राष्ट्रीय जलवायु समुत्थान कृषि में नवप्रवर्तन

National Innovations in Climate Resilient Agriculture

Managing Weather Aberrations
through Real Time Contingency Planning

AICRPDA - NICRA

वार्षिक प्रतिवेदन

Annual Report
2018-19

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना

All India Coordinated Research Project for Dryland Agriculture

ICAR-Central Research Institute for Dryland Agriculture

Hyderabad

Sixth Annual Review Workshop of AICRPDA-NICRA

ICAR-CRIDA, Hyderabad, 25-26 May, 2018

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

Release of publications

Participants of the workshop

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Front Cover: Rainwater harvesting in farm pond and supplemental irrigation through sprinklers in soybean, AICRPDA Centre, Parbhani

Back Cover: Intercultivation in groundnut in Patameghpar village, Jamnagar district; Supplemental irrigation through drip system in castor in Kalimati/Dholiya village, Banaskantha district; Short duration rice variety 'Dishang' in Chamua village, Lakhimpur district; Intercropping of pigeonpea + fieldbean (1:1) in Chikkamaranahalli village, Bengaluru Rural district

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Preface

Managing weather risks, particularly delayed onset of south-west monsoon and agricultural drought, is the key challenge in rainfed agriculture. A decrease of one standard deviation from the mean annual rainfall often leads to a complete loss of the crop. Dry spells of 2 to 4 weeks during critical crop growing stages cause partial or complete crop failure. Under National Innovations in Climate Resilient Agriculture (NICRA), the 23 network centres of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) conceptualized Real-Time Contingency Plan (RTCP) implementation to manage weather risks. The RTCP was implemented, both on-station and on-farm trials/demonstrations, with two pronged approach i.e. preparedness and real-time contingency measures, with established village level institutional mechanisms.

During the Sixth Annual Review Workshop of AICRPDA-NICRA held during 25-26 May, 2018 at ICAR-CRIDA, the trials/demonstrations at both on-station and in 55 AICRPDA-NICRA villages in 24 districts across 15 states, were critically reviewed. The Technical programme 2018-19 was strengthened at 23 centres including collaboration with All India Coordinated Research Project on Agrometeorology, ICAR-IIOR & AICRPs on Castor/Sesame/Niger, ICAR-IIMR & AICRPs on Millet Crops, and NICRA-KVK villages.

During 2018-19, the onset of monsoon was delayed by 15, 18 and 20 days, respectively in NICRA villages of Garhwa, Faizabad and Rewa districts. The crops experienced 2 to 4 dry spells in NICRA villages in Akola, Anantapuramu, Bhilwara, Bengaluru Rural, Vijayapura, Bhiwani, Indore, Parbhani, Jamnagar, Solapur and Mirzapur districts during *kharif* and 2 to 4 dry spells in Lakhimpur, Garwa, Bastar, Samba, Vijayapura and Thoothukkudi districts during *rabi* season. The interventions to cope with delayed onset of monsoon and seasonal drought were demonstrated in more than 1000 farmers' fields in 55 villages. The real-time coping measures helped in enhancing the crop yields and more income to the farmers.

The salient achievements of AICRPDA-NICRA technical programme 2018-19, both on-station and on-farm, are presented in this document. I compliment the team of scientists from PC Unit, AICRPDA and 23 AICRPDA centres for implementing the technical program and for generating real-time data on impact of NICRA programme.

We are highly grateful to Dr. T. Mohapatra, Secretary (DARE) & DG, ICAR, New Delhi for his valuable guidance to the project. We profusely 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 acknowledge the support of Dr. M. Prabhakar, PI, NICRA, PC, AICRPAM and scientists of NICRA-KVKs. We are also highly thankful to all the participating farmers from 55 AICRPDA-NICRA villages across the country for their participation, contribution and support.

(G. Ravindra Chary)
Director (Acting), ICAR-CRIDA

Contents

कार्यकारी सारांश

मौसम की प्रतिकूलताओं से जूझने के लिए सही समय की आकस्मिक योजना (आरटीसीपी) का कार्यान्वयन एवं तैयारी पर विशेष ध्यान देते हुए राष्ट्रीय जलवायु समुत्थान कृषि में नवप्रवर्तन (निक्रा) के अंतर्गत अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना (एक्रीपडा) के 23 केंद्रों में एवं खेतों पर प्रदर्शन/जांचों का आयोजन किया जा रहा है। सही समय की आकस्मिक योजनाओं (आरटीसीपी) का कार्यान्वयन द्विस्तरीय दृष्टिकोण से किया जा रहा है, यानि i) सही समय के आकस्मिक उपाय एवं ii) तैयारी। वर्ष 2018-19 के दौरान, 15 राज्यों में व्याप्त 24 जिलों के 23 गांव केंद्रों (55 गांवों) के 1000 से अधिक किसानों के खेतों में मानसून के आरंभ में देरी एवं मौसमी सूखा (शीर्ष, मध्य एवं अंतिम) से जूझने के हस्तक्षेपों को प्रदर्शित किया गया। वर्ष 2018 के दौरान गढ़वाह (झारखंड़), फैज़ाबाद (उत्तर प्रदेश) एवं रीवा (मध्य प्रदेश) के निक्रा के गांवों में मानसून के आने में क्रमश: 15,18 एवं 20 दिनों की देरी हुई। इसके अलावा, अकोला (महाराष्ट्र), अनंतपुरमु (आंध्र प्रदेश), भीलवाड़ा (राजस्थान), बेंगलुरू ग्रामीण (कर्नाटक), विजयपुर (कर्नाटक), भिवानी (हरियाणा), इंदौर (मध्य प्रदेश), परभनी (महाराष्ट्र), जामनगर (गुजरात), सोलापुर (महाराष्ट्र) एवं मिर्जापुर (उत्तर प्रदेश) के निक्रा के गावों में फसलों के विभिन्न स्तरों पर 2-4 शुष्क दौर आए। विशेष उपलब्धियां नीचे दी जा रही हैं :

1) केंद्र पर

मानसून की शुरुआत में देरी

चियान्की में, मानसून की शुरुआत में 15 दिनों (24 जून) की देरी हुई। स्थानीय किस्म (3146 किलोग्राम प्रति हेक्टेयर) की तुलना में वर्षा आधारित मध्यम चावल की उन्नत किस्म अरैज़-तेज ने अधिक लाभ (55284/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.96) सहित 47 प्रतिशत उन्नत अनाज पैदावार (4624 किलोग्राम प्रति हेक्टेयर) दर्ज किया। इसके बाद किस्म पीएसी-801 (4151 किलोग्राम प्रति हेक्टेयर) का स्थान था। तिल की स्थानीय किस्म (389 किलोग्राम प्रति हेक्टेयर) की तुलना में शेखर ने उन्नत बीज पैदावार (634 किलोग्राम प्रति हेक्टेयर), कुल लाभ (18798/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.71) दिया। इसके बाद जेएलटी-408 (627 किलोग्राम प्रति हेक्टेयर) का स्थान था।

मध्य मौसमी सूखा

अरजिया के अर्ध-शुष्क वर्टीसोल मृदाओं में, शुष्क दौर (2579 किलोग्राम प्रति हेक्टेयर) के तुरंत बाद पर्याप्त नमी पर पर्ण प्रयोग की तुलना में शुष्क दौर (14 दिन) के दौरान मैक्रो -माइक्रोन्यूट्रिएंट्स के पर्ण प्रयोग से महत्वपूर्ण रूप से उन्नत मक्का अनाज का पैदावार (2887 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। इसके अलावा, नियंत्रण (2326 किलोग्राम प्रति हेक्टेयर) की तुलना में 0.5 प्रतिशत की दर से जल में घुलनशील नाइट्रोन, फासफोरस, पोटाश (18:18:18) + 0.5 प्रतिशत की दर से $ZnSO_4$ के पर्ण प्रयोग से अधिक लाभ (44761/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (3.43) सहित 38.3 प्रतिशत तक का अधिक अनाज (3217 किलोग्राम प्रति हेक्टेयर) पैदावार दर्ज किया गया।

बिस्वनाथ चरिअलि के आर्द्र इनसेप्टीसोल मृदाओं में, सूखे से तनाव के बाद (885 किलोग्राम प्रति हेक्टेयर) पर्ण छिड़काव की तुलना में शुष्क दौर (35 दिनों में) के दौरान तोरिया की फसल पर पर्ण छिड़काव से महत्वपूर्ण रूप से उन्नत बीज पैदावार (948 किलोग्राम प्रति हेक्टेयर) एवं अधिक लाभ (21519/-रुपए प्रति हेक्टेयर) दर्ज किया गया। पोषकों के स्रोतों में, अन्य उपचारों की तुलना में 0.5 प्रतिशत की दर से जल में घुलनशील कंप्लेक्स उर्वरक (19:19:19) + 05 प्रतिशत की दर से $ZnSO_4$ + 0.5 प्रतिशत की दर से बोरॉक्स के पर्ण प्रयोग से महत्वपूर्ण रूप से उन्नत बीज पैदावार (1027 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया जबकि 2 प्रतिशत की दर से यूरिआ के पर्ण छिड़काव से अधिक लाभ (27558/-रुपए प्रति हेक्टेयर) दर्ज किया गया।

2) खेत पर

I. सही समय के आकस्मिक उपाय

मानसून की शुरुआत में देरी

कुंभी एवं बनखेता गांवों (गढवाह जिला, झारखंड) में, मानसून की शुरुआत में 15 दिनों तक की देरी हुई। स्थानीय किस्म (2857 किलोग्राम प्रति हेक्टेयर) की तुलना में अधिक पैदावार, सूखा सहीष्णु, मध्यम अवधि हाइब्रिड चावल चावल (पीएसी-801) ने उन्नत अनाज पैदावार (3718 किलोग्राम प्रति हेक्टेयर) एवं कुल लाभ (40788/-रुपए प्रति हेक्टेयर) दिया। मक्का की स्थानीय किस्म (1774 किलोग्राम प्रति हे-क्टेयर) की तुलना में किस्म कंचन ने उन्नत अनाज पैदावार (2354 किलोग्राम प्रति हेक्टेयर) दिया। इसी प्रकार, स्थानीय किस्मों की तुलना में रागी (ए-404), ज्वार (सीएसवी-20) एवं तिल (शेखर) के उन्नत किस्मों ने 33.2 प्रतिशत से 55.4 प्रतिशत तक का उन्नत पैदावार दिया।

हरदोया गांव (फैज़ाबाद जिला, उत्तर प्रदेश) में, मानसून की शुरुआत में 18 दिनों तक की देरी हुई। चावल की स्थानीय किस्म (1315 किलोग्राम प्रति हेक्टेयर) की तुलना में किस्म एनडीआर-97 ने उन्नत अनाज पैदावार (1906 किलोग्राम प्रति हेक्टेयर) एवं कुल लाभ (10216/-रुपए प्रति हेक्टेयर) दिया। इसी प्रकार, अरहर की स्थानीय किस्म (1250 किलोग्राम प्रति हेक्टेयर) की तुलना किस्म एनडीए-1 ने उन्नत बीज पैदावार (1846 किलोग्राम प्रति हेक्टेयर), कुल लाभ (73250/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (3.85) दिया।

राउरा एवं पटुना गांव (रीवा जिला, मध्य प्रदेश) में, मानसून की शुरुआत में 20 दिनों तक की देरी हुई। अरहर की स्थानीय किस्म (720 किलोग्राम प्रति हेक्टेयर) की तुलना में किस्म आशा ने उन्नत बीज पैदावार (920 किलोग्राम प्रति हेक्टे-यर) एवं कुल लाभ (38,600/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (4.21) दिया। इसी प्रकार, उड़द की स्थानीय किस्म (220 किलोग्राम प्रति हेक्टेयर) की तुलना किस्म एलबीजी-20 ने उन्नत बीज पैदावार (350 किलोग्राम प्रति हेक्टेयर) एवं कुल लाभ (9250/-रुपए प्रति हेक्टेयर) दिया।

शुरुआती मौसमी सूखा

वन्नेदोड्डी गांव (अनंतपुरमु जिला, आंध्र प्रदेश) के वर्षा आधारित एल्फीसोल मृदाओं में, बिना संरक्षण कूंड (550 कि-लोग्राम प्रति हेक्टेयर) की तुलना में देशी हल से अरंड फसल की हर पंक्ति के पास संरक्षण कूंडों की खुदाई द्वारा स्व-स्थाने नमी संरक्षण से अधिक लाभ (16884/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.4) सहित 21 प्रतिशत उन्नत अरंड पैदावार (666 किलोग्राम प्रति हेक्टेयर) प्राप्त हुआ।

वरखेड गांव (अकोला जिला, महाराष्ट्र) के मध्यम काली मृदाओं में, बिना संरक्षण कूंड (1536 किलोग्राम प्रति हेक्टेयर) की किसानों की प्रक्रिया की तुलना में सोयाबीन फसल की बोवाई 30-35 दिनों के बाद हर पंक्ति के पास संरक्षण कूंडों की खुदाई द्वारा स्व-स्थाने नमी संरक्षण से उन्नत बीज पैदावार (1875 किलोग्राम प्रति हेक्टेयर), कुल लाभ (33120/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.4) एवं वर्षाजल उपयोग क्षमता (1.86 किलोग्राम प्रति हेक्टेयर-मि.मी) दर्ज किया गया।

मध्य मौसमी सूखा

चमुआ गांव (लखिमपुर जिला, असम) में, बिना अतिरि-क्त सिंचाई (3015 किलोग्राम प्रति हेक्टेयर) की तुलना में कृषि तालाबों से वाटर लिफ्टिंग पंपों द्वारा 2 सेंटीमीटर की गहराई तक एक अतिरिक्त सिंचाई देने से अधिक कुल लाभ (27700/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.58) सहित चावल की पैदावार (4520 किलोग्राम प्रति हेक्टेयर) में 33.3 प्रतिशत तक की बढ़ोत्तरी हुई।

वरखेड गांव (अकोला जिला, महाराष्ट्र) में, बिना संरक्षण सिंचाई (1726 किलोग्राम प्रति हेक्टेयर) की तुलना में कृषि तालाबों में संचित वर्षाजल से एक संरक्षण सिंचाई (25 मि.मी.) के प्रयोग से सोयाबीन का उन्नत बीज पैदावार (1952 किलो-ग्राम प्रति हेक्टेयर), कुल लाभ (41905/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.70) दर्ज किया गया।

बभुलगांव (परभनी जिला, महाराष्ट्र) की हल्की काली मृदाओं में, बिना अतिरिक्त सिंचाई (842 किलोग्राम प्रति हेक्टेयर) की तुलना में कृषि तालाबों में संचित वर्षाजल से स्प्रिंकलर प्रणाली

द्वारा 5 सेंटीमीटर की एक अतिरिक्त सिंचाई सोयाबीन के फली निर्माण स्तर पर देने से कुल लाभ (27869/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.39) सहित सोयाबीन की बीज पैदावार (1410 किलोग्राम प्रति हेक्टेयर) में 67.5 प्रतिशत तक वृद्धि हुई।

अंतिम मौसमी सूखा

तहकपाल गांव (बस्तर जिला, छत्तीसगढ़) में, वर्षा आधारित मिडलैंड्स के अंतर्गत बिना अतिरिक्त सिंचाई (1883 किलोग्राम प्रति हेक्टेयर) की तुलना में कृषि तालाबो में संचित वर्षाजल से 2 सेंटीमीटर की एक जीवनरक्षक सिंचाई ने चावल की उन्नत अनाज पैदावार (2097 किलोग्राम प्रति हेक्टेयर), कुल लाभ (7493/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.05) दिया।

बुधादानी गांव (कंधमाल जिला, ओडिशा) में, बिना अतिरिक्त सिंचाई (1970 एवं 1910 किलोग्राम प्रति हेक्टेयर) की तुलना में चावल की किस्म नवीन एवं सहाभागी में निकटवर्ती जलाशय से अतिरिक्त सिंचाई देने से क्रमश: अधिक कुल लाभ (15925/-रुपए एवं 14000/-रुपए प्रति हेक्टेयर) सहित 27.4 एवं 25.7 प्रतिशत उन्नत अनाज पैदावार (2510 एवं 2400 किलोग्राम प्रति हेक्टेयर) दिया।

कालिमति गांव (बनस्कांता जिला, गुजरात) के गहरी दोमट मृदा में, बिना अतिरिक्त सिंचाई (1395 किलोग्राम प्रति हेक्टेयर) की तुलना में अरंड में पुष्पण से कैप्सूल विकास के दौरान सूक्ष्म सिंचाई द्वारा कृषि तालाब में संचित वर्षाजल से दो अतिरिक्त सिंचाई (हर बार 30 मि.मी.) देने से अधिक कुल लाभ (65414/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (4.53) एवं वर्षाजल उपयोग क्षमता (2.27 किलोग्राम प्रति हेक्टेयर-मि.मी.) सहित 39 प्रतिशत उन्नत बीज पैदावार (1943 किलोग्राम प्रति हेक्टेयर) दिया।

उजलांबा गांव (परभनी जिला, महाराष्ट्र) के हल्की से मध्यम काली मृदा में, बिना अतिरिक्त सिंचाई (900 किलोग्राम प्रति हेक्टेयर) की तुलना में सोयाबीन (किस्म एमएयूएस-158) में कृषि तालाब में संचित वर्षाजल से 5 सेंटीमीटर की गहराई तक अतिरिक्त सिंचाई देने से उन्नत बीज उत्पादन (1430 किलोग्राम प्रति हेक्टेयर), अधिक लाभ (28620/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.43) प्राप्त हुआ।

कदेसारा कलान गांव (ललितपुर जिला, उत्तर प्रदेश) में, बिना अतिरिक्त सिंचाई (708 किलोग्राम प्रति हेक्टेयर) की तुलना में संचित वर्षाजल से (40 मि.मी.) अतिरिक्त सिंचाई देने से मूंगफली की फली के पैदावार में 49 प्रतिशत (1078 किलोग्राम प्रति हेक्टेयर) की वृद्धि हुई। इसके साथ ही साथ अधिक कुल लाभ (38448/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.35) प्राप्त हुआ।

कालिमति गांव(बनस्कांता जिला, गुजरात) में, बिना अतिरिक्त सिंचाई (892 किलोग्राम प्रति हेक्टेयर) की तुलना में अरंड में पुष्पण से कैप्सूल विकास के दौरान सूक्ष्म सिंचाई द्वारा कृषि तालाब में संचित वर्षाजल से दो अतिरिक्त सिंचाई (हर बार 30 मि.मी.) देने से अधिक कुल लाभ (41528/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.52) सहित 27.1 प्रतिशत उन्नत बीज पैदावार (1134 किलोग्राम प्रति हेक्टेयर) दिया।

II. तैयारियां

वर्षाजल प्रबंधन

कवलगी एवं हन्नुतगी गांव (विजयपुर जिला, कर्नाटक) के मध्यम काली मृदाओं में, किसानों की प्रक्रिया (325 – 341 किलोग्राम प्रति हेक्टेयर) की तुलना में चना में गहरी जुताई द्वारा स्व-स्थाने नमी संरक्षण से 21.2 एवं 21.6 प्रतिशत उन्नत बीज पैदावार (394 एवं 415 किलोग्राम प्रति हेक्टेयर) हुआ।

नगला दुल्हे खान गांव (आग्रा जिला, उत्तर प्रदेश) के वर्षा आधारित इनसेप्टीसोल मृदा में, किसानों की छिड़काव प्रक्रिया (1999 किलोग्राम प्रतिहेक्टेयर) की तुलना रिडजर सीडर से बाजरे की बोवाई ने उन्नत अनाज पैदावार (2363 किलोग्राम प्रति हेक्टेयर), कुल लाभ (39230/-रुपए प्रति हेक्टेयर),बी:सी अनुपात (3.50) एवं वर्षाजल उपयोग क्षमता (5.42 किलोग्राम प्रति हेक्टेयर मि.मी.) दिया।

घंघुआ गांव (बनस्कांता जिला, गुजरात) में, बिना खंड मेंढ़ (888 किलोग्राम प्रति हेक्टेयर) की किसानों की प्रक्रिया की तुलना खंड मेंढ़ सहित बाजरा में स्व-स्थाने नमी संरक्षण से

उन्नत अनाज एवं कडबी (958 एवं 2595 किलोग्राम प्रति हेक्टेयर) पैदावार, कुल लाभ (18593/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.91) एवं वर्षाजल उपयोग क्षमता (2.50 किलोग्राम प्रति हेक्टेयर-मि.मी) दर्ज किया गया।

बुधादानी गांव (कंधमाल जिला, आडिशा) में, एकल मक्का एवं बिना स्व-स्थाने नमी संरक्षण (2140 किलोग्राम प्रति हेक्टेयर) की तुलना में मक्का + लोबिया अंतर सस्ययन प्रणाली में गहरी ग्रीष्म जुताई द्वारा स्व-स्थाने नमी संरक्षण एवं मेंढ़ की ऊंचाई में वृद्धि ने उन्नत मक्का समतुल्य पैदावार (4420 किलोग्राम प्रति हेक्टेयर), कुल लाभ (30565/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.49) एवं वर्षाजल उपयोग क्षमता (3.49 किलोग्राम प्रति हेक्टेयर-मि.मी.) दिया।

