for ensuing *Kharif* season
	26.10.2017	Possibility of sowing of *rabi* crop on receding moisture in the wake of non-receipt of winter rains. Sowing of wheat with seed and fertilizer drill

3.2.2 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 maintained and used for repair of the implements. Implements availability for various agricultural operations on custom hiring during 2017-18 in adopted NICRA villages, are given below:

Improved implements used for various agricultural operations on custom hiring

NICRA village	Implement used	Farm operation	Area covered (ha)	Labour saving (hr/ha)	Cost saving (Rs/ha)
Muthukrishnapuram, (Kovilpatti)	Rotavator	*In situ* soil mulching	2	5.0	3000
Patameghpar, Jamnagar district, Gujarat. (Rajkot)	Rotavator	Ploughing	27	3.0	525
	Cultivator	Primary tillage	26	3.0	285
	Reversible plough	Deep ploughing	17	2.5	515
Budhadani village, Kandhamal district, Odisha (Phulbani)	Power tiller	Land preparation	2.5	25%	15%
	Reaper	Harvesting	2	60%	35%
	Winnower	Threshing	2	60%	40%
	Water Pump	Irrigation	1	40%	30%
	Sprayer	Plant protection	1.5	60%	40%

NICRA village	Implement used	Farm operation	Area covered (ha)	Labour saving (hr/ha)	Cost saving (Rs/ha)
Vannedoddi village, Ananthapuramu district, A.P. (Anantapuramu)	Chisel plough	Preparatory cultivation	2	--	--
Achalpur & Nainwan (Old villages) Bhawanipur (New village), Hoshiarpur district, Punjab (Ballowal Saunkhri)	Rotavator	Field preparation	8	48%	41%
	Bund maker	Field preparation			
	Diesel pump	Supplementary irrigation	11	60%	54%
	Maize planter	Sowing of maize	15	56%	48%
	Oilseed drill	Sowing of oilseed crops	-	-	-
	Ridger	Field preparation	8	48%	46%
	Wheat seed drill	Sowing of wheat	12	61%	54%
Warkhed and Kajleshwar village Akola district, Maharashtra(Akola)	Multipurpose Thresher	Threshing	21	-	1170
	Rotavator	Land preparation	4	-	900
Babhulgaon village, Parbhani district, Maharashtra (Parbhani)	Seed cum ferti drill	sowing and fertilizer application	4	-	400
	Stubble collector	After ploughing, stubbles were collected	4	-	600/ha
Nignoti village, Indore district, Madhya Pradesh (Indore)	Reversible MB plough	Summer tillage	12	-	30%
	Sprayers	Plant protection	10	-	50%
	Spiral seed grader	Seed grading	12	-	50%
Kavalagi village, Vijayapura district, Karnataka (Vijayapura)	Bund former	Making of bunds	1	-	1000
	Power sprayer	Plant protection	4	-	100
	Cycle operated fertilizer drill	Fertilizer application	0.5		400
	Tractor drawn Seed cum fertilizer drill	Sowing	2	-	800
Kochariya and Mandpiya village in Bhilwara district and Lapsiya and Tara ka kheda villages in Rajsamanad district Rajasthan (Arjia)	Intercropping seed drill	Sowing	-	-	-
	Seed drill for sowing of groundnut	Sowing	-	-	-
	Raised bed seed drill	Sowing	-	-	-
	Arjia wheel hoe	Interculture	-	-	-
	Single row power weeder-4 type	Weeding/interculture	-	-	-
	Battery operated power sprayer	Spraying	-	-	-