सस्ययन प्रणालियां

पतामेघपार गांव (जामनगर जिला, गुजरात) की मध्यम काली मृदा में, एकल कपास (2213 किलोग्राम प्रति हेक्टेयर) की तुलना में कपास + तिल अंतर सस्ययन प्रणाली (1:1) ने उन्नत कपास समतुल्य पैदावार (2850 किलोग्राम प्रति हेक्टेयर), भूमि समतुल्य अनुपात (1.29), कुल लाभ (80670/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.47) एवं वर्षाजल उपयोग क्षमता (4.52 किलोग्राम प्रति हेक्टेयर-मि.मी.) दिया।

मदाना गांव (सांबा जिला, जम्मु एवं कश्मीर) में, एकल मक्का (1850 किलोग्राम प्रति हेक्टेयर) की तुलना में मक्का + उड़द अंतर सस्ययन प्रणाली (1:1) ने 19.1 प्रतिशत उन्नत मक्का समतुल्य पैदावार (2609 किलोग्राम प्रति हेक्टेयर) सहित कुल लाभ (31993/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.42) एवं वर्षाजल उपयोग क्षमता (4.73 किलोग्राम प्रति हेक्टेयर-मि.मी.) दिया।

मुथुकृष्णापुरम गांव (थुथुक्कुडी जिला, तमिलनाडु) के गहरी काली मृदा में, एकल कपास (625 किलोग्राम प्रति हेक्टेयर) की तुलना में कपास + उड़द अंतर सस्ययन प्रणाली (2:1) ने उन्नत कपास समतुल्य पैदावार (1036 किलोग्राम प्रति हेक्टेयर), कुल लाभ (15729/-रुपए प्रति हेक्टेयर), एवं वर्षाजल उपयोग क्षमता (4.5 किलोग्राम प्रति हेक्टेयर-मि.मी.) दिया।

पोषकतत्व प्रबंधन

लापसिया गांव (राजसमंद जिला (राजस्थान) में, Zn प्रयोग रहित (2287 किलोग्राम प्रति हेक्टेयर) की किसानों की प्रक्रिया की तुलना में, मक्का में 25 किलोग्राम प्रति हेक्टेयर की दर से $ZnSO_4$ के प्रयोग ने अधिक कुल लाभ (29012/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.89) सहित 17.8 प्रतिशत उन्न्त अनाज पैदावार (2693 किलोग्राम प्रति हेक्टेयर) दिया।

नगला दुल्हे खान गांव (आग्रा जिला, उत्तर प्रदेश) में, पोटाश (K) प्रयोग रहित (1920 किलोग्राम प्रति हेक्टेयर) की किसानों की प्रक्रिया की तुलना में, सिफारिश की गई उर्वरक मात्रा (60:40 किलोग्राम नाइट्रोजन, फासफोरस प्रति हेक्टेयर) सहित 50 किलोग्राम K_2O प्रति हेक्टेयर के प्रयोग से अधिक कुल लाभ (95473/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (6.6) सहित सरसों की पैदावार में 32.3 प्रतिशत (2540 किलोग्राम प्रति हेक्टेयर) तक की वृद्धि हुई।

चिक्कामारनहल्ली गांव (बेंगलूरू ग्रामीण जिला, कर्नाटक) में, केवल 100 प्रतिशत सिफारिश किए गए उर्वरकों (2502 किलोग्राम प्रति हेक्टेयर) के प्रयोग की तुलना में, रागी (एमआर-1) + अरहर (बीआरजी-5) (8:2) के अंतर सस्ययन प्रणाली में 100 प्रतिशत सिफारिश किया गया उर्वरक (50:40:37.5 किलोग्राम नाइट्रोजन, फासफोरस, पोटाश प्रति हेक्टेयर) + 12.5 किलोग्राम प्रति हेक्टेयर $ZnSO_4$ के प्रयोग से उन्नत रागी समतुल्य पैदावार (2677 किलोग्राम प्रति हेक्टेयर), कुल लाभ (59173/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (3.22) दर्ज किया गया।

ऊर्जा प्रबंधन

नरोटेवाड़ी गांव (सोलापुर जिला, महाराष्ट्र) के मध्यम काली मृदा में, स्थानी बीज ड्रिल (610 किलोग्राम प्रति हेक्टेयर) की तुलना में टू-बाउल फर्टी सीड ड्रिल से रबी ज्वार की बोवाई ने अधिक कुल लाभ (6940/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.27) एवं ऊर्जा उपयोग क्षमता (1.89) सहित 18 प्रतिशत अधिक उन्नत अनाज पैदावार (720 किलोग्राम प्रति हेक्टेयर) दिया।

वन्नेदोड्डी गांव (अनंतपुरमु जिला, आंध्र प्रदेश) के वर्षा आधारित एल्फीसोल मृदाओं में, बैलों द्वारा चालित स्थानीय बीज ड्रिल की तुलना में बैलों द्वारा चालित अनंता प्लांटर से मूंगफली की बोवाई करने से प्रचालन लागत एवं श्रम में क्रमश: 14 एवं 55 प्रतिशत की बचत हुई। इसके अलावा, किसानों की प्रक्रिया (190 किलोग्राम प्रति हेक्टेयर) की तुलना में बैलों द्वारा चालित अनंता प्लांटर से 10.5 प्रतिशत उन्नत फली पैदावार (210 किलोग्राम प्रति हेक्टेयर) प्राप्त हुआ।

खनेर गांव (सांबा जिला, जम्मु एवं कश्मीर) में, किसानों की बीज छिड़काव प्रक्रिया (2082 किलोग्राम प्रति हेक्टेयर) की तुलना में मैज प्लांटर से मक्का की बोवाई से अधिक कुल लाभ (35198/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.72) सहित 17.5 प्रतिशत अधिक उन्नत अनाज पैदावार दिया। मैज़ प्लांटर से 16.70 का ऊर्जा उपयोग क्षमता सहित ऊर्जा का निवेश एवं उत्पाद क्रमश: 6905 एमजे प्रति हेक्टेयर एवं 115298 एमजे प्रति हेक्टेयर था।

वैकल्पिक भूमि उपयोग

नरोटेवाड़ी गांव (सोलापुर जिला, महाराष्ट्र) के मध्यम काली मृदा में, एकल आंवला (1500 किलोग्राम प्रति हेक्टेयर) की तुलना में आंवला + बाजरा प्रणाली से उन्नत आंवला समतुल्य पैदावार (2511 किलोग्राम प्रति हेक्टेयर), कुल लाभ (27229/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.87) दर्ज किया गया।

निक्रा अनुकूल अनुसंधान

जैविक, अजैविक एवं समेकित उत्पादन प्रणालियों के अंतर्गत विभिन्न फसलों के निष्पादन के मूल्यांकन ने स्पष्ट किया कि अजैविक एवं जैविक प्रबंधन की तुलना में समेकित प्रबंधन (1138 किलोग्राम प्रतिहेक्टेयर) के अंतर्गत प्लॉटों में सूरजमुखी का बीज पैदवार क्रमश: 17.8 एवं 18.9 प्रतिशत था। जबकि, मूंग (744-791 किलोग्राम प्रति हेक्टेयर) एवं अरहर (400-443 किलोग्राम प्रति हेक्टेयर) के बीज पैदावारों पर विभिन्न उत्पादन प्रणालियों का कोई विशेष प्रभाव नहीं था। अजैविक एवं समेकित उत्पादन प्रणालियों की तुलना में जैविक प्रबंधन के अंतर्गत वाले प्लॉटों में महत्वपूर्ण रूप से उन्नत कार्बन (C) (0.66 प्रतिशत) दर्ज किया गया। अजैविक उत्पादन प्रणाली की तुलना में जैविक प्रबंधन के अंतर्गत प्लॉट समेकित उत्पादन प्रणाली के समान थे। इसके साथ ही उन्नत उपलब्ध पोटाश (K) (242.3 किलोग्राम प्रति हेक्टेयर), कॉपर (Cu) (2.01 पीपीएम), लोहा (Fe) (13.4 पीपीएम) एवं जिंक (Zn) (0.69 पीपीएम) दर्ज किया गया।

गांव जलवायु जोखिम प्रबंधन समिति (वीसीआरएमसी)

आकस्मिक फसल योजना, मृदा एवं फसल आधारित हस्तक्षेप एवं कस्टम हायरिंग केंद्रों का उन्नत कामकाज जैसे विभिन्न जलवायु जोखिम समुत्थान हस्तक्षेपों के लाभार्थियों एवं कार्यान्वयन की पहचान करने में निक्रा के हर गांव में स्थापित गांव जलवायु जोखिम प्रबंधन समिति (वीसीआरएम-सी) प्रभाव गांव स्तरीय संस्थान सिद्ध हुई।

कस्टम हायरिंग केंद्र

कस्टम हायरिंग केंद्र संसाधनहीन गरीब किसानों को कम लागत पर आवश्यकता आधारित उपकरणों/मशीनों को किराए पर देता है। ताकि ये किसान कम समय में अधिक ऊर्जा क्षमता सहित बडे भू-भाग पर भूमि की तैयारी, सटीक बोवाई एवं अन्य कृषि प्रचालन का कार्य पूरा कर सकें। वर्ष 2018-19 के दौरान, कस्टम हायरिंग केंद्रों द्वारा 55 गांवों में फैले 900 हेक्टेयर क्षेत्र के विभिन्न कृषि प्रचालनों कार्यों को पूरा किया गया एवं भारी मांग के समय श्रमिकों की कमी को दूर करने में महत्वपूर्ण योगदान दिया।

गांव बीज बैंक

निक्रा के गांवों में विभिन्न क्षेत्रीय फसलों के कम अवधि, सूखा एवं बाढ़ सहीष्णु किस्मों को भागीदारी गांव स्तरीय बीज उत्पादन शुरू किया गया। बीजों की अनुपलब्धता की समस्या को दूर करने के लिए वर्षा आधारित वैकल्पिक फसलों एवं किस्मों के बीजों को प्रदान करने का प्रयास किया गया। वर्ष के दौरान, विभिन्न निक्रा के गांवों में विभिन्न वर्षा आधारित फसलों के करीब 21.7 टन बीजों का उत्पादन/रख-रखाव किया गया।

चारा बैंक

तहकपाल गांव, बस्तर जिला (छत्तीसगढ़) में, किसानों ने स्टाइलोसनथेस (56.0 किलोग्राम), संकर नेपियर बाजरा (9.0 किलोग्राम), बरसीम (38.0 किलोग्राम) एवं चारा ज्वार (45.0 किलोग्राम) के बीजों की पैदावार की। कदेसरा कालान गांव, ललितपुर जिला (उत्तर प्रदेश) में, विभिन्न गांवों के किसानों को करीब 10 टन संकर नेपियर स्लिप्स बेचा गया। इसके अलावा, वर्ष के दौरान हर साइलेज के करीब 1.0 टन एवं यूरिआ उपचारित कड़बी का उत्पादन किया गया। चिक्का-मारनहल्ली गांव, बेंगलूरू ग्रामीण जिला (कर्नाटक) में, दूधारू पशुओं को बेहतर चारा आपूर्ति के लिए 20 किसानों के 4 हे-क्टेयर क्षेत्र में चारा मक्का (साउथ अफ्रीकन टॉल) को उगाया गया।

कृषि-सलाह/कृषि-मौसम सलाह

ब्लैक बोर्डों पर मौसम सूचना एवं कृषि सलाहों का प्रद-र्शन, मोबाइल द्वारा एसएमएस सेवा एवं ऑल इंडिया रेडियो द्वारा सभी गांवों में कार्यान्वयन के लिए सही समय की आक-स्मिक उपायों को सूचित किया गया। वर्ष 2018-19 के दौरान, अकोला, अनंतपुरमु, बेंगलूरू ग्रामीण, कोविलपट्टी, परभनी, सोलापुर एवं विजयपुर जिलों के अपनाए गए गांवों में एक्रीपाम के सहयोग से सही समय की कृषि-मौसम सलाह दी गई।

मृदा स्वास्थ्य कार्ड

वर्ष के दौरान, अकोला, अनंतपुरमु, अरजिया, बेंगलूरू, बिस्वनाथ चरिआलि, जगदलपुर, कोविलपट्टी, परभनी, फुलबानी, राजकोट, राख धियंसर, रीवा एवं एसके नगर के अपनाए गए गांवों में 728 मृदा स्वास्थ्य कार्ड प्रदान किए गए।

प्रशिक्षण/ क्षेत्रीय दौरा/ क्षेत्रीय दिवस

वर्ष के दौरान, केंद्रों द्वारा 70 प्रशिक्षण कार्यक्रम एवं 21 क्षेत्रीय दिवस/प्रदर्शन दौरों का आयोजन किया गया जिससे किसानों सहित 5344 पणधारियों को लाभ हुआ।

एक्रीपाम एवं कृषि विज्ञान केंद्रों से सहयोग

एक्रीपडा निक्रा गांवों में एक्रीपाम द्वारा एक्रीपडा-एक्रीपाम के समान केंद्रों से कृषि-मौसम सलाह जारी किए गए। इसी प्रकार, एक्रीपडा केंद्रों (अकोला, अनंतपुरमु, बेंगलूरू, बिस्व-नाथ चरिआलि, हिसार, इंदौर, जगदलपुर, झांसी, कोविलप-ट्टी, परभनी, राजकोट, राख धियंसर, रीवा एवं एसके नगर, सोलापुर, वारणासी एवं विजयपुर) के जिलों में निक्रा-कृषि विज्ञान केंद्रों द्वारा सही समय की आकस्मिक योजनाएं एवं अपनाने योग्य प्रौद्योगिकियों पर तकनीकी सलाह दी गई।

परिचालनरत जिला कृषि आकस्मिक योजनाओं के लिए संपर्क

वर्ष 2018-19 के दौरान, केंद्रों के वैज्ञानिक जिला स्तरीय फसल आकस्मिक योजनाओं के उन्नयन में कृषि विज्ञान केंद्रों के वैज्ञानिकों एवं अधिकारियों तथा संबंधित राज्यों के संबंधित विभागों को शामिल कर सक्रिय रूप से कार्यरत हैं। इसके अलावा, केंद्रों के वैज्ञानिक जिला कृषि आकस्मिक योजनाओं के परिचालन के लिए 2 राज्यों (कर्नाटक एवं तमिलनाडु) में आयोजित राज्य स्तरीय बैठकों में भाग लिया एवं कार्ययोजना-ओं के विकास में योगदान दिया।

Executive Summary

The 23 Centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) are conducting on-station and on-farm demonstrations/trials under National Innovations in Climate Resilient Agriculture (NICRA) with the focus on real time contingency plan (RTCP) implementation and preparedness to cope with weather aberrations. The RTCPs implementation has been in a two-pronged approach i.e. i) Real-time contingency measures and ii) Preparedness. During 2018-19, 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 23 village clusters (55 villages) in 24 districts across 15 states. The onset of monsoon during 2018 was delayed by 15, 18 and 20 days, respectively in NICRA villages of Garhwa (Jharkhand), Faizabad (Uttar Pradesh) and Rewa (Madhya Pradesh) districts. Further, there were 2-4 dry spells at different stages of crops in NICRA villages of Akola (Maharashtra), Anantapuramu (Andhra Pradesh), Bhilwara (Rajasthan), Bengaluru Rural (Karnataka), Vijayapura (Karnataka), Bhiwani (Haryana), Indore (Madhya Pradesh), Parbhani (Maharashtra), Jamnagar (Gujarat), Solapur (Maharashtra) and Mirzapur (Uttar Pradesh) districts. The salient achievements are summarized below.

A. On-station

Delayed onset of monsoon

At Chianki, the onset of monsoon was delayed by 15 days (24th June). Improved variety of rainfed medium land rice, Arize-Tej recorded 47% higher grain yield (4624 kg/ha) with higher net returns (Rs.55284/ha) and B:C ratio (2.96) followed by PAC-801 (4151 kg/ha) compared to local variety (3146 kg/ha). Sesame variety Shekar gave higher seed yield (634 kg/ha), net returns (Rs.18798/ha) and B:C ratio (1.71) followed by JLT-408 (627kg/ha) compared to local variety (389 kg/ha).

Mid season drought

At Arjia, in Semiarid Vertisols, foliar application of macro- and micronutrients during dry spell (14 days) recorded significantly higher maize grain yield (2887 kg/ha) compared to foliar application at sufficient moisture just after dry spell (2579 kg/ha). Further, foliar application of water soluble NPK (18:18:18) @ 0.5% + $ZnSO_4$ @ 0.5% increased grain yield (3217 kg/ha) by 38.3% as compared to control (2326 kg/ha), with higher net returns (Rs. 44671/ha) and B:C ratio (3.43).

At Biswanath Chariali, in Humid Inceptisols, foliar spray in toria during dry spell (35 days) recorded significantly higher seed yield (948 kg/ha) and net returns (Rs. 21519/ha) compared to foliar spray after relieving of stress (885 kg/ha). Among sources of nutrients, foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + ZnSO4 @ 0.5% + borax @ 0.5% resulted in significantly higher seed yield (1027 kg/ha) whereas foliar spray of urea @ 2% recorded higher net returns (Rs. 27558/ha) compared to other treatments.

B. On-farm

I. Real-time contingency measures

Delayed onset of monsoon

At Kumbhi and Bankheta villages (Garhwa district, Jharkhand), the onset of monsoon was delayed by 15 days. High yielding drought tolerant medium duration hybrid rice (PAC-801) gave higher grain yield (3718 kg/ha) and net returns (Rs.40788/ha) compared to local variety (2857 kg/ha). Mazie var. Kanchan gave higher grain yield (2354 kg/ha) compared to local variety (1774 kg/ha). Similarly,

improved varieties of fingermillet (A-404), sorghum (CSV-20) and sesame (Shekhar) gave 33.2 to 55.4% higher yields compared to local varieties.

At Hardoya village (Faizabad district, Uttar Pradesh), the onset of monsoon was delayed by 18 days. Rice var. NDR-97 gave higher grain yield (1906 kg/ha) and net returns (Rs. 10216/ha) compared to local variety (1315 kg/ha). Similarly, pigeonpea var. NDA-1 gave higher seed yield (1846 kg/ha), net returns (Rs. 73250/ha) and B:C ratio (3.85) compared to local variety (1250 kg/ha).

At Raura and Patuna villages (Rewa district, Madhya Pradesh), the onset of monsoon was delayed by 20 days. Pigeonpea var. Asha recorded higher seed yield (920 kg/ha), net returns (Rs.38600/ha) and B:C ratio (4.21) compared to local variety (720 kg/ha). Similarly, blackgram var. LBG-20 gave higher seed yield (350 kg/ha) and net returns (Rs. 9250/ha) compared to local variety (220 kg/ha).

Early season drought

At Vannedoddi village (Ananthapuramu district, Andhra Pradesh), in rainfed Alfisols, *in-situ* moisture conservation through opening of conservation furrows adjacent to every row of castor with country plough gave 21% higher castor yield (666 kg/ha) compared to without conservation furrow (550 kg/ha), with higher net returns (Rs. 16884/ha) and B:C ratio (2.07).

At Warkhed village (Akola district, Maharashtra), in medium black soils, *in-situ* moisture conservation through opening of furrows in each row after 30-35 DAS of soybean recorded higher seed yield (1875 kg/ha), net returns (Rs.33120/ha), B:C ratio (2.4) and RWUE (1.86 kg/ha-mm) as compared to farmers' practice of without furrow opening (1536 kg/ha).

Mid season drought

At Chamua village (Lakhimpur district, Assam), one supplemental irrigation of 2 cm depth with the water lifting pump from farm pond increased the yield of rice (4520 kg/ha) by 33.3% with higher net returns (Rs. 27700/ha) and B:C ratio (1.58) compared to no supplemental irrigation (3015 kg/ha).

At Warkhed village (Akola district, Maharashtra), application of one protective irrigation (25 mm) from harvested rainwater in farm pond recorded higher seed yield of soybean (1952 kg/ha), net returns (Rs. 41905/ha) and B:C ratio (2.70) compared to no protective irrigation (1726 kg/ha).

At Babhulgaon village (Parbhani district, Maharashtra), in light to medium black soils, one supplemental irrigation of 5 cm with sprinkler system from harvested rainwater in farm pond at pod formation stage of soybean increased the seed yield by 67.5% (1410 kg/ha), with higher net returns (Rs.27869/ha) and B:C ratio (2.39) compared to no supplemental irrigation (842 kg/ha).

Terminal drought

At Tahkapal village (Bastar district, Chhattisgarh), under rainfed midlands, one life saving irrigation of 2 cm from harvested rainwater gave higher grain yield of rice (2097 kg/ha), net returns (Rs.7493/ha) and B:C ratio (2.05) compared to no supplemental irrigation (1883 kg/ha).