Field preparation by rotavator

Sowing by seed drill

Sowing by raised bed planter

NICRA village Naga Duleh Khan, Agra district, Uttar Pradesh

NICRA village	Implement used	Farm operation	Area covered (ha)	Labour saving (hr/ha)	Cost saving (Rs/ha)
Chikkamaranahalli village, Bengaluru Rural district, Karnataka (Bengaluru)	Improved sickles	Harvesting	13	40.0	1320
	Modified seed drill	Sowing	23	20.0	160
	Spike tooth harrow	Intercultivation	28	18.0	400
Narotewadi village, Solapur district, Maharashtra (Solapur)	Tractor operated four blade baliram plough	Land preparation	48	20-30%	37%
	Cultivator 9 and 5 tooth				
	Cycle hoe	Weeding			
	Laxmi sickle	Harvesting			
	Crida-9 row tractor drawn seed cum ferti planter	Sowing			
Tahkapal, Tandpal villages, Jhartarae (New village) Bastar district Bastar Chhattisgarh (Jagdalpur)	Cultivator	Land preparation	8	5.0	300
	Seed cum fertilizer	Sowing	6	6.0	250
	Rotavator	Land preparation	5	4.0	300
	Trolley	Transport	7	5.0	200
Tedha village, Mirzapur district, Uttar Pradesh (Varanasi)	M.B. plough	Summer ploughing	22	-	-
	Cultivator	Tillage and interculture	18	-	-
	Ridger	Ridge furrow planting	8	-	-
	Seed drill	Sowing	12	-	-
	Sprayers	Spraying	14	-	-
Nagla Dulhe Khan (Agra)	Seed cum ferti drill	sowing and fertilizer application	10	-	400
	Rotavator	Seedbed preparation	5	-	600
	Ridger seeder	Sowing	10		
Kalimati/Dholia, Banaskantha (SK Nagar)	Disc harrow	Ploughing	12	-	-
	Rotavator	Seed bed preparation	30	2.5	700
	Roto till drill	Sowing	8	3.5	1500
	Multi crop seed cum fertilizer drill	Sowing	26	5.0	1200
	Power weeder	Weeding /interculture	16	6.0	1200
	Improved sickle	Harvesting	24	3.0	250
	Castor decorticator	Seed decorting	18	5.0	750
	Maize sheller	Threshing	04	4.0	400
	Winnowing fan	Seed cleaning	20	5.0	900
Khaner village, Samba district (Rakh Dhiansar)	Seed cum fertilizer drill	Sowing	1	-	1080
	Maize planter	Sowing	1	-	1290
	Maize sheller	Shelling of cobs	-		2940
Chamua, Lakhimpur (Biswanath Chariali)	Power tiller	Ploughing and puddling	10	50%	5000
	Water lifting pump	Life saving irrigation	5	70%	2000
	Reaper	Harvesting of rice	5	75 %	7500

3.2.3 Village Seed Bank

Efforts were made to provide the sources of alternative crop seed and varieties to address the problem of seed unavailability. The farmers of Babhulgaon village, Parbhani district produced and maintained seed of improved varieties of soybean (2000 kg) and pigeonpea (600 kg). In Hardoiya village, Faizabad district farmers produced seed of improved varieties of pigeonpea, maize and chickpea. Similarly, farmers produced seed of recent varieties of fingermillet, pigeonpea, field bean and cowpea in Chikkamaranahalli village, Bengaluru Rural district; groundnut, sesame; rice, lentil, sesame, greengram and maize in Tedha village, Mirzapur district; rice, blackgram, pigeonpea, horsegram and small millets in Tahakapal village, Bastar district; pearlmillet, greengram, blackgram, cluster bean and fodder sorghum in Kalimati village, Banaskantha district; and seed of improved rice varieties in Chamua village, Lakhimpur district. The total seed of different crops produced/maintained in AICRPDA-NICRA villages was 33013 kg.

Seed availability in NICRA villages

NICRA village	Crop	Variety/hybrid	Quantity (kg)
Babhulgaon village, (Parbhani)	Soybean	MAUS 71 and MAUS 81	2000
	Pigeonpea	BDN 711 and BSMR 736	600
Hardoiya village, Faizabad (Faizabad)	Pigeonpea	NDA-2	75
	Pigeonpea	NDA-1	50
	Maize	Naveen	75
	Chickpea	PUSA-362	5000
	Chickpea	Udai	5000
Chikkamaranahalli village, Bengaluru Rural (Bengaluru)	Fingermillet	GPU-28	600
	Pigeonpea	GPU-48	50
	Field bean	BRG-2	60
	Cowpea	HA-4	200
Tedha village, Mizapur (Varanasi)	Rice	NDR-97, HUR-3022	6800
	Lentil	HUL-57	3000
	Sesame	Shekhar	300
	Greengram	HUM-16	250
	Maize	Malviya makka-2	600
Tahakapal village, Bastar (Jagdalpur)	Rice	197 cultivars	224
	Blackgram	04 cultivars	56
	Pigeonpea	04 cultivars	26
	Sorghum	04 cultivars	47
	Fingermillet	15 cultivars	138
	Kodo millet	09 cultivars	157
	Horsegram	04 cultivars	34
	Little millet	05 cultivars	50
	Niger	02 cultivars	11
Kalimati/ Dholia village, Banaskantha (SK Nagar)	Pearlmillet	GHB 558	90
	Maize	GM 2	350
	Greengram	GM 4	320
	Blackgram	GU 1	200
	Cluster bean	GG 2	150
	Sorghum (fodder)	CSV 21	2800