At Budhadani village (Kandhamal district, Odisha), supplemental irrigation from nearby water stream in rice varieties, Naveen and Sahabhagi gave 27.4 and 25.7% higher grain yield (2510 and 2400 kg/ha) with higher net returns (Rs.15925 and 14000/ha) compared to without supplemental irrigation (1970 and 1910 kg/ha), respectively.

At Kalimati village (Banaskantha district, Gujarat), in deep loamy soils, two supplemental irrigations (30 mm each) from harvested rainwater in farm pond 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 Ujalamba village (Parbhani district, Maharashtra), in light to medium black soils, supplemental irrigation of 5 cm depth, from harvested rainwater in farm pond, in soybean (var. MAUS-158) gave higher seed yield (1430 kg/ha), net returns (Rs.28620/ha) and B:C ratio (2.43) compared to no supplemental irrigation (900 kg/ha).

At Kadesara Kalan village (Lalitpur district, Uttar Pradesh), supplemental irrigation (40 mm) from harvested rainwater increased the pod yield of groundnut by 49% (1078 kg/ha) with higher net returns (Rs.38448/ha) and B:C ratio (2.35) compared to no supplemental irrigation (708 kg/ha).

At Kalimati village (Banaskantha district, Gujarat), supplemental irrigation (30 mm) twice through micro-irrigation after flowering to capsule development in castor, from harvested rainwater in farm pond, gave 27.1% higher seed yield (1134 kg/ha) with higher net returns (Rs. 41528/ha) and B:C ratio (2.52) compared to no supplemental irrigation (892 kg/ha)

II. Preparedness

Rainwater management

At Kavalagi and Honnutagi villages (Vijayapura district, Karnataka), in medium black soils, *in-situ* moisture conservation through deep ploughing in chickpea recorded 21.2 and 21.6% higher seed yield (394 and 415 kg/ha) compared to farmers' practice (325-341 kg/ha).

At Nagla Dulhe Khan village (Agra district, Uttar Pradesh), in rainfed Inceptisols, sowing of pearlmillet with ridger seeder gave higher grain yield (2363 kg/ha), net returns (Rs.39230/ha), B:C ratio (3.50) and RWUE (5.42 kg/ha-mm) compared to farmers' practice of broadcasting (1999 kg/ha).

At Ghanghu village (Banaskanta District, Gujarat), *in-situ* moisture conservation in pearlmillet with compartmental bunding recorded higher grain and stover yield (958 and 2595 kg/ha), net returns (Rs. 18593/ha), B:C ratio (1.91) and RWUE (2.50 kg/ha-mm) compared to local practice of no compartmental bunding (888 kg/ha).

At Budhadani village (Kandhamal district, Odisha), *in-situ* moisture conservation through deep summer ploughing and increase in bund height in maize + cowpea intercropping system (2:2) gave higher maize equivalent yield (4420 kg/ha), net returns (Rs.30565/ha), B:C ratio (3.49) and RWUE (3.49 kg/ha-mm) as compared to sole maize without *in-situ* moisture conservation (2140 kg/ha).

Cropping systems

At Patameghpar village (Jamnagar district, Gujarat), in medium black soils, cotton + sesame intercropping system (1:1) gave higher seed cotton equivalent yield (2850 kg/ha), land equivalent ratio (1.29), net returns (Rs 80670/ha), B:C ratio (2.47) and RWUE (4.52 kg/ha-mm) compared to sole cotton (2213 kg/ha).

At Madana village (Samba district, Jammu and Kashmir), intercropping of maize + blackgram (1:1) gave 19.1% higher maize equivalent yield (2609 kg/ha) with higher net returns (Rs.31993/ha), B:C ratio (2.42) and RWUE (4.73 kg/ha-mm) compared to sole maize (1850 kg/ha).

At Muthukrishnapuram village (Thoothukkudi district, Tamil Nadu), in deep black soils, cotton + blackgram (2:1) intercropping system recorded higher cotton equivalent yield (1036 kg/ha), net returns (Rs.15729/ha) and RWUE (4.5 kg/ha-mm) compared to sole cotton (625 kg/ha).

Nutrient management

At Lapsiya village (Rajsamand district, Rajasthan), application of $ZnSO_4$ @ 25 kg/ha in maize gave 17.8% higher grain yield (2693 kg/ha) with higher net returns (Rs. 29012/ha) and B:C ratio (2.89) compared to farmers' practice of no Zn application (2287 kg/ ha).

At Nagla Dulhe Khan village (Agra district, Uttar Pradesh), application of 50 kg K_2O/ha with RDF (60:40 kg NP/ha) increased mustard yield by 32.3% (2540 kg/ha) with higher net returns (Rs. 95473/ha) and B:C ratio (6.6) compared to farmers' practice of no K application (1920 kg/ha).

At Chikkamaranahalli village (Bengaluru Rural district, Karnataka), application of 100% RDF (50:40:37.5 kg NPK/ha) + 12.5 kg/ha of $ZnSO_4$ in fingermillet (MR-1) + pigeonpea (BRG-5) (8:2) intercropping system recorded higher fingermillet equivalent yield (2677 kg/ha), net returns (Rs 59173/ha) and B:C ratio (3.22) compared to application of 100% RDF alone (2502 kg/ha).

Energy management

At Narotewadi village (Solapur district, Maharashtra), in medium black soils, sowing of *rabi* sorghum with two-bowl ferti-seed drill gave 18% higher grain yield (720 kg/ha) with higher net returns (Rs. 6940/ha), B:C ratio (1.27) and energy use efficiency (1.89) compared to sowing with local seed drill (610 kg/ha).

At Vannedoddi village (Ananthapuramu district, Andhra Pradesh), in rainfed Alfisols, groundnut sowing with bullock drawn Ananta planter saved the cost of operation and labour by 14 and 55%, respectively compared to bullock drawn local seed drill. Further, sowing of groundnut with bullock drawn Ananta planter gave 10.5% higher pod yield (210 kg/ha) over farmers' practice (190 kg/ha).

At Khaner village (Samba district, Jammu and Kashmir), sowing of maize with maize planter gave 17.5% higher grain yield over farmers' practice of broadcasting (2082 kg/ha) with higher net returns (Rs. 35198/ha) and B:C ratio (2.72). The energy input and output with maize planter was 6905 MJ/ha and 115298 MJ/ha, respectively with energy use efficiency of 16.70.

Alternate land use

At Narotewadi village (Solarpur district, Maharashtra), in medium black soils, anola + pearlmillet system recorded higher anola equivalent yield (2511 kg/ha), net returns (Rs. 27229/ha) and B:C ratio (1.87) compared to sole anola (1500 kg/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 17.8 and 18.9% higher in the plots under integrated management (1138 kg/ha) than that under inorganic and organic management, respectively. However, different production systems had no significant effect on seed yields of greengram (744-791 kg/ha) and pigeonpea (400-443 kg/ha). Plots under organic management recorded significantly higher soil organic C (0.66%) compared to inorganic and integrated production systems. Plots under organic management being on par with integrated production system also recorded significantly higher available K (242.3 kg/ha), Cu (2.01 ppm), Fe (13.4 ppm) and Zn (0.69 ppm) compared to inorganic production system.

Village Climate Risk Management Committee (VCRMC)

VCRMCs established in each NICRA village proved to be an effective village level institution in identification of beneficiaries and implementation of various climate risk resilient interventions such as contingency crop planning, soil and crop based interventions and efficient functioning of custom hiring centers.

Custom Hiring Centre (CHC)

CHCs helped in hiring the need based implements/machinery by resource poor farmers at affordable cost and carrying out land preparation, timely and precision sowing covering large area in short time and other agricultural operations with high energy efficiency. During 2018-19, more than 900 ha area was covered for various agricultural operations in 55 villages through CHCs and significantly contributed to alleviate labour shortage during peak demand period.

Village seed bank

Participatory village level seed production of short duration, drought and flood tolerant varieties of different field crops was taken up in NICRA villages. Efforts were made to provide the seed of alternative crops and varieties of the rainfed crops to address the problem of seed unavailability. During the year, about 21.7 tons seed of different rainfed crops was produced/maintained in different NICRA villages.

Fodder bank

At Tahakpal village, Bastar district (Chhattisgarh), farmers produced seed of *Stylosanthes* (56.0 kg), hybrid Napier bajra (9.0 kg), berseem (38.0 kg) and fodder sorghum (45.0 kg). In Kadesara kala village, Lalitpur district (Uttar Pradesh), about 10 tons of hybrid napier slips were sold to farmers of different villages. Further, about 1.0 ton each of silage and urea treated straw was produced during the year. At Chikkamaranahalli village, Bengaluru Rural district (Karnataka), fodder maize (South African Tall) was grown in an area of 4 ha in 20 farmers' fields for realizing better fodder supply to milch animals.

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 2018-19, timely agromet advisories were given in collaboration with AICRPAM centres in adopted villages of Akola, Anantapuramu, Bengaluru Rural, Kovilpatti, Parbhani, Solapur and Vijayapura districts.

Soil health cards

During the year, 728 soil health cards were provided in the adopted villages of Akola, Ananthapuramu, Arjia, Bengaluru, Biswanath Chalriali, Jagdalpur, Kovilpatti, Parbhani, Phulbani, Rajkot, Rakh Dhiansar, Rewa and SK Nagar.

Trainings/Field visits/Field days

During the year, 70 trainings and 21 field days/ exposure visits were organized by the centres which benefitted 5344 stakeholders including farmers.

Collaboration with AICRPAM and KVKs

Agromet advisories from common centres of AICRPDA-AICRPAM were issued by AICRPAM centres in AICRPDA NICRA villages. 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.

Linkages for operationalizing district agriculture contingency plans

During 2018-19, 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 2 states (Karnataka and Tamil Nadu) for operationalization of district agriculture contingency plans and contributed in developing action plans.

Introduction

Climate change/variability impacts are evident in Indian agriculture. The projected impacts are likely to further aggravate yield fluctuations of many crops with impact on food security and prices. Climate variability impacts are more pronounced in rainfed agriculture due to delayed onset of monsoon, deficit rainfall and long dry spells. In the XI Five Year Plan, ICAR launched the National Initiative on Climate Resilient Agriculture (NICRA). Under Technology Demonstration component of NICRA, the climate risk resilient technologies are being demonstrated in farmers' fields in a participatory mode in vulnerable districts in the country.

AICRPDA-NICRA Programme

The All India Coordinated Research Project for Dryland Agriculture (AICPRDA), a natural resource management project, has the network of 19 main, 3 sub and 9 voluntary centres (Fig.1). The AICRPDA network centres have generated agroecology-specific doable rainfed technologies/practices which 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, farm mechanization with cost effectiveness and timeliness, and alternate land use systems for diversification, higher income and resource use efficiency (Table 1).

Fig.1: Location map of AICRPDA Network Centres

Table 1: AICRPDA Network Centres - Agro-ecological setting

Name of the Centre	SAU / ICAR Institute/ Others (Hqrs)	Agro-Climatic Zone (NARP)/ Agro–ecological Sub Region (AESR)	Climate**	MARF (mm)	Dominant Soil Type	MRPS
Main centres						
Akola	PDKV, Akola	Western Vidarbha Zone in Maha-rashtra (6.3)	Semiarid (Hot moist)	824	Vertisols	Cotton
Anantapuramu	ANGRAU, Guntur	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
Bengaluru	UAS, Bengaluru	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermillet
Biswanath Chariali	AAU, Jorhat	North Bank plain zone in Assam (15.2)	Humid (Hot)	1990	Alfisols	Rice

Name of the Centre	SAU / ICAR Institute/ Others (Hqrs)	Agro-Climatic Zone (NARP)/ Agro–ecological Sub Region (AESR)	Climate**	MARF (mm)	Dominant Soil Type	MRPS
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
Jagdalpur	IGAU, Raipur	Bastar Plateau zone in Chhattis-garh (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	VNMKV, Parbhani	Central Maharashtra Plateau Zone in Maharashtra (6.2)	Semiarid (Hot moist)	901	Vertisols	Cotton
Phulbani	OUAT, Bhubaneswar	Eastern Ghat Zone in Odisha (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, Sardarkrushi-nagar	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
Vijayapura (Bijapur)	UAS, Dharwad	Northern dry zone in Karnataka (6.1)	Semiarid (Hot dry)	595	Vertisols	*Rabi* sorghum
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
Voluntary centres						
Adilabad	PJTSAU, Hyderabad	Godavari Zone of Telangana (7:3)	Semiarid	871	Alfisols/ Vertisols	Cotton
Aklera	AU, Kota	South eastern plain zone of Rajas-than (5.2)	Semiarid	844	Vertic Inceptisols	Soybean
Ballari	IISWC, Dehradun	Northern dry zone in Karnataka (3.0)	Arid (Hot)	502	Vertisols	*Rabi* sor-ghum
Darsi	ANGRAU, Guntur	Krishna-Godavari zone of Andhra Pradesh (7.3)	Semiarid	871	Alfisols/ Vertisols	Pigeonpea
Imphal	CAU, Imphal	Sub-tropical zone of Manipur (17.2)	Perhumid	1372	Inceptisols	Rice
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
Munger	BAU, Sabour	South Bihar Alluvial plain zone of Bihar (13.1)	Subhumid	1143	Inceptisols	Maize
Raichur	UAS, Raichur	North-eastern dry zone of Karna-taka (6.2)	Semiarid	621	Vertisols/ Alfisols	*Rabi* sor-ghum

**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. In the second phase (2017-20), since 2017-18, the on-farm programme as cluster approach was extended to 55 villages in 24 districts across 15 states (Fig.2 ; Table 2).

Fig.2: Location map of AICRPDA-NICRA villages

Table 2: Details of AICRPDA-NICRA villages

AICRPDA centre	Name of the villages	District	State
Agra	Nagla Duleh khan and Kherra	Agra	Uttar Pradesh
Akola	Warkhed and Kajleshwar	Akola	Maharashtra
Anantapuramu	Vannedoddipally and Bachepalli	Anantapuramu	Andhra Pradesh
Arjia	Kochariya, Lapsiya, Bagatpura and Tara ka Kheda	Bhilwara, Rajsamand	Rajasthan
Ballowal Saunkhri	Naiwan, Achalpur and Bhawanivpur	Hoshiarpur	Punjab
Bengaluru	Chikkamaranahalli and Chikkahosapalya	Bengaluru Rural	Karnataka
Biswanath Chariali	Chamua and Ganakdoloni	Lakhimpur	Assam
Vijayapura	Kavalagi and Honnutagi	Vijayapura	Karnataka
Chianki	Kumbhi, Bankheta and Chiraunjiya	Garhwa	Jharkhand
Faizabad	Hardoiya and Amavachitan	Faizabad	Uttar Pradesh
Hisar	Balawas and Nalwa	Bhiwani	Haryana
Indore	Ningnoti and Bishakhedi	Indore	Madhya Pradesh
Jagdalpur	Tahakapal, Tandapal, Gumiyapal and Jhartarae	Bastar	Chattishgarh
Jhansi	Kadesara Kalan and Hanauta	Lalitpur	Uttar Pradesh
Kovilpatti	Toppureddiapatti and Dharmathanpatti	Thoothukkudi	Tamil Nadu
Parbhani	Babhulgaon and Ujalamba	Parbhani	Maharashtra
Phulbani	Budhadani and Gunjidraga	Kandhamal	Odisha
Rajkot	Pata meghapar and Dangarvada	Jamnagar	Gujarat
Rakh Dhiansar	Khaner and Madana	Samba	Jammu& Kashmir
Rewa	Patauna, Raura and Khira	Rewa	Madhya Pradesh
SK Nagar	Kalimati, Dholia and Ghanghu	Banaskantha	Gujarat
Solapur	Narotewadi and Banegoan	Solapur	Maharashtra
Varanasi	Tedha and Patharaha (Hinauti)	Mizapur	Uttar Pradesh

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.

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 muriate 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.

Technical Programme 2018-19

The Sixth Annual Review Workshop of AICRPDA-NICRA was held during 25-26 May, 2018 at ICAR-CRIDA , Hyderabad and the following recommendations were made to develop the technical programme for 2018-19.

Major recommendations

A. On-station

- Two common on-station experiments would be continued at all the 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

- The programme to be adopted as **Cluster Approach** in the existing and new villages.
- The main focus would be 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
- The interventions to be demonstrated FARMING-SITUATION wise (Soil type/ Physiography)
- All the AICRPDA-NICRA villages to be saturated with one or two most promising real-time contingency measures

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.

E. Linkage with ICAR-IIOR and AICRPs on Castor/Sesame/Niger

The improved/popular varieties of castor, sesame, niger and other oilseed crops to be evaluated/ demonstrated as contingent crops/varieties to cope with delayed onset of monsoon

F. Linkage with ICAR-IIMR and AICRPs on Millet Crops

The minikits of improved/popular varieties of millet crops to be evaluated/demonstrated as contingent crops/varieties to cope with delayed onset of monsoon

Experienced weather at AICRPDA-NICRA villages during 2018-19

During 2018-19, the onset of monsoon was delayed by 15, 18 and 20 days respectively in NICRA villages of Garhwa (Jharkhand), Faizabad (Uttar Pradesh) and Rewa (Madhya Pradesh) districts (Table 3). Further, there were 2-4 dry spells at different stages of crops in NICRA villages in Akola, Anantapuramu, Bhilwara, Bengaluru rural, Vijayapura, Bhiwani, Indore, Parbhani, Jamnagar, Solapur and Mirzapur districts during *kharif* and 2-4 dry spells in Lakhimpur, Garwa, Bastar, Samba, Vijayapura and Thoothukkudi districts during *rabi* season.

Table 3: Details of onset of monsoon in AICRPDA-NICRA villages (2018)

Village & district	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Nagla Dulhe Khan (Agra)	South–western semiarid zone in U.P	2-July	26-June	-
Warkhed (Akola)	Western Vidarbha Zone in Maharashtra	10-June	6-June	-
Vannedoddipally (Ananthapuramu)	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh	7-June	4-June	-
Kochariya (Bhilwara)	Southern zone in Rajasthan	1-July	24-June	-
Lapsiya (Rajsamand)	Southern zone in Rajasthan	2-July	26-June	-
Achalpur & Nainwan (Hoshiarpur)	Kandi region in Punjab	1-July	27-June	-
Chikkamaranahalli (Bengaluru Rural)	Central, eastern and southern dry zone in Karnataka	2-June	2-June	-
Kavalagi (Vijayapura)	Northern dry zone in Karnataka	7-June	4-June	-
Chamua (Lakhimpur)	North Bank plain zone in Assam	5-June	11-June	6
Kumbhi (Garhwa)	Western plateau zone of Jharkhand	10-June	24-June	15
Hardoiya (Faizabad)	Eastern plain zone in Uttar Pradesh	24-June	12- July	18
Balawas & Budhshelly (Bhiwani)	South-western dry zone in Haryana	1-July	29-June	-
Nignoti (Indore)	Malwa plateau in Madhya Pradesh	12-June	17-June	5
Tahkapal (Bastar)	Basthar Plateau zone in Chattisgarh	5-June	12-June	6
Kadesara Kala (Lalitpur)	Bundhelkhand zone in Uttar Pradesh	25-June	27-June	-
Muthukrishnapuram (Thoothukkudi)	Southern zone of Tamil Nadu	19-Oct	19-Oct	-
Babhulgaon (Parbhani)	Central Maharashtra Plateau Zone in Maharashtra	10-June	9-June	-
Budhadani (Kandhamal)	Eastern Ghat Zone in Orissa	10-June	9-June	-
Patameghpar (Jamnagar)	North Saurashtra zones in Gujarat	16-June	23-June	7
Khaner (Samba)	Low altitude subtropical zone in J &K	27-June	29-June	2
Patuana & Raura (Rewa)	Keymore plateau and Satpura Hill zone in Madhya Pradesh	23-June	13-July	20
Kalimati (Banaskantha)	Northern Gujarat in Gujarat	25-June	22-June	
Narotewadi (Solapur)	Scarcity zone in Maharashtra	7-June	3-June	-
Tedha (Mirzapur)	Eastern Plain and Vindhyan Zone in U.P.	12-June	11-June	-

In general, the total rainfall during *kharif* season (June-September), 2018 was below normal in all NICRA villages except in Nagala Dulhe Khan (Agra), Warkhed (Akola), Chamuha (Lakhimpur), Kumbhi & Bankheta (Garhwa), Balawas (Bhiwani), Tahakapal (Bastar), Kadesara Kalan (Lalithpur), Babhulgaon (Parbhani) and Budhadani (Kandhamal) (Fig.3). Similarly, during *rabi* season (October -December) 2018, the rainfall was less than normal seasonal rainfall in all NICRA villages except in Chamua (Lakhimpur) and Budhadani (Kandhamal) (Fig.4).