NICRA village	Crop	Variety/hybrid	Quantity (kg)
Chamua village, Lakhimpur (Biswanath Chariali)	Paddy	Disang	300
		TTB-404	500
		Mulagabharu	100
		Mahsuri	1000
		Gitesh	150
		Kanaklata	50
		TTB-303-2-23	100
		Ranjit	1500
Total			**33013**

3.2.4 Fodder Bank

To strengthen the availability of the green fodder in the NICRA villages of Naiwan and Achalpur, Hoshiarpur district seed of improved variety of pearlmillet (FBC 16) was provided and hybrid Napier cuttings were planted on the field bunds of the farmers. At Chikkamaranahalli village, Bengaluru Rural district, farmers were supplied with seeds of *Stylosanthes hamata* for sowing on the bunds to establish perennial fodder source and to stabilize bunds. The fodder was used for feeding small ruminants. Subsequently, fodder maize (South African Tall) was grown in an area of 15 ha in 50 farmers' fields for realizing better fodder supply to milch animals in the cluster. At Tahakpal village, Bastar district farmers produced seed of *Stylosanthes* (62.7 kg), hybrid Napier bajra (22.4 kg), berseem (53.75 kg) and fodder sorghum (95.2 kg). In Babhulgaon village of Parbhani centre, sorghum was cultivated during both *kharif* (10 farmers) and *rabi* (25 farmers) for fodder and grain purpose. At Rajkot, fodder sorghum was grown by farmers having livestock, dry fodder stored and used for own cattle. Haulm of groundnut and straw of wheat also stored for own cattle and used during off-season. At Biswanth Chariali (Chamua village), in collaboration with AICRP on Forage Crops, Jorhat Centre, AAU, three species of perennial fodder varieties *viz.* - Hydrid Napier (Variety: CO -2 and CO - 4), Congo signal and *Setaria* were planted in the fodder bank.

Fodder maize at Chikkamaranahalli village, Bengaluru rural district, Karnataka

3.3 Training / Field days etc., organized

3.3.1 Trainings

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
Agra	*kharif* pre-seasonal training	72	22.06.2017
	Contingency crop/cultivars planning	41	09. 07.2017
	Climate resilient agriculture	76	28.03.2018
Akola	*Kharif* pre-seasonal training	42	29.03.2018
Anantapuramu	Importance of subsoiling	25	13.04.2017
	In-situ moisture conservation through deep tillage	30	12.05.2017
	Subsoiling in drylands	26	01.06.2017
	Improved management practices for dryland crops	24	07.06.2017
	Sowing of groundnut and pigeonpea with tractor drawn Ananta planter	25	08.06.2017
	In-situ moisture conservation through conservation furrows	27	03.08.2017
	Deep tillage with chisel plough in pigeonpea	22	08.09.2017
	Supplemental irrigation through rain water harvested in farm pond	23	10.09.2017
	Rainwater harvesting in farm pond	29	25.09.2017
	Rainwater harvesting in farm pond	24	13.10.2017
	Pest & disease management in pigeonpea	21	20.11.2017
	Pest & disease management in pigeonpea	23	28.11.2017
Arjia	Improved ryland technologies	25	29.08.2016
Hisar	Timely sowing of *rabi* crops under conserved moisture conditions	22	14.11.2017
	Weed management in *rabi* crops	18	17.11.2017
	Interculture operations in *rabi* crops	23	21.11.2017
	In-situ moisture conservation with wheel hand hoe	26	05.12.2017
	Disease management in chickpea	32	09.01.2018
	Insect-pest management in mustard	35	03.02.2018
	Role of weather under dryland conditions	28	09.02.2018
	Precautions during harvesting of *rabi* crops	25	21.03.2018
Indore	Stress management and foliar application of nutrients	25	11.07.2017
	Plant protection measures	25	09.08.2017
	Plant disease management	30	30.08.2017
	Rabi planning with proper seed treatment and managing residual moisture	20	07.09.2017
	Control measures for wilt and insects in *rabi* crops	25	12.10.2017
	Conjunctive use of ground and surface water in field crops	25	27.02.2018

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
Jagdalpur	Crop establishment planning	78	22.07.2017
	Water collection and utilization	65	12.08.2017
	Pest management in *kharif* crops	45	24.08.2017
	Integrated water management	39	16.09.2017
	Preparation for *rabi* crop production	65	15.10.2017
	Vegetable crop production in *Badi* situation	89	25.11.2017
	Post harvest technology	56	14.12.2017
Kovilpatti	Improved management practices of dryland crops	40	23.03.2018
Parbhani	*Kharif* crop management	40	18.06.2017
	Kharif crop management	70	26.07.2017
	Rabi crop management	49	17.10.2017
Rajkot	Importance of soil and water testing	70	05.05.2017
	NIM in *kharif* crops	45	28.05.2017
	Pest management in *kharif* crops	65	18.08.2017
Rakh Dhiansar	Pre-*kharif* training	35	29.06.2017
	Farmers scientists interaction meeting	60	26.11.2017
	Pre-*rabi* training	46	26.10.2017
SK Nagar	Method of sowing of different crops	250	19.06.2017
	Soil application of fertilizers in different crops	290	01.08.2017
Solapur	Pre-*kharif* training	55	10.06.2017
	Pre-*kharif* training	75	01.07.2017
	Perennial crops in drylands	65	01.07.2017
	Rabi pre-seasonal training	65	29.09.2017
Varanasi	Soil water conservation measures	40	25.06.2017
	Soil water conservation measures	34	01.08.2017
	Agro-techniques for pulses, oilseeds and upland rice production	38	19.12.2017
	Rabi cops sowing	62	25.02.2018
	Importance of MIS in crop production	80	27.11.2017
	fertilizer management in *kharif* crops	53	15.09.2017
Vijayapura	Preparedness for *rabi* crop production technology	120	12.09.2017
Total number of beneficiaries		**3098**	

Field visit in Tahkapal village, Jagdalpur district, Chettisgarh

Field visit in Warkhed village, Akola district, Maharastra State

3.3.2 Field Days

AICRPDA centre	Intervention	NICRA village	Date	Beneficiaries (No.)
Akola	*Rabi* crop production	Warkhed and Kajleshwar	20.01.2017	109
	Opening of furrows in soybean and spraying of 2% urea at flowering stage in cotton		11.07.2017	22
	Spraying of 2% DAP at boll development stage in cotton		08.10.2017	08
	Agricultural produce processing		28.03.2018	05
Ballowal Saunkhri	Sowing methods for higher production of maize	Nainwan & Bawanipur	07.07.2017	12
	Kisan Mela	Ballowal Saunkhri	08.09.2017	4000
	Crop management	Achalpur	26.09.2017	80
	Kisan Mela	Ballowal Saunkhri	06.03.2018	2500
Indore	*Kisan* mela	College of Agriculture, Indore	23.09.2017	500
	Soybean day/mela	Indian Institute of Soybean Research, Indore	11.12.2017	500
	Summer ploughing, residue management	Ningnoti	11.03.2018	50
Jagdalpur	Jal panchayat	Tahkapal	12.11.2017	87
	Farm pond technology	Tahkapal	15.07.2017	45
Parbhani	Borewell recharge technology	Ujalamba	10.05.2017	40
	Kharif crop management	Babhulgaon	20.07.2017	60
	Stress management practices	Babhulgaon & Ujalamba	25.09.2017	70
	Rabi crop management	Babhulgaon	29.10.2017	45
Rajkot	Control of pink boll warm in Bt cotton	Patameghpar	25.09.2017	119
Rakh Dhiansar	Farmers scientists interaction cum field day	Madana village	06.10.2017	37
Solapur	*Kharif* crop production	Narotewadi	16.08.2017	20
Varanasi	Microbial bio-fertilizers	Jayapur	25.09.2017	64
Vijayapura	Compartment bunding, improved varieties and profitable intercropping systems	Honnutagi	29.12.2017	140
			Total number of beneficiaries	**8513**

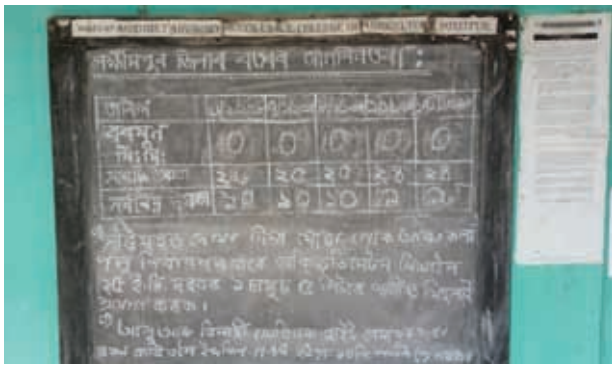
Field day in Naiawan/Achalpur village, Hoshiarpur district, Punjab