The rainfall was deficit by more than 50% during June 2018 in NICRA villages of Faizabad, Toothukkudi, Jamnagar and Mirzapur districts. In July, the deficit in rainfall was more than 50% in villages of Anantapuramu, Toothukkudi, Samba, Solapur and Mirzapur districts. Similarly, in August, villages in Anantapuramu, Bhilwara, Bengaluru Rural, Vijayapura, Jamnagar, Banaskantha, Solapur and Mirzapur districts recorded more than 50% deficit rainfall. In September, NICRA villages in Agra, Akola, Faizabad, Parbhani, Jamnagar, Banaskantha and Solapur districts received 50-100% deficit rainfall. Similarly, in October, 10 villages in Akola, Bhilwara, Garhwa, Faizabad, Bhiwani, Indore, Lalitpur, Parbhani, Jamnagar and Banaskantha districts did not receive any rainfall (Table 4).

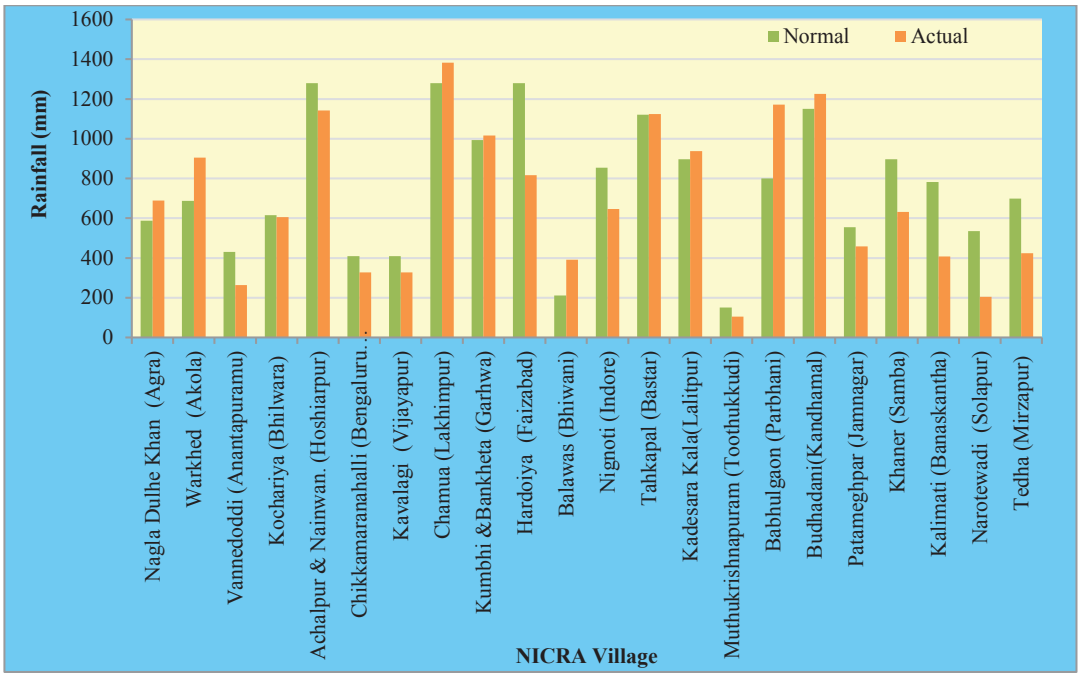


Fig.3: Normal and actual (2018) rainfall in AICRPDA-NICRA villages (June - September)

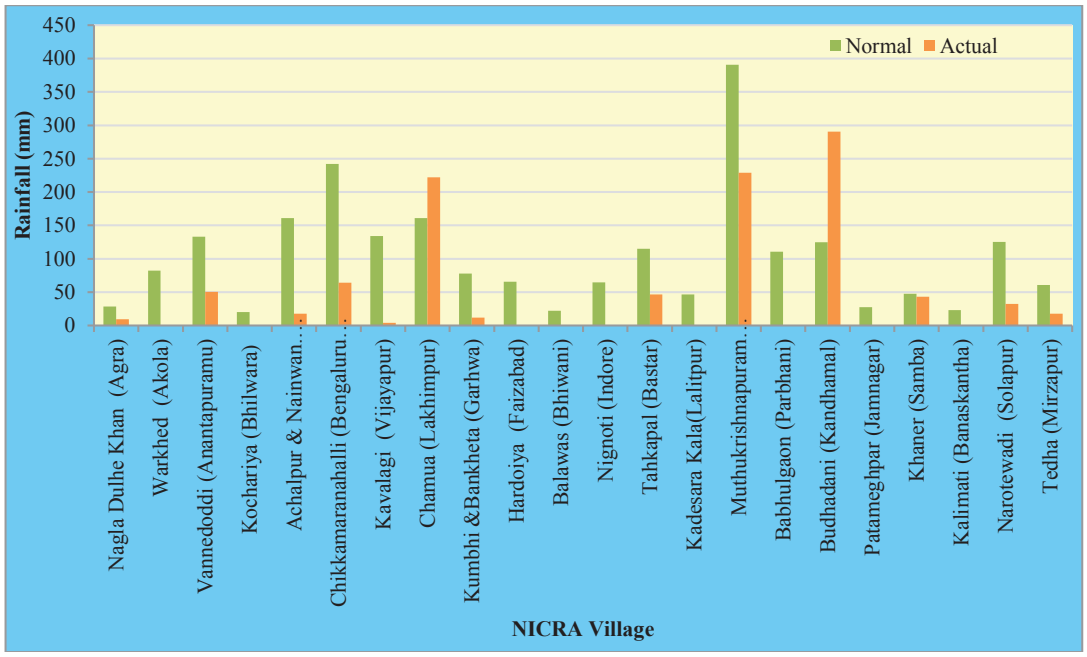


Fig.4: Normal and actual (2018) rainfall in AICRPDA-NICRA villages (October - December)

During 2018-19, 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, 2018

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)	51.5	201.0	290.3	238.6	316.0	32.4	207.2	126.0	-39.2	89.8	46.0	-48.8	24.6	4.0	-83.7	2.0	5.4	170.0	1.9	0.0	-100.0
Warkhed (Akola)	151.7	295.9	95.1	209.2	280.3	34.0	216.0	297.4	37.7	111.1	31.8	-71.4	52.3	0.0	-100.0	20.5	0.0	-100.0	9.2	0.0	-100.0
Vannedoddi (Anantapuramu)	94.0	111.0	18.1	97.0	31.2	-67.8	97.0	14.6	-84.9	142.0	106.6	-24.9	21.0	49.2	134.3	107.0	1.2	-98.9	5.0	0.0	-100.0
Kochariya (Bhilwara)	73.5	83.4	13.5	195.6	290.4	48.5	248.8	112.2	-54.9	96.6	119.2	23.4	9.6	0.0	-100.0	6.8	0.0	-100.0	3.8	0.0	-100.0
Achalpur & Nainwan (Hoshiarpur)	359.6	252.4	-29.8	363.9	258.5	-29.0	315.5	282.6	-10.4	241.1	348.9	44.7	130.1	13.4	-89.7	20.2	4.2	-79.2	10.8	0.2	-98.1
Chikkamaranahalli (Bengaluru Rural)	58.9	83.0	40.9	80.4	76.0	-5.5	131.4	66.0	-49.8	139.0	102.0	-26.6	154.1	52.0	-66.3	61.3	12.0	-80.4	26.8	0.0	-100.0
Kavalagi (Vijayapur)	58.9	83.0	40.9	80.4	76.0	-5.5	131.4	66.0	-49.8	139.0	102.0	-26.6	154.1	52.0	-66.3	61.3	12.0	-80.4	26.8	0.0	-100.0
Chamua (Lakhimpur)	359.6	333.0	-7.4	363.9	281.0	-22.8	315.5	387.2	22.7	241.1	382.0	58.4	130.1	81.1	-37.7	20.2	106.0	424.8	10.8	35.0	224.1
Kumbhi &Bankheta (Garhwa)	162.1	124.5	-23.2	319.5	334.4	4.7	358.8	379.4	5.7	152.1	178.5	17.4	62.1	0.0	-100.0	9.6	3.5	-63.5	5.9	8.2	39.0
Hardoiya (Faizabad)	359.6	12.4	-96.6	363.9	340.6	-6.4	315.5	349.4	10.7	241.1	113.4	-53.0	130.1	0	-100.0	20.2	0	-100.0	10.8	0	-100.0
Balawas (Bhiwani)	20.2	40.5	100.5	80.2	178.1	122.1	60.0	40.7	-32.2	50.3	131.9	162.2	8.6	0.0	-100.0	10.0	0.0	-100.0	3.4	0.0	-100.0
Nignoti (Indore)	120.8	153.5	27.1	260.8	196.6	-24.6	225.4	148.2	-34.3	247.5	147.6	-40.4	39.7	0.0	-100.0	18.3	0.0	-100.0	6.5	0.0	-100.0
Tahkapal (Bastar)	235.5	181.6	-22.9	342.6	274.8	-19.8	350.5	429.8	22.6	192.9	238.6	23.7	88.2	6.3	-92.9	20.2	0.0	-100.0	6.4	40.4	531.3
Kadesara Kala (Lalitpur)	95.2	90.6	-4.8	323.1	248.0	-23.2	336.7	276.0	-18.0	141.9	323.0	127.6	18.7	0.0	-100.0	5.7	0.0	-100.0	22.2	0.0	-100.0
Muthukrishnapuram (Thoothukkudi)	11.1	2.0	-82.0	19.8	1.0	-94.9	35.1	18.0	-48.7	84.2	84.0	-0.2	198.6	138.0	-30.5	138.5	77.0	-44.4	53.8	14.0	-74.0
Babhulgaon (Parbhani)	172.4	186.9	8.4	225.0	542.5	141.1	235.8	359.1	52.3	167.3	82.3	-50.8	80.4	0.0	-100.0	20.9	0.0	-100.0	9.2	0.0	-100.0
Budhadani (Kandhamal)	188.7	185.6	-1.6	350.4	438.8	25.2	383.2	334.0	-12.8	228.2	267.7	17.3	95.7	226.2	136.4	24.0	0.0	-100.0	5.0	64.2	1176.3
Patameghpar (Jamnagar)	102.7	28.0	-72.7	252.0	349.0	38.5	103.3	43.0	-58.4	96.5	39.0	-59.6	21.6	0.0	-100.0	5.4	0.0	-100.0	0.3	0.0	-100.0
Khaner (Samba)	95.2	48.7	-48.8	323.1	141.3	-56.3	336.7	313.2	-7.0	141.9	128.6	-9.4	18.7	1.2	-93.6	5.7	21.7	280.7	22.2	20.3	-8.6
Kalimati (Banaskantha)	87.3	74.0	-15.2	278.1	287.0	3.2	275.4	46.0	-83.3	142.0	0.0	-100.0	19.7	0.0	-100.0	2.8	0.0	-100.0	0.6	0.0	-100.0
Narotewadi (Solapur)	107.1	88.6	-17.3	115.8	30.1	-74.0	139.6	68.1	-51.2	172.7	17.6	-89.8	97.9	24.3	-75.2	21.6	8.2	-62.0	6.0	0.0	-100.0
Tedha (Mirzapur)	86.8	25.5	-70.6	283.3	123.0	-56.6	326.9	165.4	-49.4	2.5	110.1	4304.0	49.1	16.7	-66.0	7.2	0.0	-100.0	4.6	1.1	-76.1

N: Normal A: Actual during 2018 % 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 2018-19

During the year 2018, the onset of monsoon was early by 9 days (24th June). A rainfall of 701.5 mm was received which was excess by 43.8 mm compared to normal rainfall of 657.7 mm. During south-west monsoon (June to September), 691.1 mm rainfall was received which was excess by 76.6 mm (12.5%). During October-December, there was 4.0 mm of rainfall against normal rainfall of 20.2 mm. During summer (March-May), 6.4 mm of rainfall was received compared to normal (15.1 mm) (Fig.5).

Normal onset of monsoon	2 July
Onset of monsoon during 2018	24 June
Annual mean rainfall	657.7 mm
Annual rainfall during 2018-19	701.5 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	614.5 and 20.2 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	691.1 and 4.0 mm, respectively

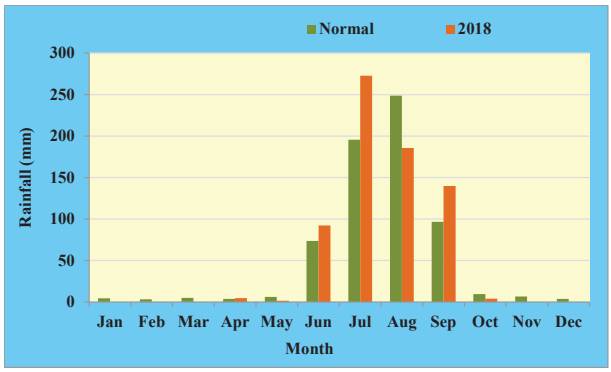


Fig.5: Normal and actual (2018) monthly rainfall at Arjia

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	26 July to 8 August	Maize, sorghum, greengram, blackgram	Vegetative
-	24 September to till harvest	Maize	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Maize	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

During *kharif* 2018, one dry spell occurred during vegetative stage (26 July to 8 August) of maize. Foliar application of macro and micronutrients during dry spell recorded significantly higher maize grain yield (2887 kg/ha) compared to foliar application after dry spell (2579 kg/ha). Further, foliar application of NPK soluble (18:18:18) @ 0.5% + $ZnSO_4$ @ 0.5% increased grain yield (3217 kg/ha) by 38.3% as compared to control (2326 kg/ha). Mean data also revealed that foliar application of nutrients during dry spell significantly enhanced

the maize grain yield by 12.7% (2808 kg/ha) compared to foliar application after dry spell (2491 kg/ha). Further, foliar application of NPK soluble (18:18:18) @ 0.5% with $ZnSO_4$ @ 0.5% also recorded higher net returns, B:C ratio and RWUE compared to other treatments (Table 5).

Table 5: Yield and economics of maize as influenced by foliar spray

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain (2018)	Mean grain (2 yrs)	Stover (2018)	Mean stover (2 yrs)				
Main plot								
Foliar spray after relieving of stress	2579	2491	4893	4929	17763	31958	2.80	4.21
Foliar spray during >10 days dry spell	2887	2808	5455	5496	17763	37531	3.11	4.74
CD at 5%	279	-	453	-	-	-	-	-
Sub plot								
Urea @ 1%	2560	2511	4963	4978	17685	33123	2.87	4.32
Urea @ 2%	2732	2599	5332	5207	17745	36565	3.06	4.61
NPK soluble (18:18:18) @ 0.5%	3021	2966	5678	5828	18099	41411	3.29	5.10
NPK soluble (18:18:18) @ 0.5% + $ZnSO_4$ @ 0.5%	3217	3089	5926	5997	18399	44671	3.43	5.43
$ZnSO_4$ @ 0.5%	2866	2833	5352	5535	17965	38405	3.14	4.84
Water spray	2409	2301	4558	4516	17625	29905	2.70	4.07
Control (no spray)	2326	2249	4410	4429	16825	29090	2.73	3.93
CD at 5%	228	-	474	-	-	-	-	-

Maize under control (no spray)

Maize with foliar spray of NPK soluble (18:18:18) @ 0.5% + $ZnSO_4$ @ 0.5%

c. On-farm demonstrations

Village profile

The program is being implemented in Kochariya village, Suwana block, Bhilwara Tehsil & district and in Lapsiya village, Railmagra block, 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 semiarid. 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^{0}C in maximum temperature as compared to normal for the past 20 years. The extreme events like unusual and high intensity rainfall in short span were increasing during August. The area has been experiencing drought during *kharif* and frost during *rabi*. There has been considerable shift in rainfall pattern which resulted to change in climate from dry sub-humid to semi-arid and sowing window has been shifted by almost one week to 25 SMW for the dominant rainfed crops.

Experienced weather conditions during 2018-19

During 2018, in Lapsiya village, onset of monsoon was advanced by 6 days (26 June). A rainfall of 536.6 mm was received which was deficit by 121.1 mm compared to normal (657.7 mm) (Fig.6). During south-west monsoon (June to September), 529.2 mm rainfall was received which was deficit by 85.3 mm (13.9%) than normal rainfall of 614.5 mm. During *rabi*, there was no rainfall as against normal of 20.2 and in summer 7.4 mm against normal of 15.1 mm, respectively. In Kachariya village, onset of monsoon was advanced by 8 days. An annual rainfall of 616.4 mm was received against normal (657.7 mm). The seasonal rainfall was 529.2 mm during *kharif* and no rainfall during *rabi* (Fig.7).

Normal onset of monsoon	2 July (Bhilwara and Rajsamand)
Onset of monsoon during 2018	24 June (Kochariya), 26 June (Lapsiya)
Annual mean rainfall	657.7 mm
Annual rainfall during 2018-19	616.4 (Kochariya), 536.6 mm (Lapsiya)
Mean crop seasonal rainfall during *kharif* and *rabi*	614.5 and 20.2 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	605.2 mm (Kochariya); 529.2 mm (Lapsiya)

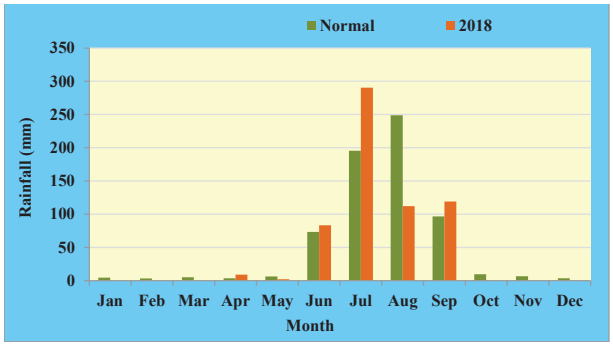


Fig.6: Normal and actual (2018) monthly rainfall at Kochariya

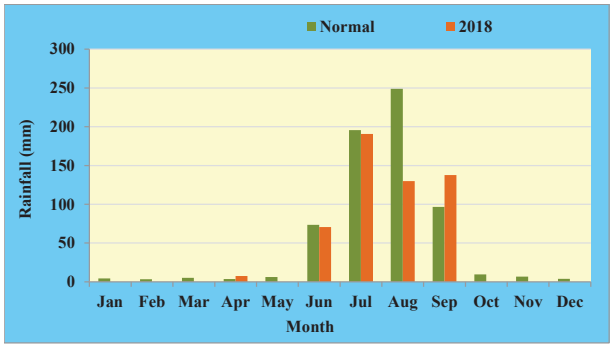


Fig.7: Normal and actual (2018) monthly rainfall at Lapsiya

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	26 July - 08 August	Maize, sorghum, greengram, blackgram	Vegetative
-	22 September to till harvest	Maize	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	RTCP implemented	
		Crop	RTCP implemented
Early season drought	Shallow black soils	Sorghum	Gap filling with blackgram due to motility of sorghum
	Medium black soils	Maize	Soil stirring + gap filling with blackgram due to motility of maize
	Deep black soils	Maize	Foliar spray of NPK @ 1%
Terminal drought	Shallow black soils	Sorghum	Foliar spray of KNO_3 @ 1%
	Medium black soils	Maize + blackgram (2:2)	Supplemental irrigation
		Maize	Foliar spray of KNO_3 @ 1%
	Deep black soils	Maize	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

At village Tara ka Kheda (Lapsiya), supplemental irrigation from harvested water in farm pond, during dry spell at 45 DAS gave 28.4% higher MGEY of maize + blackgram (2:2) intercropping system (3201kg/ha) over farmers' practice of no supplemental irrigation (2404 kg/ha). Similarly, at village Kochariya, supplemental irrigation gave 26.3% higher MGEY of maize + blackgram (2:2) intercropping system (3151 kg/ha) over farmers' practice (2494 kg/ha). At new village Dagoliya ka kheda, supplemental irrigation during dry spell at 42 DAS gave 26.4% higher MGEY of maize + blackgram (2:2) intercropping system (3013 kg/ha) with higher net returns, B:C ratio and RWUE (Table 6).

Table 6: Yield and economics of maize + blackgram (2:2) intercropping system with supplemental irrigation

Treatment	MGEY (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Tara ka Kheda (Lapsiya) village						
With supplemental irrigation	3201	4275	6.47	13100	39600	3.02
Without supplemental irrigation	2404	3367	4.84	11550	27271	2.36
Kochariya village						
With supplemental irrigation	3151	4275	5.55	12900	38851	3.01
Without supplemental irrigation	2494	3367	4.39	11900	26544	2.23
Dagoliya ka kheda (new) village						
With supplemental irrigation	3013	4059	5.49	16600	29152	2.75
Without supplemental irrigation	2452	3323	4.35	15450	19933	2.29

MGEY: maize grain equivalent yield

At Lapsiya village, supplemental irrigation from harvested rain water in farm pond, during dry spell at 45 DAS gave 26.2% higher GPEY of groundnut + sesame (6:2) intercropping system (1073 kg/ha) over farmers' practice of no supplemental irrigation (850 kg/ha). Similarly, at village Kochariya (Bhilwara), supplemental irrigation in groundnut + sesame (6:2) intercropping system gave 23.7% higher GPEY (1320 kg/ha) over farmers' practice (1068 kg/ha). At new village Dagoliya ka kheda, supplemental irrigation during dry spell at 35 DAS gave 42.6% higher GPEY in groundnut + sesame (6:2) intercropping system (1043 kg/ha) over farmers' practice (732 kg/ha) with higher net returns, B:C ratio and RWUE (Table 7).