Field day in Budhshelly village, Bhiwani district, Hisar

3.4 Agro-Advisories

Centre	Agro-advisories	
	Mode	Frequency
Agra	SMS through farmer's portal	Twice in a week
Akola	Pamphlets	23 no. of advisories
Anantapuramu	Black board in NICRA village and Mobile SMS	Twice in a week (Tuesday and Friday)
Arjia	Black board in NICRA village	As required
Ballowal Saunkhri	Weekly bulletin	Weekly
Bengaluru	Black board in NICRA village	Twice in a week (Tuesday and Friday)
Biswanth Chariali	Black board in NICRA village	Every Tuesday
Faizabad	All India Radio, Faizabad and through kisan call centre of the University	Daily
Indore	Radio, Newspapers, SMS	Twice in a week
Jagdalpur	Black board in NICRA village	Time to time
Kovilpatti	All India Radio, SMS, Village notice board	Twice in a week
Parbhani	Black board in NICRA village	Weekly
Rajkot	SMS through farmer's portal	Twice in a week
Vijayapura	Meetings in NICRA village	2 to 3/month

Agro advisories to the farmers of Warkhed and Kajleshwar villages, Akola district, Maharastra State



Agromet advisory in Chamua village, Sonitpur district, Assam

3.5 Soil Health Cards

Distribution of soil health cards in NICRA villages during 2017-18

Centre	NICRA village	Soil health cards issued (No. of farmers)
Kovilpatti	Thoppurediapatti, Ilayarasanenthal, Muthukrishnapuram, Dharmathanpatti, Vadakkupatti and Nakkalamuthanpatti	23
Akola	Warkhed	108
Arjia	Kochariya and Lapsiya	40
Hisar	Balawas and Budhshelly	71
Phulbani	Budhadani	38
Rajkot	Patameghpar	25
SK Nagar	Kalimati	15
	Dholiya	32

3.6 Linkages developed

The AICRPDA centres have developed linkages with ICAR institutes, Central government schemes/ State Government programmes for implementation of NICRA programmes, and with state line department, KVKs, ATMA, KSDA, and NGOs for capacity building of various stake holders. During 2017-18, the scientists of the centres were actively involved in 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 5 states (Karnataka, Andhra Pradesh, Telangana, Maharashtra and Rajasthan) for operationalization of district agriculture contingency plans and contributed in developing action plans.

4. Publications

a) Research papers

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b) Presentation in conference/symposia etc

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Acronyms

AAU	Assam Agricultural University
AICRPAM	All India Coordinated Research Project for Agrometeorology
AICRPDA	All India Coordinated Research Project for Dryland Agriculture
AM	Arbuscular Mycorrhiza
ANGRAU	Acharya NG Ranga Agricultural University
ARS	Agriculture Research Station
AU	Agriculture University
AVT	Advanced Varietal Trial
AWC	Available Water Capacity
BAU	Bihar Agricultural University
BBF	Broad Bed Furrow
BC ratio	Benefit : Cost ratio
BD	Bulk Density
BHU	Banaras Hindu University
BMT	Bamboo Mat
CAL	Cetyl Alcohol
CAU	Central Agricultural University
CAZRI	Central Arid Zone Research Institute
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CCT	Continuous Contour Trenches
CD	Critical Difference
CHC	Custom Hiring Center
CHMC	Custom Hiring Management Committee
CR	Crop Residue
CRIDA	Central Research Institute for Dryland Agriculture
CT	Conventional Tillage
DAS	Days After Sowing
DFRS	Dryland Farming Research Station
Dr. PDKV	Dr Panjabrao Deshmukh Krishi Vidyapeeth
DSI	Drought Susceptibility Index
DTE	Drought Tolerance Efficiency
DTI	Drought Tolerance Index
EC	Electrical Conductivity
FP	Farmers' Practice
FYM	Farmyard Manure
GRD	General Recommended Dose
ha	Hectare
Hb	Herbicide
HC	Hydraulic Conductivity
HDPS	High Density Planting System
HW	Hand Weeding
ICAR	Indian Council of Agricultural Research
IF	Inorganic Fertilizer
IFS	Integrated Farming System
IGAU	Indira Gandhi Agricultural University
IGFRI	Indian Grassland and Fodder Research Institute
IISWC	Indian Institute of Soil and Water Conservation
IMD	Indian Meteorological Department
INM	Integrated Nutrient Management
IP	Improved Practice
IVT	Initial Varietal Trial
JAU	Junagadh Agricultural University
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya
kg	Kilogram
LAI	Leaf Area Index
LER	Land Equivalent Ratio
LSVT	Large Scale Varietal Trial
LT	Low Tillage
MCEY	Main Crop Equivalent Yield
MJ	Mega Joule
MLT	Multi Location Trial
mm	Milli Meter
MPKV	Mahatma Phule Krishi Vidyapeeth
MPUAT	Maharana Pratap University of Agriculture and Technology