Table 7: Yield and economics of groundnut + sesame (6:2) intercropping system as influenced by supplemental irrigation

Treatment	GPEY (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Pod	Haulm				
Tara ka Kheda (Lapsiya) village						
With supplemental irrigation	1073	1698	2.83	20600	37683	2.83
Without supplemental irrigation	850	1429	2.25	18900	27630	2.46
Kochariya village						
With supplemental irrigation	1320	1962	2.32	20600	50608	3.46
Without supplemental irrigation	1068	1596	1.88	18900	38725	3.05
Dagoliya ka kheda village						
With supplemental irrigation	1043	1705	2.11	19800	37103	2.87
Without supplemental irrigation	732	1496	1.48	17600	23511	2.34

GPEY: Groundnut pod equivalent yield

Preparedness

Rainwater management

In village Tara ka Kheda (Lapsiya), *in-situ* moisture conservation practices (chiseling, peripheral bunding and ridging 30 DAS) in maize gave 22.4% higher grain yield (2750 kg/ha) over cultivator twice (farmers' practice) (2248 kg/ha), with higher net returns, B:C ratio and RWUE. Similarly, at village Kochariya (Bhilwara), *in-situ* moisture conservation practices gave 25.4% higher maize grain yield (2670 kg/ha) over farmers' practice (2130 kg/ha), with higher net returns, B:C ratio and RWUE. Further, at new village Dagoliya ka kheda, improved practices in maize gave 23.3% higher grain yield (2603 kg/ha) over farmers' practice (2110 kg/ha) with higher net returns, B:C ratio and RWUE (Table 8).

Table 8: Yield and economics of maize as influenced by *in-situ* moisture conservation

Treatment	Yield (kg /ha)			RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B:C ratio
	Grain (2018)	Stover	Mean grain (8 yrs)				
Tara ka Kheda (Lapsiya) village							
With *in-situ* practices	2750	4035	1791	7.27	17900	33438	2.87
Without *in-situ* practices	2248	3338	1454	5.94	17150	24906	2.45
Kochariya village							
With *in-situ* practices	2670	3875	3775	4.70	17900	31838	2.78
Without *in-situ* practices	2130	3238	3119	3.75	17150	22894	2.33
Dagoliya ka kheda village							
With *in-situ* practices	2603	3525	2364(2)*	5.26	17600	30250	2.72
Without *in-situ* practices	2110	3030	1904(2)	4.27	16900	22325	2.32

*Mean of two years

In village Tara ka Kheda (Lapsiya), improved practice (chiseling, peripheral bunding and ridging 30 DAS) gave 19.9% higher grain yield (2653 kg/ha) over farmers' practice of cultivator twice (2213 kg/ha), with higher net returns, B:C ratio and RWUE. Similarly, at village Kochariya (Bhilwara) improved *in-situ* moisture conservation practices gave 19.8% higher grain yield (2517 kg/ha) over farmers' practice (2100 kg/ha). At new village Dagoliya ka kheda, improved *in-situ* moisture conservation practices gave 26.4% higher grain yield (2717 kg/ha) over farmers' practice (2150 kg/ha) (Table 9).

Table 9: Yield and economic of sorghum as influenced by *in-situ* moisture conservation

Treatment	Yield (kg/ha)			RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain (2018)	Mean grain (4 yrs)	Straw				
Tara ka Kheda (Lapsiya) village							
With *in-situ* practices	2653	2208	5200	5.36	16400	28440	2.73
Without *in-situ* practices	2213	1765	3790	4.47	15350	20685	2.35
Kochariya village							
With *in-situ* practices	2517	-	5017	4.43	16400	26342	2.61
Without *in-situ* practices	2100	-	3670	3.70	15350	19025	2.24
Dagoliya ka kheda village							
With *in-situ* practices	2717	2522(2)*	5250	5.49	16600	29125	2.75
Without *in-situ* practices	2150	2010(2)	3833	4.35	15450	19933	2.29

*Mean of two years

Cropping systems

At village Tara ka Kheda (Lapsiya), among improved varieties of maize, PEHM-2 gave 28.5% higher grain yield (2473 kg/ha) over local cultivar (1925 kg/ha). Similarly, at village Kochariya (Bhilwara), improved variety of maize, PEHM-2 followed by PM-3 gave 29.4 and 22.31% higher grain yield (2337 and 2209 kg/ha) over local variety (1806 kg/ha). At new village Dagoliya ka kheda, improved variety of maize, PEHM-2 followed by PM-3 gave 25.9 and 23.3% higher grain yield (2312 and 2263 kg/ha) over local cultivar (1836 kg/ ha), with higher net returns (Rs.28135 and 28806/ha) and B:C ratio (3.04 and 2.98) (Table 10).

Table 10: Yield and economics of maize varieties

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) village						
PEHM-2	2473	4025	5.00	14270	32888	3.30
PM-3	2310	3822	4.67	14280	29925	3.10
Local	1925	2932	3.89	13900	22305	2.60
Kochariya village						
PEHM-2	2337	3568	4.11	14270	29705	3.08
PM-3	2209	3526	3.89	14280	27670	2.94
Local	1806	3020	3.18	13900	20740	2.49
Dagoliya ka kheda village						
PEHM-2	2312	3322	4.67	14150	28835	3.04
PM-3	2263	3332	4.58	14170	28106	2.98
Local	1836	2942	3.71	13700	21195	2.55

At village Tara ka Kheda (Lapsiya), among improved varieties of sorghum, CSV-15 gave 33.6% higher grain yield (2424 kg/ha) compared to local cultivar (1814 kg/ha) with higher net returns (Rs.31750/ha), B:C ratio (3.30) and RWUE (4.9 kg/ ha-mm). Similarly, at village Kochariya (Bhilwara), CSV-15 gave 40.5% higher grain yield (2318 kg/ ha) over local variety (1650 kg/ha). At new NICRA village Dagoliya ka kheda, CSV-15 gave 24.9% higher grain yield (2150 kg/ha) over local cultivar (1722 kg/ha) with higher net returns (Rs 27880/ ha), B:C ratio (3.15) and RWUE (4.35 kg/ha-mm) (Table 11).

Table 11: Yield and economics of sorghum varieties

Variety	Yield (kg/ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Tara ka Kheda (Lapsiya) village						
CSV-15	2424	3676	4.90	13800	31750	3.30
CSV-17	2162	3740	4.37	13150	28630	3.18
Local	1814	3047	3.67	12370	22458	2.82
Kochariya village						
CSV-15	2318	4120	4.08	12560	32510	3.59
Local	1650	3232	2.90	11270	21560	2.91
Dagoliya ka kheda village						
CSV-15	2150	3432	4.35	12950	27880	3.15
CSV-17	2078	3542	4.20	11780	26245	3.10
Local	1722	2912	3.48	10900	22210	3.04

At village Tara ka Kheda (Lapsiya), improved variety of groundnut, TG-37A gave 38.3% higher pod yield (1198 kg/ha) over local cultivar (867 kg/ha) with higher net returns (Rs. 43987/ha) and B:C ratio (3.51). Similarly, at village Kochariya, TG-37A gave 44.3% higher pod yield (1072 kg/ha) over local cultivar (743 kg/ha) with higher net returns (Rs. 26941/ha) and B:C ratio (2.54). Similar results were recorded at new NICRA village Dagoliya ka kheda (Table 12).

Table 12: Yield and economics of groundnut varieties

Variety	Yield (kg/ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Pod	Haulm				
Tara ka Kheda (Lapsiya) village						
PM-2	1097	1387	2.90	17370	38737	3.23
TG- 37A	1198	1607	3.17	17550	43987	3.51
Local	867	1203	2.29	16450	28158	2.71
Kochariya (old village) village						
PM-2	940	1250	1.90	17450	20445	2.17
TG- 37A	1072	1457	2.17	17550	26941	2.54
Local	743	1093	1.50	16800	11263	1.67
Dagoliya ka kheda (new) village						
PM-1	1060	1633	2.14	17480	29003	2.66
TG- 37A	1277	1870	2.58	17520	38222	3.18
Local	812	1273	1.64	16700	18950	2.13

At Tara ka Kheda (Lapsiya), blackgram variety, PU 31 gave 44.2% higher seed yield (450 kg/ha) as compared to local cultivar (312 kg/ha) with higher net returns. Similarly, at village Kochariya improved blackgram cultivar, PU 31 gave 65.8% higher seed yield (437 kg/ha) over local cultivar (263 kg/ha) with higher net returns (Rs.11733/ha) and B:C ratio (2.66). Further, At new NICRA village Dagoliya ka kheda, improved variety of blackgram, PU 31 gave 46.9% higher seed yield (470 kg/ha) over the local cultivars (320 kg/ha) (Table 13).

Table 13: Yield and economic of blackgram varieties

Variety	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B: C ratio
	Seed	Stover				
Taraka Kheda (Lapsiya) village						
PU-31	450	650	0.91	9300	15475	2.66
Local	312	470	0.63	8750	8495	1.97
Kochariya village						
PU-31	437	700	0.77	9500	11733	2.66
Local	263	417	0.46	8700	10300	1.97
Dagoliya ka kheda village						
PU-31	470	680	0.95	9670	16210	2.68
Local	320	480	0.65	8400	9280	2.10

At Tara ka Kheda (Lapsiya) village, maize + blackgram (2:2) intercropping system gave 22.4% higher MGEY (2246 kg/ha) with higher net returns (Rs. 24164/ha) and B:C ratio (2.53) compared to mixed cropping of maize and blackgram (farmers' practice) (1835 kg/ha). Similarly, at Kochariya village, maize + blackgram (2:2) intercropping system gave 27.9% higher MGEY (2419 kg/ha) over farmers' practice (1891 kg/ha). Further, at Dagoliya ka kheda village, intercropping system of maize + blackgram (2:2) gave 32.9% higher MGEY (2319 kg/ha), net returns (Rs.22908/ha) and B:C ratio (2.31) over farmers' practice of mixed cropping (1744 kg/ha) (Table 14).

Table 14: Yield and economics of maize + blackgram (2:2) intercropping system

Treatment	MEY (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C Ratio
	Grain	Stover				
Tara ka Kheda (Lapsiya) village						
Improved practice	2246	3410	4.54	15800	24164	2.53
Farmers' practice	1835	3008	3.71	15300	17904	2.17
Kochariya village						
Improved practice	2419	3624	4.26	15800	27125	2.72
Farmers' practice	1891	3079	3.33	15300	18863	2.23
Dagoliya ka kheda village						
Improved practice	2319	3155	4.69	17450	22908	2.31
Farmers' practice	1744	2718	3.53	16800	14418	1.86

MGEY: Maize grain equivalent yield; Improved practice: Maize + blackgram (2:2) intercropping system; Farmers' practice: Mixed cropping of maize and blackgram

At Tara ka Kheda (Lapsiya) village, improved practice of groundnut + sesame (6:2) intercropping system recorded 28.6% higher GPEY (877 kg/ha) with net returns of Rs. 23462/ha and B:C ratio of 1.49 as compared to farmers' practice of mixed cropping (682 kg/ha). Similarly, at Kochariya village, groundnut + sesame (6:2) intercropping system gave 27.1% higher GPEY (929 kg/ha) over farmers' practice (731 kg/ha) with higher net returns (Rs. 25880/ha) and B:C ratio (1.49). While at Dagoliya ka kheda village, improved practice of groundnut + sesame (6:2) intercropping system recorded 44.7% GPEY (1157 kg/ha) with net returns of Rs. 27546/ha and B:C ratio of 1.53 as compared to farmers' practice (795 kg/ha) (Table 15).

Table 15: Yield and economic of groundnut + sesame (6:2) intercropping system

Treatment	GEY (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Pod	Haulm				
Tara ka Kheda (Lapsiya) village						
Improved practice	877	1031	2.32	15700	23462	1.49
Farmers' practice	682	832	1.27	14950	18730	1.25
Kochariya (old) village						
Improved practice	929	1176	1.63	15450	25880	1.67
Farmers' practice	731	951	0.93	14340	19658	1.37
Dagoliya ka kheda village						
Improved practice	1150	1398	2.25	17950	27546	1.53
Farmers' practice	795	1032	1.31	17480	21130	1.21

GPEY: Groundnut pod equivalent yield; Improved practice: Groundnut + sesame (6:2) intercropping system; Farmers' practice: Mixed cropping of groundnut and sesame

At Tara ka Kheda (Lapsiya) village, improved practice of blackgram + sesame (2:2) intercropping system recorded 20.9% higher blackgram seed equivalent yield (556 kg/ha) compared to farmers' practice of mixed cropping of blackgram and sesame (460 kg/ha) with higher net returns (Rs.16550/ha) and B:C ratio (1.47). Similarly, at Kochariya village, blackgram + sesame (2:2) intercropping system gave 24.6% higher blackgram seed equivalent yield (491 kg/ha) over farmers' practice (394 kg/ha) with higher net returns (Rs. 14780/ha) and B:C ratio (1.35). While at Dagoliya ka kheda village, blackgram + sesame (2:2) intercropping system recorded 15.6% higher blackgram seed equivalent yield (505 kg/ha) with higher net returns (Rs.16005/ha) and B:C ratio (1.44) as compared to farmers' practice of mixed cropping of blackgram and sesame (437 kg/ha) (Table 16).

Table 16: Yield and economics of blackgram+ sesame (2:2) intercropping system

Treatment	Blackgram equivalent yield (kg/ha)		RWUE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk				
Tara ka Kheda (Lapsiya) village						
Improved practice	556	692	1.12	11250	16550	1.47
Farmers' practice	460	524	0.93	10840	12160	1.12
Kochariya (Bhilwara) (old) village						
Improved practice	491	617	0.86	10970	14780	1.35
Farmers' practice	394	490	0.69	9930	11770	1.19
Dagoliya ka kheda village						
Improved practice	505	742	0.89	11100	16005	1.44
Farmers' practice	437	634	0.77	10640	12795	1.22

Improved practice: Balckgram + sesame (2:2) intercropping system; Farmers' practice: Mixed cropping of balckgram and sesame

Nutrient management

At village Tara ka Kheda (Lapsiya), application of $ZnSO_4$ @ 25 kg/ha in maize gave 17.8% higher grain yield (2693 kg/ha) with higher net returns (Rs. 29012/ha) and B:C ratio (2.89) over farmers' practice of no Zn application (2287 kg/ ha). Similarly at village Dagoliya ka kheda application of $ZnSO_4$ @ 25 kg/ha gave 21.9% higher grain yield (2377 kg/ha) with higher net returns (Rs. 25723/ha) and B:C ratio (2.55) over farmers' practice (1948 kg/ha) (Table 17).

Table 17: Yield and economics of maize as influenced by application of zinc sulphate

Treatment	Yield (kg/ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B: C ratio
	Grain	Stalk				
Tara ka Kheda (Lapsiya) village						
25 kg $ZnSO_4$/ha	2693	4817	5.45	15350	29012	2.89
Control	2287	3883	4.62	14800	22348	2.51
Dagoliya ka kheda village						
25 kg $ZnSO_4$/ha	2377	3600	4.81	16550	25723	2.55
Control	1948	3167	3.94	15700	19493	2.24

Alternate land use

At Kochariya village, the horti-pastoral system model consisting of forage (*Cenchrus setgerus – CAZRI-76*) and Ber (var. Gola) with *in-situ* rainwater management (contour trenches at 5 m interval for *ber* platation) to stabilize the fruit and grass yields was demonstrated. Improved grasses with rainwater conservation practices gave the highest dry grass yield (3790 kg/ha) compared to local grass (2150 kg/ha). Similarly at Bagatpura village (Lapsiya), Ber plantation recorded fruit yield of 2860 kg/ha and intercropped cenchrus grass gave highest dry grass yield (4320 kg/ha) with higher net returns (Rs. 46210/ha), B:C ratio (4.79) and RWUE (7.60 kg/ha-mm) as compared to local grass (2270 kg/ha) (Table 18).

Table 18: Performance of horti-pastoral system

Treatment	Yield (kg/ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Fruit	Grass				
Kochariya village						
Ber + *Cenchrus* with rainwater conservation	0	3790	6.67	5650	5720	1.01
Without rainwater conservation practices	0	2150	3.79	5050	1400	0.28
Bagatpura (Lapsiya) village						
Ber + *Cenchrus* grass with rainwater conservation	2860	4320	7.60	9650	46210	4.79
Without rainwater conservation	0	2270	3.99	5050	1400	0.28

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 2018-19

During 2018, the onset of monsoon was normal (4th June). A total rainfall of 321.3 mm was received which was deficit by 248.7 mm (43.6%) compared to normal (570 mm). Out of total rainfall, 274.9 mm was received in *kharif* season which was 77.1 mm deficit (21.9%) than normal of 352 mm. In *rabi*, rainfall was 4.4 mm and was deficit by 19.6 mm (96.9%) than normal of 144.0 mm and in summer season, 42 mm rainfall was received which was deficit by 29.5 mm (41.3%) than normal of 71.5 mm (Fig.8).

Normal onset of monsoon	1-5 June
Onset of monsoon during 2018	4 June
Annual mean rainfall	570.0 mm
Annual rainfall during 2018-19	321.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	352.0 & 144.0 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	274.9 & 4.4, respectively

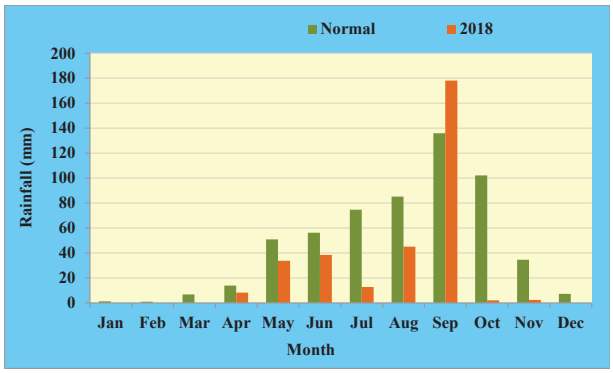


Fig.8: Normal and actual (2018) monthly rainfall at Anantapuramu

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
14	17 - 30 August	Groundnut, pigeonpea, castor	Seedling to vegetative
11	1 - 11 September	Groundnut	Vegetative to flowering
123	27 September - 27 January	Groundnut	Peg formation, pod development and maturity
		Pigeonpea	Flowering and pod development

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Groundnut + pigeonpea (8:1)	Supplemental irrigation
	Groundnut	Foliar spray of KNO_3 @ 0.5%

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* 2018, a dry spell of more than 50 days occurred coinciding with pod formation in groundnut and flowering in pigeonpea. Among treatments, higher groundnut pod and haulm yield (225 and 1561 kg/ha) was recorded with sole groundnut with one supplemental irrigation of 20 mm given at pod filling stage (70 DAS) through micro-sprinklers. However pigeonpea crop failed due to severe moisture stress at flowering and pod development stages. The net returns were negative and higher B:C ratio (0.62) and WUE (1.01 kg/ha-mm) was recorded by sole groundnut followed with one supplemental irrigations of 20 mm at pod filling stage through micro-sprinklers (Table 19)

Table 19: Yield and economics of groundnut + pigeonpea (8:1) intercropping system as influenced by supplemental irrigation

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Pod (2018)	Mean pod/ seed (2 yrs)		Haulm yield				
	Groundnut	Groundnut	Pigeonpea					
Sole groundnut	139	1182	-	1023	27750	-15945	0.43	0.69
Groundnut + pigeonpea (8:1)	102	807	549	868	28250	-19014	0.33	0.50
Groundnut + pigeonpea (15:1)	122	879	382	706	28000	-18637	0.33	0.60
Sole groundnut with irrigations (sprinkler) of 20 mm each at flowering & pod filling stage	225	1305	-	1561	30250	-11643	0.62	1.01
Groundnut + pigeonpea (8:1) with two irrigations of 20 mm each at flowering & pod filling in groundnut (sprinkler) and pigeonpea (furrow)	148	972	1082	957	30750	-18860	0.39	0.67
Groundnut + pigeonpea (8:1) with two irrigations of 20 mm each at flowering & pod filling in groundnut (sprinkler) and pigeonpea (drip)	160	974	973	938	30750	-18382	0.40	0.72

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Pod (2018)	Mean pod/ seed (2 yrs)		Haulm yield				
	Groundnut	Groundnut	Pigeon pea					
Groundnut + pigeonpea (15:1) with two irrigations of 20 mm each at flowering & pod filling in groundnut (sprinkler) and pigeonpea (furrow)	189	1045	785	1035	30500	-16254	0.47	0.85
Groundnut + pigeonpea (15:1) with two irrigations of 20 mm each at flowering & pod filling in groundnut (sprinkler) and pigeonpea (drip)	185	1039	654	1023	30500	-16504	0.46	0.83

Groundnut (K-6), pigeonpea (PRG-176)

During *kharif* 2018, there was a long dry spell of 52 days during 27 September to maturity coinciding with peg formation, pod development and maturity stage and drastically reduced the pod yield of groundnut. However, the pod yield (152 kg/ha) of groundnut was improved significantly through foliar spray after relieving of stress/dry spell (with favorable soil moisture) over foliar spray during dry spell (135 kg/ha). Foliar spray during dry spell with water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient ($ZnSO_4$ @ 0.2%) recorded higher groundnut pod yield (189 kg/ha), B:C ratio (0.42) and RWUE of 0.89 kg/ha-mm compared to other treatments (Table 20).

Table 20: Performance of groundnut (K-6) as influenced by foliar sprays

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod	Haulm			
Main plot					
Foliar spray during dry spell	135	904	-17199	0.31	0.64
Foliar spray after relieving of stress/dry spell	152	955	-16328	0.35	0.72
CD at 5%	16.7	NS	-	-	-
Sub plot					
Urea @ 1%	118	909	-18336	0.28	0.57
Urea @ 2%	145	908	-17909	0.32	0.69
Water soluble complex fertilizer (19:19:19) @ 0.5%	175	993	-14912	0.40	0.83
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.2%	186	1050	-14445	0.42	0.89
$ZnSO_4$ @ 0.2%	149	945	-16250	.35	0.71
Water spray	135	857	-16914	.32	0.64
Control (no spray of any material/water)	98	845	-18581	.25	0.47
CD at 5%	13.3	31.9	-	-	-

Recommended dose of fertilizer of 20-40-40 N-P_2O_5-K_2O kg/ha

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.

Normal onset of monsoon	7-8 June
Onset of monsoon during 2018	4 June
Annual mean rainfall	618.0 mm
Annual rainfall during 2018-19	333.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	430.0 and 133.0 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	283.4 and 50.4 mm, respectively

Experienced weather conditions during 2018-19

During 2018, in Vannedoddi village, onset of monsoon was timely (4 June) and total rainfall received was 333.8 mm which was deficit by 284.2 mm than normal rainfall of 618.0 mm. Out of the total annual rainfall, *kharif* season recorded 283.4 mm which was deficit by146.6 mm (34.1%) than normal of 430.0 mm and in *rabi* 50.4 mm rainfall was recorded against normal rainfall of 133.0 mm and during summer, there was no rainfall as against normal rainfall of 53.0 mm (Fig.9)

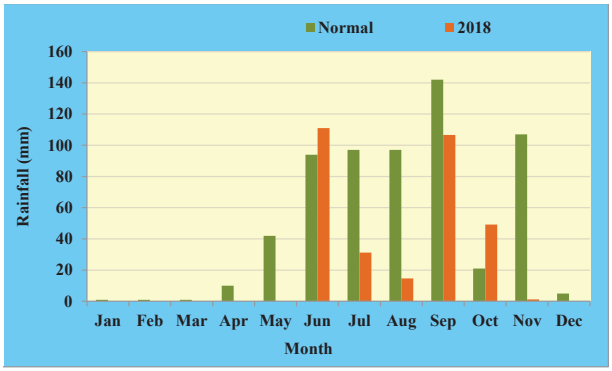


Fig.9: Normal and actual (2018) monthly rainfall at Vannedoddi

Dry spells during crop growing season (2018-19)

Dry spell		Stage of the crop		
Duration (days)	**Dates & months**	**Groundnut**	**Pigeonpea**	**Castor**
29	11 June - 8 July	-	Seedling to vegetative	Seedling to vegetative
38	12 July - 18 August	Vegetative to flowering	Vegetative	Vegetative to flowering
11	20-30 August	Peg formation	Vegetative	Flowering to primary spike development
23	26 September - 17 October	Pod development	Vegetative to pre-flowering	Spike development to maturity
101	18 October - 27 January, 2019	Pod filling to maturity	Flowering to pod development	Spike development to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/soil type	Crop	RTCP implemented
Early season drought	Rainfed, *Alfisols*	Castor	*In-situ* moisture conservation through conservation furrows
Mid season drought	Rainfed, *Alfisols*	Castor	*In-situ* moisture conservation through conservation furrows
	Rainfed, *Alfisols*	Groundnut	Foliar spray of KNO_3 @ 0.5%
Terminal drought	Rainfed, *Alfisols*	Groundnut	Foliar spray of KNO_3 @ 0.5%

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

Conservation furrows formed at vegetative stage adjacent to every row of castor with country plough for *in-situ* moisture conservation gave 21% higher castor yield (666 kg/ha) compared to without conservation furrow (550 kg/ha), with higher net returns (Rs. 16884/ha), B:C ratio (2.07) and RWUE (1.79 kg/ha-mm) (Table 21).

***In-situ* moisture conservation through conservation furrow in castor**

Table 21: Effect *in-situ* moisture conservation 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
Rainfed *Alfisols*	With conservation furrows	666	1.79	16884	2.07
	Without conservation furrows	550	1.48	11200	1.71

Situation: Mid season drought

Groundnut crop (Kadiri 6) was subjected to severe moisture stress due to scanty rainfall during peg penetration to pod initiation. Foliar spray of KNO_3 @ 0.5% during peg penetration to pod initiation stage recorded higher groundnut pod yield (630 kg/ha) compared to without foliar spray (315 kg/ha), and gave higher net returns (Rs.4290/ha), B:C ratio (1.14) and RWUE (3.05kg/ha-mm) (Table 22).

Table 22: Yield and economics of groundnut (Kadiri 6) as influenced by foliar spray

Farming situation/soil type	Intervention	Yield (kg/ha)		RWUE (kg/ha- mm)	Net returns (Rs/ha)	B:C ratio
		Pod	Haulm			
Rainfed *Alfisols*	With foliar spray	630	1250	3.05	4290	1.14
	Without foliar spray	315	630	1.52	-10440	0.62

Opening of conservation furrows adjacent to every row of pigeonpea for *in-situ* moisture conservation in pigeonpea + pearlmillet (1:1) intercropping system gave 20.8% higher pigeonpea equivalent yield (192 kg/ha) compared to without conservation furrows (159 kg/ha), with higher B:C ratio (0.84) and RWUE (0.72 kg/ha-mm) (Table 23).

Table 23: *In-situ* moisture conservation through conservation furrows in pigeonpea + pearlmillet (1:1) intercropping system

Farming situation/ soil type	Intervention	Yield (kg/ha)		Pigeonpea equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Intercrop	2018	Mean (2yrs)				
Rainfed *Alfisols*	With conservation furrows	105	162	192	792	12750	-1998	0.84	0.72
	Without conservation furrows (Farmers' practice)	90	128	159	703	11750	-2846	0.76	0.60

Improved practice

Farmers' practice (no conservation furrow)

Pigeonpea+pearlmillet (1:1) intercropping system

Preparedness

Rainwater management

Deep ploughing using chisel plough after pre-monsoon showers in June, recorded higher gorundnut pod and haulm yield (244 and 1920 kg/ha), compared to the farmers' practice of no deep ploughing (135 and 1562 kg/ha) and gave higher B:C ratio (0.71) and RWUE (1.11 kg/ha-mm) (Table 24).

Table 24: Effect of *in-situ* moisture conservation on yield and economics of 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 (2018)	Mean pod (2 yrs)	Haulm				
Rainfed *Alfisols*	Deep tillage with chisel plough	244	928	1920	22535	-6495	0.71	1.11
	Without deep tillage	135	753	1562	21735	-11861	0.45	0.61

Cropping systems

Groundnut + pigeonpea intercropping system gave higher groundnut equivalent yield (281 kg/ha), B:C ratio (0.67) and RWUE (1.28 kg/ha-mm) gave compared to pigeonpea + pearlmillet (1:1) intercropping system (Table 25).

Table 25: Evaluation of intercropping systems under rainfed conditions

Farming situation/ soil type	Intervention	Yield (kg/ha)			GEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Groundnut	Pigeon pea	Pearl millet					
Rainfed *Alfisols*	Pigeonpea + pearlmillet (1:1)	--	95	125	162	13750	- 5974	0.57	0.74
	Groundnut + pigeonpea (15:1)	263	15	--	281	25350	-8362	0.67	1.28

GEY: Groundnut equivalent yield

Energy management

During 2018-19, the actual field capacity and seed rate of the bullock drawn Ananta planter was recorded as 2 ha/day and 100 kg/ha, respectively. The saving in cost of operation and labour was 14% and 55%, respectively. Sowing of groundnut with bullock drawn Ananta planter recorded 10.5 and 3.1% higher pod and haulm yield (210 and 2110 kg/ha), over farmers' practice (190 and 2046 kg/ha). (Table 26)

Table 26: Effect of sowing with bullock drawn Ananta planter 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	Haulm				
Rainfed *Alfisols*	Bullock drawn Ananta planter	210	2110	21575	-4745	0.78	0.87
	Farmers' practice (Local seed drill)	190	2046	28375	-12737	0.55	0.8

During 2018-19, the actual field capacity, seed rate and energy requirement of the tractor drawn Ananta planter was recorded as 7 ha/day, 100 kg/ha and 435.82 MJ/ha, respectively. The saving in cost of operation and labour was 35% and 75-80%, respectively. Sowing of groundnut with tractor drawn Ananta planter recorded higher pod and haulm yield (215 and 2170 kg/ha), respectively over farmers' practice (190 and 2046 kg/ha). (Table 27).

Table 27: Effect of sowing with Tractor drawn Ananta planter 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	Haulm				
Rainfed *Alfisols*	Tractor drawn Ananta Planter	215	2170	18575	-1495	0.92	0.9
	Farmers' practice (local seed drill)	190	2046	28375	-12737	0.55	0.8

Sowing of groundnut using tractor drawn Ananta planter (left) and field view of groundnut (right)

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 2018-19

During 2018, the onset of monsoon was advanced by 7 days (26th June) in Agra. An annual rainfall of 1109.8 mm was received which was excess by 444.8 mm (66. 9%) than normal (665.0 mm). During *kharif*, there was a rainfall of 931.8 mm, excess by 342.7 mm (58.2%) than normal

(589.1 mm) and in *rabi* season, 5.0 mm rainfall was recorded which was deficit by 53.4 mm (91.4%) against normal of 58.4 mm. (Fig.10)

Normal onset of monsoon	2 July
Onset of monsoon during 2018	26 June
Annual mean rainfall (mm)	665.0 mm
Annual rainfall received during 2018-19	1109.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	589.1 mm and 58.4 mm
Cop seasonal rainfall during 2018-19 (*kharif* & *rabi*)	931.8 mm and 5.0 mm, respectively

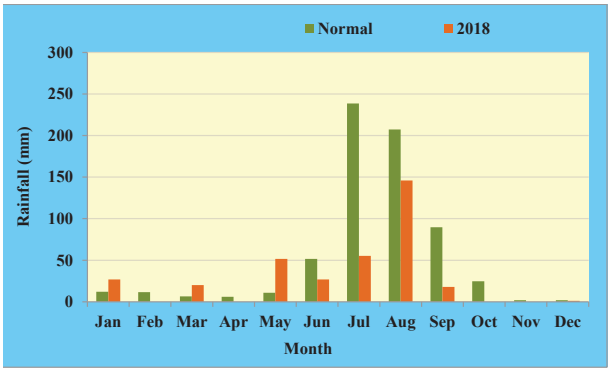


Fig. 10: Normal and actual (2018) monthly rainfall at Agra

Dry spells during crop growing season (2018-19): Nil

Real time contingency practices (RTCP) implemented: Nil

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 from 1.42 to1.50 gm/cm^3 and 2.40 to 2.71 g/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 and alkaline in nature.

Experienced weather conditions during 2018-19

During *kharif* 2018, the onset of monsoon was advanced by 6 days (26 June). An annual rainfall of 848.4 mm was received, which was excess by 183.9 mm (27.7%) as compared to normal annual rainfall (664.5 mm). During southwest monsoon (kharif), a rainfall of 689.0 mm was received, which was excess by 100 mm (16.9%) than normal rainfall (589.1 mm). During *rabi*, the rainfall of 32.6 mm which was deficit by 25.8 mm than normal rainfall of 58.4 mm (Fig.11)

Normal onset of monsoon	2 July
Onset of monsoon during 2018	26 June
Annual mean rainfall	664.5 mm
Annual rainfall during 2018-19	484.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	589.1 mm and 58.4 mm
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	689.0 mm and 32.6 mm

Dryspell during crop growing season (2018-19)

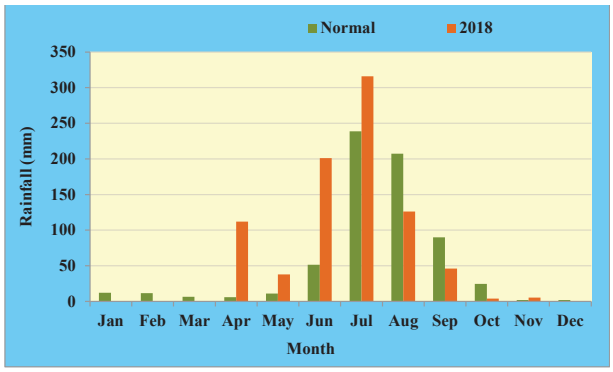


Fig.11: Normal and actual (2018) monthly rainfall at Nagla Dulhe Khan

Dry spells during crop growing season (2018-19)

Duration (days)	Dates & months	Crop	Stage of crop
-	10 September to maturity	Pearlmillet, clusterbean, sesame	Grain filling and maturity

Real time contingency practices (RTCP) implemented: Nil

Salient achievements of on-farm demonstrations

Real time contingency planning: Nil

Preparedness

Rainwater management

Sowing of pearlmillet with ridger seeder gave higher grain yield (2363 kg/ha), net returns (Rs.39230/ha), B:C ratio (3.50) and RWUE of 5.42 kg/ha-mm as compared to broadcasting (1999 kg/ha) (Table 28).

Table 28: Effect of ridge and furrow method of sowing on yield and economics of pearlmillet

intervention	Grain yield (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2018	Mean (8 yrs)					
Ridger seeder	2363	2272	5890	15673	39230	3.50	5.42
Without ridger seeder	1999	1719	3387	14912	29144	2.95	4.58

Pearlmillet under ridge sowing

Pearlmillet under broadcasting

In-situ moisture conservation through compartmental bunding in pearlmillet gave 12.3% higher grain yield (2240 kg/ha) compared to farmers' practice (1995 kg/ha) with higher net returns (Rs.36391/ha), B:C ratio (3.32) and RWUE (5.14 kg/ha-mm) (Table 29).

Table 29: Effect of compartmental bunding on yield and economics of pearlmillet

Intervention	Grain yield (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2018-19	Mean (8 yrs)					
Compartmental Bunding	2240	2144	5590	15673	36391	3.32	5.14
No compartmental bunding	1995	1671	3395	14912	29082	2.95	4.58

Deep ploughing in summer produced 27.7% higher seed yield of mustard (2350 kg/ha) with higher net returns (Rs.87093/ha) and B:C ratio (6.14) as compared to without deep ploughing (1840 kg/ha) (Table 30).

Table 30: Performance of mustard with deep ploughing in summer

Intervention	Seed yield (kg/ha)	Mean seed yield (kg/ha) (8 yrs)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Deep ploughing (summer)	2350	1911	16929	87093	6.14
Conventional ploughing	1840	1514	16215	65180	5.02

Mustard under deep tillage

Mustard under conventional tillage

Cropping systems

Pearlmillet variety Pro agro 9450 gave 6.5% higher grain yield (2194 kg/ha) over JKBH-36 (2060 kg/ha) with higher net returns of Rs. 34320 /ha and B:C ratio of 3.19 (Table). Sesame variety Shekhar gave 20.6 % higher seed yield (305 kg/ha) with higher net returns (Rs.8673/ha) and B:C ratio (1.65) as compared to HT-01 (253 kg/ha) (Table). Cluster bean variety RGC-1025 produced 5.5% higher seed yield (580 kg/ha) with higher net returns (Rs.11854/ha) and B:C ratio (1.80) compared to RGC-1015 variety (550 kg/ha) (Table 31).

Table 31: Performance of improved varieties of different crops

Crop	Varieties	Grain/seed yield (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2018	Mean (5 yrs)					
Pearlmillet	Proagro-9450	2194	2068	4810	15673	34320	3.19	5.03
	JKBH-36	2060	1883	4677	15673	31512	3.01	4.72
Sesame	Shekar	305	347	802	13287	8673	1.65	0.70
	HT-01	253	314	664	13287	4953	1.37	0.58
Clusterbean	RGC-1025	580	512	1430	14826	11854	1.80	1.33
	RGC-1002	550	454	1329	14826	10474	1.71	1.26

Sesame var. Shekar

Sesame var. HT-1

Strip cropping of pearlmillet + clusterbean (4:4) gave 10.6% higher pearlmillet equivalent yield (2273 kg/ha) than pearlmillet sole (2055 kg/ha), with higher net returns (Rs.36227/ha) and B:C ratio (3.38) (Table 32).

Table 32: Performance of pearlmillet + clusterbean strip cropping (4:4)

Intervention	PEY (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	2018	Mean (8 yrs)			
Strip cropping of pearlmillet + clusterbean (4:4)	2273	2633	15250	36227	3.38
Pearlmillet sole	2055	1619	14192	31086	3.19

PEY: Pearlmillet equivalent yield

Strip cropping of pearlmillet + sesame (4:4) gave 10.6% higher pearlmillet equivalent yield (2269 kg/ha) as compared to sole pearlmillet (2110 kg/ha), with higher net returns (Rs. 35308/ha) and B:C ratio (3.44) (Table 33).

Table 33: Performance of pearlmillet + sesame strip cropping (4:4)

Intervention	PEY (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	2018	Mean (8 yrs)			
Strip cropping of pearlmillet + sesame (4:4)	2269	2787	14480	35308	3.44
Sole pearlmillet	2110	1654	14192	32370	3.28

PEY: Pearlmillet equivalent yield

Pearlmillet +sesame strip cropping (4:4)

Pearlmillet sole

Chickpea + mustard intercropping system (5:1) recorded 45.3% higher chickpea equivalent yield (2761 kg/ha) with higher net returns (Rs.97632/ha) and B:C ratio (6.49) as compared to sole chickpea (1900 kg/ha) (Table 34).

Table 34: Performance of chickpea + mustard (5:1) intercropping system

Intervention	CEY (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	2018	Mean (8 yrs)			
Chickpea + mustard (5:1) intercropping	2761	2144	17778	97632	6.49
Chickpea sole	1900	1570	16115	63305	4.93

CEY: Chickpea equivalent yield

Chickpea + mustard (5:1) intercropping system

Chickpea sole

Musatard var. Giriraj gave 3.6 and 6.9% higher seed yield (2305 kg/ha) as compared to RH-749 (2225 kg/ha) and RH-406 (2115 kg/ha), respectively with higher net returns (Rs.84992/ha) and B:C ratio (6.02). Chickpea var. Avarodhi gave 20.2 % higher seed yield (2415 kg/ha) over Uday (2010 kg/ha), with higher net returns of Rs. 83169/ha and B:C ratio of 5.68. Barley var. Narendra-2 gave 6.9% higher grain yield (2800 kg/ha) as compared to BH-946 (2620 kg/ha), with higher net returns of Rs. 52625/ha and B:C ratio of 3.45 (Table 35).

Table 35: Performance of improved varieties of different crops

Crop	Variety	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Seed (2018)	Mean seed (4 yrs)	Stalk			
Mustard	Giriraj	2305	2187	4944	16929	84992	6.02
	RH-749	2225	1822	4644	16929	81262	5.80
	RH-406	2115	1966	4492	16929	78164	5.62
Chickpea	Avarodhi	2415	1806	4217	17778	83169	5.68
	Uday	2010	1541	3378	17778	66240	4.73
Barley	Narendra-2	2800	2465	6787	21496	52625	3.45
	BH-946	2620	2288	6399	21496	48005	3.23

Nutrient management

Application of K @ 50 kg K_2O/ha with RDF (60+40 kg NP/ha) increased mustard yield by 32.3% (2540 kg/ha) with higher net returns of Rs. 95473/ha and B:C ratio of 6.6 compared to farmers' practice of no K application (1920 kg/ha) (Table 36).