MR	Maize Residue
MUE	Moisture Use Efficiency
MWD	Mean Weight Diameter
NCPC	Nano Clay Polymer Composite
NDUAT	Narendra Dev University of Agriculture and Technology
NICRA	National Innovations on Climate Resilient Agriculture
NMR	Net Monetary Returns
NOL	Neem Oil
NRM	Natural Resource Management
OC	Organic Carbon
ORP	Operational Research Project
OT	Off-Season Tillage
OUAT	Orissa University of Agriculture & Technology
PAN	Pan Evaporation
PAU	Punjab Agricultural University
PET	Potential Evapotranspiration
PMT	Permanent Manurial Trail
PSB	Phosphate Solubilizing Bacteria
PSF	Phosphate Solubilizing Fungi
PST	Paddy Straw
PVA	Polyvinyl alcohol
RBSC	Raja Balwant Singh College
RDF	Recommended Dose of Fertilizer
RDN	Recommended Dose of Nitrogen
RFS	Ridge Furrow System
Rs.	Rupees
RT	Reduced Tillage
RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
RWC	Relative Water Content
RWUE	Rainwater Water Use Efficiency
SAL	Steryl Alcohol
SDAU	Sardarkrushinagar Dantiwada Agricultural University
SDT	Saw Dust
SE	Semi Erect
SI	Supplemental Irrigation
SK Nagar	Sardarkrushi Nagar
SKDAU	Sardar Krushinagar Dantiwada Agricultural University
SKUAS&T	Sher-e-Kashmir University of Agricultural Science & Technology
SMW	Standard Meteorological Week
Sol	Silicon Oil
SSP	Single Super Phosphate
STBF	Soil Test Based Fertilizer
SW	South-West
SWC	Soil & Water Conservation
SYI	Sustainable Yield Index
TNAU	Tamil Nadu Agricultural University
UAS	University of Agricultural Sciences
UAS_B	University of Agricultural Sciences, Bengaluru
UAS_D	University of Agricultural Sciences, Dharwad
UAS_R	University of Agricultural Sciences, Raichur
VC	Vermicompost
VNMKV	Vasantrao Naik Marathwada Krishi Vidyapeeth
WUE	Water Use Efficiency
ZT	Zero Tillage

Best farmers from AICRPDA-NICRA villages felicitated during 33rd Foundation Day of ICAR - CRIDA, Hyderabad, 12th April, 2017

Shri Kalidas Balajidhumal
Parbhani, Maharashtra

Shri Subhash Siddaraya
Chappat, Vijayapura

Shri Daji Chandu Kale
Solapur, Maharashtra

Shri Muralidhara Ganda
Phulbani, Odisha

Dr. David Bergvinson, DG, ICRISAT and Dr. Ch. Srinivasa Rao, Director CRIDA felicitated the above farmers

Best farmers from AICRPDA-NICRA villages felicitated during XVI Working Group Meeting of AICRPDA IGKV, Jagdalpur, 1-5 February, 2018

Shri Kedar Kashyapji Hon'ble Edu. Minister,
Govt.of Chhattisgarh, felicitated
Smt. Sonadayi,Tahkapal village, Bastar district, Chhattisgarh

Shri Mahadeo Gulabrao Dange, Warkhed village,
Akola district, Maharashtra

Shri Patel Shantibhai Kantibhai,
Kalimati village, Banaskantha district, Gujarat

Dr. JC Katyal, Hon'ble Chairman VII QRT, CRIDA-AICRPDA-AICRPAM, Dr. SK Patil, Hon'ble Vice Chancellor, IGKV, Dr. S Bhaskar, ADG (AAF&CC), Dr. MB Chetti, ADG (HRD) felcitated the above farmers

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