Table 36: Effect of potassium application on mustard yield and economics on farmer's field

Treatment	Seed yield (kg/ha)		Stalk (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	2018	Mean (8 yrs)				
RDF + 50 kg K_2O/ha	2540	2004	5508	16929	95473	6.64
RDF alone	1920	1511	4068	16215	68607	5.23

RDF: 60:40 kg NP/ha

Mustard under RDF + 50 kg K_2O/ha

Mustard under RDF alone

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 (*AESR 2.3)* 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 2018-19

During 2018, the onset of monsoon was normal (29th June) and an annual rainfall of 427.8 mm was received which was excess by 15.8 mm (3.8%) compared to normal (412.0 mm) (Fig.12). During *kharif*, 381.6 mm rainfall was received which was excess by 45.8 mm (13.6%) than normal (335.8 mm). In *rabi*, 46.2 mm rainfall was received which was 37.0 mm excess than normal (9.2 mm).

Normal onset of monsoon	1st week of July
Onset of monsoon during 2018	29 June
Annual mean rainfall	412.0 mm
Annual rainfall during 2018-19	427.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	335.8 mm and 9.2 mm
Crop seasonal rainfall during 2018-19 (*kharif* & *rabi*)	381.6 mm and 46.2 mm

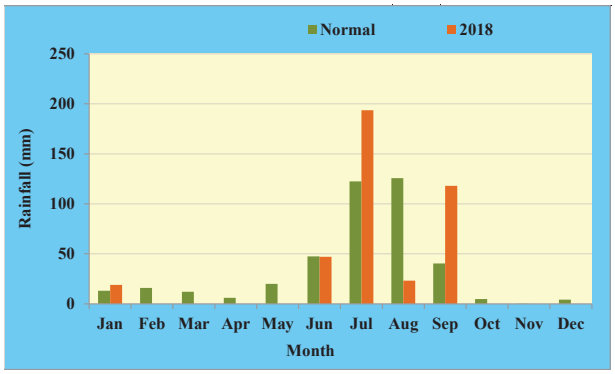


Fig.12: Normal and actual (2018) monthly rainfall at Hisar

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
11	10-20 August	Pearlmillet, mungbean, clusterbean	Flowering (pearl-millet, mungbean), Vegetative (clusterbean)
12	22 August - 03 Sep-tember	Pearlmillet, mungbean, clusterbean	Grain filling (pearlmillet), Pod formation (mungbean), Flowering (clusterbean)

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Pearlmillet	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* 2018, two dry spells of 11 and 12 days occurred coinciding with flowering and grain filling stage of pearlmillet. Foliar spray during the dry spell and after relieving the stress had no significant effect on both grain and stover yield of pearlmillet. However, foliar spray after relieving the stress gave marginally higher grain and stover yield (1814 and 4408 kg/ha), net returns (Rs. 23107/ha), B:C ratio (2.14) and RWUE (8.64 kg/ha-mm) compared to foliar spray during the dry spell. Among various treatments, foliar spray of water soluble complex fertilizer (18:18:18) @ 0.5% + recommended dose of micronutrient foliar spray (0.5% $ZnSO_4$) recorded significantly higher grain yield of pearlmillet (1952 kg/ha) with higher net returns (Rs 26082/ha), B:C ratio (2.27) and RWUE (9.29 kg/ha-mm) compared to control (1584 kg/ha), water spray (1610 kg/ha) and 0.5% $ZnSO_4$ spray (1731 kg/ha) (Table 37).

Table 37: Effect of foliar spray 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	1748	4230	20200	21500	2.06	8.32
Foliar spray after relieving the stress	1814	4408	20200	23107	2.14	8.64
CD @ 5%	NS	NS				
Sub plot						
Urea @ 1%	1830	4480	20230	23519	2.16	8.72
Urea @ 2%	1852	4510	20260	23972	2.18	8.82
Water soluble complex fertilizer (18:18:18) @ 0.5%	1910	4687	20400	25282	2.24	9.09
Water soluble complex fertilizer (18:18:18) @ 0.5% + $ZnSO_4$ @ 0.5%	1952	4760	20550	26082	2.27	9.29
$ZnSO_4$ @ 0.5%	1731	4262	20350	21076	2.04	8.24
Water spray	1610	3910	20200	18233	1.90	7.67
Control (no spray of any material/water)	1584	3850	19400	18418	1.95	7.55
CD @ 5%	132	298	-	-	-	-

Pearlmillet with foliar spray of water soluble complex fertilizer (18:18:18) @ 0.5% + 0.5% $ZnSO_4$

Pearlmillet with no spray

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 southwest 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/- 0.0710C) 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 2018-19

The onset of monsoon was normal (29th June). An annual rainfall of 429.5 mm in Balawas and 406.4 mm in Nalwa was received which was excess by 129.5 mm and 106.4 mm, respectively compared to normal (300 mm) (Fig.13). During *kharif*, 391.2 mm in Balawas and 363.5 mm in Nalwa respectively was received compared to normal (210.7 mm); *rabi* season recorded 38.3 mm in Balawas and 42.9 mm in Nalwa as against normal of 22 mm.

Normal onset of monsoon	1st week of July
Onset of monsoon during 2018	29 June
Normal annual mean rainfall	300 mm
Annual rainfall during 2018-19	429.5 mm (Balawas) and 406.4 mm (Nalwa)
Mean crop seasonal rainfall during *kharif* & *rabi*	210.7 and 22 mm, respectively
Crop seasonal rainfall during 2018-19 *(kharif* and *rabi)*	391.2 mm and 38.3 mm, respectively in (Balawas) and 363.5 mm and 42.9 mm, respectively in (Nalwa)

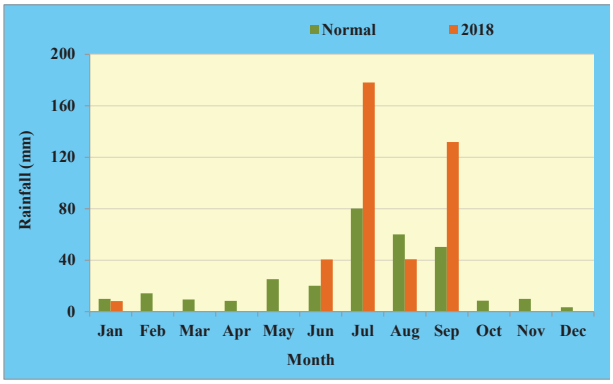


Fig. 13: Normal and actual (2018) monthly rainfall at Balawas

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
14	26 July - 08 August	Pearlmillet, mungbean, cluster bean	Flowering (pearlmillet, mungbean), Vegetative (cluster bean)
12	10-21August	Pearlmillet, mungbean, cluster bean	Grain filling (pearlmillet), Pod formation (mungbean), Flowering (cluster bean)
13	23 August - 04 September	Pearlmillet, mungbean, cluster bean	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	Crop	RTCP implemented
Mid season drought	Deep sandy to loamy sand soil	Pearlmillet	Weeding with wheel hand hoe, foliar spray
		Mung bean	Weeding with wheel hand hoe
		Cluster bean	Weeding with wheel hand hoe

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

Intercultural operations using wheel hand hoe (WHH) in pearlmillet, mungbean and clusterbean resulted in 18.9, 25.8, 24.1% and 20.4, 29.3, 25.0% higher seed yield in village Balawas and Nalwa, respectively as compared to no weeding. Similarly, weeding with WHH also recorded higher net returns, B:C ratio and RWUE over no weeding in all the three crops at both the villages (Table 38).

Table 38: Effect of weeding with wheel hand hoe on crop yield and economics

Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Balawas village						
Deep sandy soil	Pearlmillet	Weeding with wheel hand hoe	1618	7.92	12151	1.63
		Without weeding	1360	6.65	8620	1.48
Deep loamy sand soil	Mungbean	Weeding with wheel hand hoe	448	2.19	12248	1.64
		Without weeding	356	1.74	7331	1.41
Deep loamy sand soil	Cluster bean	Weeding with wheel hand hoe	1328	4.12	34020	2.78
		Without weeding	1070	3.32	25200	2.43
Nalwa village						
Deep sandy soil	Pearlmillet	Weeding with wheel hand hoe	1508	8.21	10006	1.51
		Without weeding	1252	6.82	6514	1.36
Deep loamy sand soil	Mungbean	Weeding with wheel hand hoe	476	2.59	14201	1.74
		Without weeding	368	2.01	8168	1.46
Deep loamy sand soil	Cluster bean	Weeding with wheel hand hoe	1270	4.31	31700	2.66
		Without weeding	1016	3.45	23040	2.31

Pearlmillet weeding with WHH

Pearlmillet under no weeding

Clusterbean under weeding with WHH

Clusterbean under no weeding

Foliar spray of 1% KNO_3 on 4th and 19th August in pearlmillet helped in mitigating dry spell and gave 7.0 and 7.1 % higher grain yield (1692 and 1572 kg/ha), net returns (Rs.13594 and11254/ha), B:C ratio (1.69 and 1.58) and RWUE (8.28 and 8.56 kg/ha-mm) as compared to farmers' practice of no foliar spray in both villages Balawas and Nalwa, respectively (Table 39).

Table 39: Effect of foliar spray on 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
Balawas					
Deep sandy soil	Foliar spray of 1% KNO_3	1692	8.28	13594	1.69
	Farmers' practice (no foliar spray)	1586	7.76	12427	1.67
Nalwa					
Deep sandy soil	Foliar spray of 1% KNO_3	1572	8.56	11254	1.58
	Farmers' practice (no foliar spray)	1468	7.18	10126	1.54

Preparedness

Cropping systems

During *kharif*, in Balawas village, pearlmillet hybrid HHB 197 recorded higher grain yield (1724 kg/ha), net returns (Rs. 14163/ha), B:C ratio (1.73) and RWUE (8.44 kg/ha-mm) compared to HHB 67 (Improved). Mungbean variety MH 421 gave higher seed yield (480 kg/ha), net returns (Rs. 14473/ha), B:C ratio (1.76) and RWUE (2.35 kg/ha-mm) compared to sattya. Clusterbean variety HG 2-20 recorded highest seed yield (1340 kg/ha), net returns (Rs. 34464/ha), B:C ratio (2.80) and RWUE (4.16 kg/ha-mm) compared to HG 563 and HG 365

During *rabi*, mustard variety RH 725 recorded higher seed yield (2614 kg/ha), net returns

(Rs. 81388/ha), B:C ratio (3.86) and RWUE (68.25 kg/ha-mm) compared to RH 30. Similarly chickpea variety HC 1 recorded the higher seed yield (960 kg/ha), net returns (Rs. 22752/ha), B:C ratio (2.05) and RWUE (25.06 kg/ha-mm) compared to C 235 variety (Table 40).

Table 40: Performance of drought tolerant varieties of rainfed crops (Balawas village)

Farming situation/ soil type	Crops	Variety	Seed/grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Deep sandy soil	Pearl millet	HHB 67 (Improved)	1610	19455	11940	1.61	7.88
		HHB 197	1724	19455	14163	1.73	8.44
	Mung bean	Sattya	435	19050	11291	1.59	2.13
		MH 421	480	19050	14473	1.76	2.35
	Cluster bean	HG 365	1224	19136	29824	2.56	3.80
		HG 563	1280	19136	32064	2.67	3.98
		HG 2-20	1340	19136	34464	2.80	4.16
	Mustard	RH 30	2231	28400	65302	3.29	58.3
		RH 725	2614	28400	81388	3.86	68.3
	Chickpea	C 235	870	21600	18594	1.86	22.7
		HC 1	960	21600	22752	2.05	25.1

During *kharif*, in Nalwa village, pearlmillet hybrid, HHB 197 recorded higher grain yield (1556 kg/ha), net returns (Rs. 15173/ha), B:C ratio (1.79) and RWUE (8.48 kg/ha-mm) compared to HHB 67 (Improved). Mungbean variety MH 421 gave higher seed yield (493 kg/ha), net returns (Rs. 15173/ha), B:C ratio (1.79) and RWUE (2.69 kg/ha-mm) compared to sattya. Cluster bean variety HG 2-20 recorded highest seed yield (1294 kg/ha), net returns (Rs. 32900/ha), B:C ratio (2.74) and RWUE (4.40 kg/ha-mm) compared to HG 563 and HG 365

During *rabi*, mustard variety RH 725 recorded higher seed yield (2438 kg/ha), net returns (Rs. 73996/ha), B:C ratio (3.60) and RWUE (56.81 kg/ha-mm) compared to RH 30. Similarly, HC 1 variety of chickpea recorded higher seed yield (890 kg/ha), net returns (Rs. 19518/ha), B:C ratio (1.90) and RWUE (27.74 kg/ha-mm) compared to C 235 (Table 41).

Table 41: Performance of drought tolerant varieties of rainfed crops (Nalwa village)

Farming situation/ soil type	Crops	Variety	Seed/grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Deep sandy soil	Pearl millet	HHB 67 (Improved)	1495	19115	10038	1.53	8.15
		HHB 197	1556	19115	11227	1.59	8.48
Deep loamy sand soil	Mung bean	Sattya	452	19214	12313	1.64	2.46
		MH 421	493	19214	15173	1.79	2.69
Deep loamy sand soil	Cluster bean	HG 365	1187	18860	28620	2.52	4.03
		HG 563	1242	18860	30820	2.63	4.22
		HG 2-20	1294	18860	32900	2.74	4.40
Deep sandy loam soil	Mustard	RH 30	2109	28400	60178	3.11	49.2
		RH 725	2438	28400	73996	3.60	56.8
Deep loamy sand soil	Chick pea	C 235	815	21600	16053	1.74	19.0
		HC 1	890	21600	19518	1.90	27.7

Pearlmillet Hyb. HHB 197

Pearlmillet Hyb. HHB 67 (Improved)

Clusterbean Var. HG 2-20

Clusterbean Var. HG 365

During *kharif*, at Balawas, weeding with wheel hand hoe increased the yield of pearlmillet (1590 kg/ha), mungbean (486 kg/ha) and clusterbean (1395 kg/ha) by 7.0, 7.5 and 6.8%, respectively compared to weeding with *kasola* (a traditional implement) at 30 DAS, and recorded higher net returns, B:C ratio and RWUE (Table 42).

Table 42: Effect of weeding with wheel hand hoe on yield and economics of crops

Crop	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain/ seed	Stover				
Pearlmillet	Weeding with wheel hand hoe	1590	4229	19455	19162	1.98	7.78
	Weeding with *kasola* at 30 DAS	1486	3997	20904	15268	1.73	7.27
Mungbean	Weeding with wheel hand hoe	486	745	19050	15370	1.81	2.38
	Weeding with *kasola* at 30 DAS	452	696	20500	11514	1.56	2.22
Cluster bean	Weeding with wheel hand hoe	1395	2469	19136	41108	2.15	4.34
	Weeding with *kasola* at 30 DAS	1306	2312	20636	35765	1.73	4.06

During *rabi*, intercultural operations with wheel hand hoe resulted in 6.0% and 5.6 % increase in seed yield of mustard (2492 kg/ha) and chickpea (824kg/ha) over farmer's practice of using *kasola* (2350 and 780 kg/ha) and gave higher net returns (Rs. 82793 and 18428/ha), B:C ratio (3.91 and 1.85) and RWUE (65.1 and 21.5 kg/ha-mm) (Table 43).

Table 43: Effect of weeding with wheel hand hoe on yield and economics of crops

Crop	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed	Stalk				
Mustard	Weeding with wheel hand hoe	2492	6529	28400	82793	3.91	65.1
	Weeding with *kasola* at 30 DAS	2350	6204	29800	75104	3.52	61.4
Chickpea	Weeding with wheel hand hoe	824	980	21600	18428	1.85	21.5
	Weeding with *kasola* at 30 DAS	780	934	22900	15004	1.65	20.4

During *kharif*, at village Nalwa, intercultural operations using wheel hand hoe resulted in 6.8, 7.4 and 7.3% higher grain/seed yield of pearlmillet (1613 kg/ha), mungbean (479 kg/ha) and clusterbean (1378 kg/ha), over farmers' practice of using *kasola* (1511, 446 and 1284 kg/ha), with higher net returns, B:C ratio and RWUE (Table 44).

Table 44: Effect of weeding with wheel hand hoe on crop yield and economics

Crop	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain/ seed	Stover/ stalk				
Pearlmillet	Weeding with wheel hand hoe	1613	4291	19115	20062	2.05	8.79
	Weeding with *kasola* at 30 DAS	1511	4026	20612	16099	1.78	8.23
Mungbean	Weeding with wheel hand hoe	479	748	19214	14720	1.77	2.61
	Weeding with *kasola* at 30 DAS	446	698	20708	10889	1.53	2.43
Clusterbean	Weeding with wheel hand hoe	1378	2426	18860	40626	2.15	4.68
	Weeding with *kasola* at 30 DAS	1284	2285	20355	35118	1.72	4.36

During *rabi*, at village Nalwa, intercultural operations with wheel hand hoe gave 6.0 and 5.7% higher seed yield of mustard (2422 kg/ha) and chickpea (850 kg/ha) over farmer's practice of using *kasola* (2284 and 804 kg/ha) in mustard and chickpea, respectively with higher net returns (Rs.79889 and 19706/ha), B:C ratio (3.8 and 1.9) and RWUE (56.5 and 19.8 kg/ha-mm) (Table 45).

Table 45: Effect of weeding with wheel hand hoe on crop yield and economics

Crop	Intervention	Yield (kg/ha)		Cost of cultiva-tion (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed	Stalk				
Mustard	Weeding with wheel hand hoe	2422	6563	28400	79889	3.8	56.5
	Weeding with *kasola* at 30 DAS	2284	6349	29800	72477	3.4	53.2
Chickpea	Weeding with wheel hand hoe	850	1018	21600	19706	1.9	19.8
	Weeding with *kasola* at 30 DAS	804	962	22900	16168	1.7	18.7

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 2018-19

During 2018-19, no rainfall was received during 1 June to 14 August and onset of north-east monsoon was early (2 October). A rainfall of 410.6 mm was received which was deficit by 312.0 mm compared to normal (722.6 mm). During *kharif* (June-September), 94.4 mm rainfall was received which was deficit by 55.8 mm than normal of 150.2 mm; in *rabi* season (October-December), 213.9 mm rainfall was received which was deficit by 177.0 mm than normal of 391 mm and during summer (March to May), 100.0 mm rainfall was received which was deficit by 40.9 mm than normal of 140.9 mm (Fig.14)

Normal onset of monsoon	20 October
Onset of monsoon during 2018	2 October
Annual mean rainfall	722.6 mm
Annual rainfall during 2018-19	410.6 mm
Mean crop seasonal rainfall	150.2 and 391.0 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018-19	94.4 and 213.9 mm, during *kharif* and *rabi*, respectively

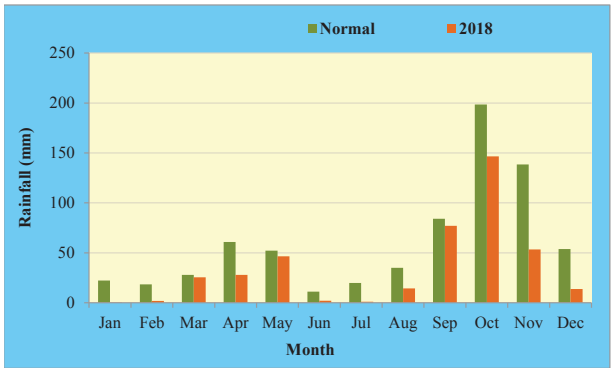


Fig. 14: Normal and actual (2018) monthly rainfall at Kovilpatti

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
8	24-31 October	Pearlmillet, sorghum	Germination
8	8-15 November	Pearlmillet	Tillering
		Sorghum	Grand growth
28	25 November - 22 December	Pearlmillet, sorghum	Flowering and grain filling

Real time contingency practices (RTCP) implemedmm

Weather aberration	Crop	RTCP implemented
Mid season drought	Sorghum	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

A dry spell of 28 days occurred during November-December, coinciding with flowering stage of crops. Foliar spray in sorghum during dry spell recorded higher grain yield (771 kg/ha), gross returns (Rs.13107/ha), B:C ratio (0.67) and RWUE of (3.60 kg/ha-mm) as compared to foliar spray after relieving of stress/dry spell (738 kg/ha). Further, foliar spray of both water soluble complex fertilizer (19:19:19) @ 0.5% recorded significantly higher grain yield (885 kg/ha) with higher gross returns (Rs.15045/ha), B:C ratio (0.77) and RWUE (4.14 kg/ha-mm) compared other treatments (Table 46).

Table 46: Effect of foliar sprays on yield and economics of sorghum (var. K12)

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Gross returns (Rs/ha)	B:C ratio
Main plot				
Foliar spray during dry spell	771	3.60	13107	0.67
Foliar spray after relieving of stress/dry spell	738	3.45	12546	0.64
CD at 5%	9	-	-	-
Sub plot				
Foliar spray of 1% urea	768	3.59	13056	0.67
Foliar spray of 2% urea	726	3.39	12342	0.63
Water soluble complex fertilizer (19.19.19) @ 0.5% (T_3)	885	4.14	15045	0.77
T_3 + $ZnSO_4$ @ 0.5%	764	3.57	12988	0.67
$ZnSO_4$ @ 0.5%	732	3.42	12444	0.64
Water spray	797	3.73	13549	0.69
Control (no spray)	650	3.09	11220	0.58
CD at 5%	50	-	-	-

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 2018-19

During 2018, in Muthukrishnapuram village, the onset of south-west monsoon was delayed by 17 days and onset of north-east monsoon was normal (19 October). A rainfall of 440.0 mm was received which was deficit by 282.6 mm compared to normal (722.6 mm). During *kharif* (June-September), 105.0 mm rainfall was received which was deficit by 45.2 mm than normal of 150.2 mm; in *rabi* season (October-December), 229.0 mm rainfall was received which was deficit by 161.9 mm than normal of 391.0 mm and during summer (March to May), 102.0 mm rainfall was received which was deficit by 38.9 mm than normal of 140.9 mm (Fig.15)

Normal onset of monsoon	20 October
Onset of monsoon during 2018	19 October
Annual mean rainfall	722.6 mm
Annual rainfall during 2018-19	440.0 mm
Mean crop seasonal rainfall	150.2 and 391.0 mm, during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018-19	105.0 and 229.0 mm, during *kharif* and *rabi*, respectively

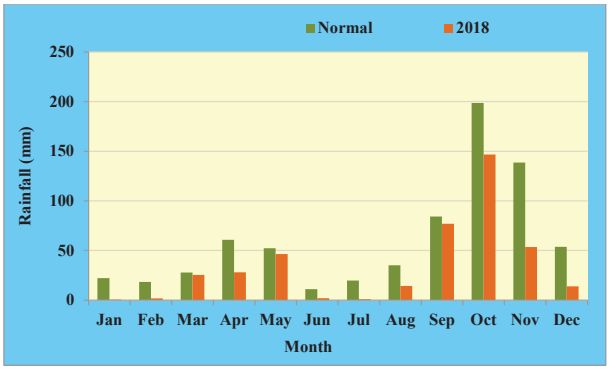


Fig.15: Normal and actual (2018) monthly rainfall at Muthukrishnapuram

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
7	24-30 September	Cotton, pearl millet, sorghum	Germination
8	8- 15 November	Cotton	Square formation
		Pearlmillet	Tillering
		Sorghum	Grand growth
		Blackgram, greengram	Flowering
28	25 November – 22 December	Cotton	Boll formation
		Pearlmillet, sorghum	Flowering and grain filling
		Black gram and Green gram	Seed filling

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of the crop	RTCP implemented
Mid- season drought	Cotton	Flowering	Foliar spray
Terminal drought	Maize	Grain filling	Foliar spray and supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

A dry spell of 28 days occurred coinciding with flowering stage of cotton. Foliar spray of both TNAU cotton plus and pink pigmented facultative methylotrophs (PPFM) recorded significantly higher seed cotton yield (795 and 750 kg/ha) compared to control (560 kg/ha). However, higher net returns (Rs.23995/ha), B:C ratio (1.98) and RWUE (3.47 kg/ha-mm) were recorded with foliar spray of TNAU cotton plus compared to other treatments (Table 47).

Table 47: Effect of foliar spray on yield and economics of cotton (KC 3)

Farming situation/ soil type	Intervention	Seed cotton yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep black soil	TNAU cotton plus (2.5 kg/ha)	795	3.47	23995	1.98
	PPFM spray (500 ml/ha)	750	3.28	21250	1.87
	Control (no spray)	560			

PPFM: Pink pigmented facultative methylotrophs

Situation: Terminal drought

A dry spell of 28 days occurred coinciding with flowering and grain filling stages of maize. Improved practice of foliar spray, mulching and supplemental irrigation from harvested rainwater in farm pond gave 12.1-18.3% higher yield in maize varieties. Among the varieties COH(M)7 gave higher maize grain yield (1255 kg/ha), net returns (Rs.10875/ha), B:C ratio (1.53) and RWUE (5.48 kg/ha-mm). (Table 48)

Table 48: Effect of foliar spray, mulching and supplemental irrigation on yield and economics of maize

Farming situation/ soil type	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With farmers' practice			
Deep black soil	COH(M)6	1125	989	4.91	7625	1.37
	COH(M)7	1255	1025	5.48	10875	1.53

IP: 1% KCl (or) PPFM foliar spray, mulching (sorghum straw @ 5 t/ha) and supplemental irrigation

Preparedness

Rainwater management

Maize variety COH (M)7 recorded higher grain yield (1280 kg/ha), net returns (Rs.7380/ha) and B:C ratio (1.38) compared to COH(M)6 (1198 kg/ha). Among the land configuration treatments, ridges and furrow method recorded higher maize grain yield (1305 kg/ha), net returns (Rs.7905/ha), B:C ratio (1.41) and RWUE (5.70 kg/ha-mm) compared to check basin method (1264 kg/ha) (Table 49).

Table 49: Effect of *in-situ* moisture conservation and varieties on yield of maize

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep black soil	**Variety**				
	COH(M)6	1198	5.23	5658	1.29
	COH(M)7	1280	5.59	7380	1.38
	Land configuration				
	Ridges and furrow	1305	5.70	7905	1.41
	Check basin	1264	5.52	7044	1.36

Among the cotton varieties, SVPR 4 recorded higher seed cotton yield (680 kg/ha), net returns (Rs.6600/ha) and B:C ratio (1.28) compared to SVPR 2 (658 kg/ha) and local variety (536 kg/ha). Among the land configuration treatments, ridges and furrow method recorded higher seed cotton yield (665 kg/ha) compared to check basin method (650 kg/ha) and farmers practice (490 kg/ha) (Table 50).

Table 50: Effect of *in-situ* moisture conservation on yield and economics of cotton

Farming situation/ soil type	Intervention	Seed cotton yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep black soil	**Variety**				
	SVPR 2	658	2.87	5610	1.23
	SVPR 4	680	2.97	6600	1.28
	Local variety	536	-	-	-
	Local variety				
	Ridges and furrow	665	2.90	5925	1.25
	Check basin	650	2.84	5250	1.22
	Farmers' practice (flat bed)	490	-	-	-

Cotton var. SVPR 2

Cotton var. SVPR 4

Cropping systems

Though the crops experienced terminal dry spell, all the cotton based intercropping systems recorded higher cotton equivalent yield, net returns and LER over sole cotton. Cotton + blackgram (2:1) intercropping system recorded higher cotton equivalent yield (1036 kg/ha), net returns (Rs.15729/ ha) and RWUE (4.5 kg/ha-mm) as compared to other cropping systems and sole cotton (Table 51).

Cotton + blackgram (2:1) intercropping system

Table 51: performance of cotton based intercropping systems

Farming situation/ soil type	Intervention	Yield (kg/ha)		CEY (kg/ha)	LER	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Main crop	Inter crop					
Deep black soil	Sole cotton (KC3)	625	-	625	1.000	2.7	5625	1.25
	Cotton + clusterbean (2:1)	594	1526	865	1.276	3.8	14438	1.59
	Cotton + blackgram (2:1)	605	462	1036	1.525	4.5	15729	1.51
	Cotton + onion (2:1)	582	365	923	1.438	4.0	11520	1.38

LER: Land equivalent ratio; CEY: Cotton equivalent yield

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 2018-19

During 2018, the onset of monsoon was delayed by 8 days (24th June). A rainfall of 614.4 mm was received which was excess by 24.0 mm compared to normal of 590.4 mm. During *kharif*, 613.6 mm rainfall was recorded against normal rainfall of 557.9 mm (Fig. 16)

Normal onset of monsoon	16 June
Onset of monsoon during 2018	24 June
Annual mean rainfall	590.4 mm
Annual rainfall during 2018-19	614.4 mm
Mean crop seasonal rainfall during *kharif*	557.9 mm
Crop seasonal rainfall during 2018-19 (*kharif*)	613.6 mm

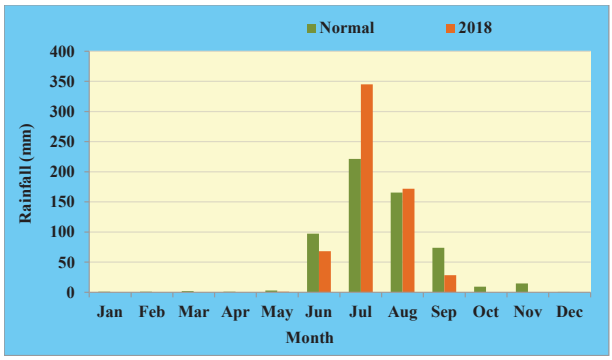


Fig.16: Normal and actual (2018) monthly rainfall at Rajkot

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
08	4 - 12 July	Groundnut, cotton, sesame, green/blackgram, castor	Vegetative
15	23 July - 07 August	Groundnut, greengram	Flowering
		Cotton, sesame, castor	Vegetative
13	4 - 17 September	Groundnut	Pegging & pod formation
		Cotton	Square formation
		Sesame	Flowering and capsule formation
		Green/black gram	Pod development

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	Flowering	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

The onset of monsoon was delayed by 8 days (24th June). Among different semi-spreading varieties of groundnut, GG-20 recorded higher pod yield (1723 kg/ha) as compared to GJG-20. Among semi-bunch groundnut varieties, TGA-37A recorded higher pod yield (2356 kg/ha), net returns (Rs.84990/ha) and B:C ratio (2.62) compared to other varieties. In case of spreading varieties, GJG-17 performed better with higher pod yield of (1633 kg/ha) and net returns (Rs. 52345/ha) compared to var. GG11 (1389 kg/ha) (Table 52).

Table 52: Performance of groundnut varieties under delayed onset of monsoon

Variety	Yield (kg/ha)			RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Pod (2018)	Mean pod (2 years)	Haulm			
Semi-spreading						
GG-20	1723	1803	4680	2.81	57331	2.10
GJG-22	1681	1654	5110	2.74	57381	2.10
Bunch						
GG-7	1859	2023	3789	3.03	59485	2.13
GJG-9	2223	2414	4675	3.62	82115	2.57
JL-501	2122	2294	3412	3.46	70750	2.35
TG-37A	2356	2550	3920	3.84	84990	2.62
Spreading						
GG-11 (C)	1389	1418	4856	2.26	41420	1.79
GJG-17 (C)	1633	1706	4601	2.66	52345	2.00

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 cowpea varieties, GC-4 gave

22.5% higher seed yield than GC-3 (1579 kg/ha) with higher net returns (Rs 56932/ha) and B:C ratio (3.87). Among soybean varieties, G.Soy.-3 gave higher seed yield (3458 kg/ha), net returns (Rs 95679/ha), B:C ratio (4.47) and RWUE (5.64 kg/ha-mm) followed by G.Soy.-1 (3442 kg/ha) compared to other varieties (Table 53).

Table 53: Performance of improved varieties of blackgram, cowpea and soybean

Crop	Variety	Yield (kg/ha)			RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Seed (2018)	Mean seed (2 years)	Stover yield			
Blackgram	GU-1	998	1043	1212	1.63	29770	2.84
	T-9	1002	1094	1235	1.63	30045	2.85
Cowpea	GC-5	1589	1679	1602	2.59	51747	3.61
	GC-4	1706	1821	1703	2.78	56932	3.87
	GC-3	1422	1501	1533	2.32	44722	3.26
Soybean	JS-335	3233	3338	4506	87084	4.18	5.27
	G.Soy.-1	3422	3332	4498	93486	4.38	5.58
	G.Soy.-2	2566	2501	3376	61016	3.29	4.18
	G.Soy.-3	3458	3571	4821	95679	4.47	5.64

Situation: Mid season drought

A dry spell of 15 days occurred during 15 July -7 August coinciding with flowering stage of groundnut. The pod yield of groundnut was increased due to foliar spray during dry spell and foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1% recorded higher pod yield (2416 kg/ha), net returns (Rs.92956/ha), B:C ratio (2.75) and RWUE (3.94 kg/ha-mm) compared to other treatments (Table). Similarly, foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1% after dry spell recorded higher pod yield (2396 kg/ha), net returns (Rs.95621/ha) and B:C ratio (2.80) and RWUE (3.9 kg/ha-mm) compared to other treatments (Table 54).

Table 54: Effect of different foliar sprays on yield and economics of groundnut

Treatment	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod (2018)	Pod (3 years)	Haulm			
Foliar sprays during dry spell						
Urea @ 1%	2316	2196	5058	88771	2.70	3.77
Urea @ 2%	2257	2141	5135	86106	2.64	3.68
Water soluble complex fertilizer (19:19:19) @ 0.5%	2226	2162	5064	83946	2.59	3.63
Water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @1%	2416	2423	5057	92956	2.75	3.94
$FeSO_4$ @ 1%	2138	2202	4864	78718	2.50	3.48
$ZnSO_4$ @ 1%	2022	2061	4600	71458	2.36	3.30
Water spray	1951	1940	4439	67526	2.29	3.18
Control (no spray)	1701	1899	4025	64255	2.24	3.13
Foliar sprays after relieving of dry spell						
Urea @ 1%	2049	2182	5250	76362	2.46	3.30
Urea @ 2%	2014	2135	5208	74317	2.42	3.30
Water soluble complex fertilizer (19:19:19) @ 0.5%	2083	2155	5535	79166	2.50	3.40
Water soluble complex fertilizer (19:19:19) @0.5% + $FeSO_4$ @1%	2396	2406	5792	95621	2.80	3.90
$FeSO_4$ @1%	2257	2197	5701	88852	2.69	3.70
$ZnSO_4$ @1%	2014	2018	5375	74927	2.42	3.30
Water spray	1806	1878	4583	60975	2.17	2.90
Control (no spray)	1701	1812	4097	53536	2.03	2.80

C. On-farm demonstrations

Village profile

The NICRA villages Patameghpar (22°14.33' N longitude 70°31.0' E and 95.7 m above MSL) and Dangar vada are 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 MSW). 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 2018-19

During 2018, at Patameghpar village, the onset of monsoon was delayed by 7 days. A rainfall of 459 mm was received which was deficit by 142.4 mm compared to normal (601.4 mm). During *kharif* season, 459.0 mm of rainfall was recorded against normal rainfall of 554.5 mm (Fig 17).

Normal onset of monsoon	16 June
Onset of monsoon during 2018	23 June
Annual mean rainfall	601.4 mm
Annual rainfall during 2018-19	459.0 mm
Mean crop seasonal rainfall during *kharif*	554.5 mm
Crop seasonal rainfall during 2018 (*kharif)*	459.0 mm

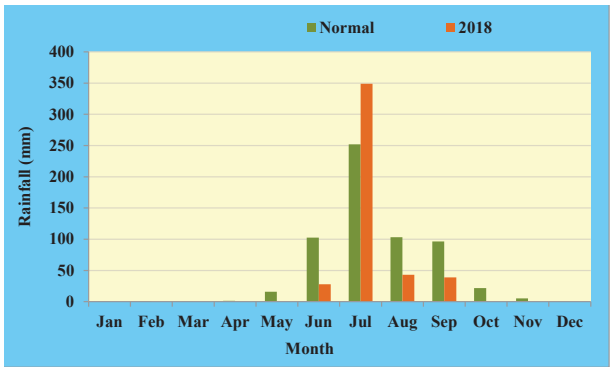


Fig. 17 Normal and actual (2018) monthly rainfall at Patameghpar

Dry spells during crop growing season (2018-19)

a. Patameghpar village

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
25	22 July -16 August	Groundnut, greengram, blackgram	Flowering
		Cotton, sesame, castor	Vegetative
39	23 August -30 September	Groundnut	Pegging, pod development
		Cotton	Flowering, square formation
		Sesame	Flowering and capsule formation
		Greengram, blackgram	Pod development

b. Dangarvada village

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
14	6 -20 August	Groundnut, cotton, sesame, greengram/blackgram, castor	Vegetative
29	2- 30 September	Groundnut	Flowering and pegging
		Cotton	Flowering and square formation
		Sesame	Flowering and capsule formation
		Greengram, black gram	Flowering and pod development

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of the crop	RTCP implemented
Delayed onset of monsoon	Groundnut, cotton	-	Improved varieties
Early season drought	Groundnut, cotton	Vegetative	*In-situ* moisture conservation Inter-culture / weeding, Mulching, foliar spray
Mid season drought	Groundnut, cotton	Flowering	Weeding/ interculture, supplemental irrigation
Terminal drought	Groundnut, cotton	Maturity	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2018, at Patameghpar, the onset of monsoon was delayed by 7 days and at Dangarvada village, the onset of monsoon was delayed by 32 days. Short duration groundnut var. GJG-9 gave 16.7% and 14.5%, higher pod yield compared to var. GG-20 at Patameghpar and Dangarvada villages. In cotton, seed cotton yield was increased by 15.9% and 14.5%, respectively at Patameghpar and Dangarvada villages with short duration variety of cotton G.Cotton-Hy-8 BG- ll, with higher net returns, B:C ratio and RWUE compared to research varieties (Table 55).

Table 55: Performance of groundnut and cotton cultivars under delayed onset of monsoon

Village	Farming situation/ soil type	Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Patameghpar	Rainfed /medium black	Groundnut	GJG 9 (100 days)	2130	3.55	73670	2.42
			GG-20 (110-120 days)	1826	3.04	55734	2.07
		Cotton	G.Cotton-Hy-8 BG- ll (140 days)	2180	3.63	70284	2.74
			Research varieties (160 to 180 days)	1880	3.13	54144	2.14
Dangarvada	Rainfed /medium black	Groundnut	GJG 9 (100 days)	2110	3.51	72490	2.39
			GG-20 (110-120 days)	1843	3.07	56737	2.09
		Cotton	G.Cotton-Hy-8 BG- ll (140 days)	2126	3.54	67379	2.67
			Research varieties (160 to 180 days)	1875	3.12	53875	2.14

Situation: Early season drought

At Patameghpar, a dry spell of 25 days occurred during 22 July -16 August coinciding with vegetative and flowering stage of crops. Intercultivation and mulching with wheat straw @ 5 t/ha in groundnut gave 9.6% higher pod yield (2215 kg/ha) with

higher net returns (Rs.78685/ha), B:C ratio (2.51) and RWUE (3.69 kg/ha-mm) compared to normal practice of intercultivation (2021 kg/ha). Similarly, intercultivation and mulching increased the yield in cotton by 8.2% (2150 kg/ha) with higher net returns (Rs.68670/ha), B:C ratio (2.70) and RWUE (3.58 kg/ha-mm) compared to normal practice of intercultivation (1987 kg/ha) (Table 56).

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

Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed /medium black soil	Groundnut	Intercultivation & mulching with wheat straw @ 5 t/ha	2215	3.69	78685	2.51
		Farmers practice (Intercultivation)	2021	3.36	67239	2.29
	Cotton	Intercultivation & mulching with wheat straw @ 5 t/ha	2150	3.58	68670	2.70
		Farmers practice (Intercultivation)	1987	3.31	59901	2.27

Intercultivation in groundnut

Intercultivation in cotton

At Patameghpar, supplemental irrigation from harvested rainwater with sprinklers in groundnut gave 10.38% higher pod yield (2201 kg/ha) with higher net returns (Rs 77859/ha), B:C ratio (2.50) and WUE (3.66 kg/ha-mm) compared no supplemental irrigation (1994 kg/ha). Similarly, supplemental irrigation through drip system in cotton gave 8.5% higher yield (2131 kg/ha) with higher net returns (Rs.67648/ha), B:C ratio (2.68) and WUE (3.55 kg/ha-mm) compared to no supplemental irrigation (1965 kg/ha) (Table 57).

Drip irrigation in cotton

Table 57: Effect of supplemental irrigation on crop yield and economics

Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed /medium black soil	Groundnut	Supplemental irrigation	2201	3.66	77859	2.50
		Farmers' practice (no supplemental irrigation)	1994	3.32	65646	2.26
	Cotton	Supplemental irrigation	2131	3.55	67648	2.68
		Farmers' practice (no supplemental irrigation)	1965	3.27	58717	2.24

At Patameghpar, foliar spray of $FeSO_4$ @ 1% during first week of August in groundnut gave 6.4% higher pod yield (2089 kg/ha), net returns (Rs. 71251/ha), B:C ratio (2.37) and RWUE (3.48 kg/ha-mm) compared to no foliar spray (1963 kg/ha). Similarly, in cotton foliar spray of KNO_3 @ 1% gave 4.5% higher yield (1998 kg/ha), net returns (Rs.60492/ha), B:C ratio (2.51) and RWUE (3.33 kg/ha-mm) compared to no foliar spray (1912 kg/ha). (Table 58).

Table 58: Effect foliar spray on yield and economics of groundnut and cotton

Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed /medium black soil	Groundnut	Foliar spray of $FeSO_4$ @ 1%	2089	3.48	71251	2.37
		Farmers' practice (no foliar spray)	1963	3.27	63817	2.23
	Cotton	Foliar spray of KNO_3 @ 1%	1998	3.33	60492	2.51
		Farmers' practice (no foliar spray)	1912	3.18	55866	2.18

Foliar spray of KNO_3 @ 1% in cotton

Foliar spray of $FeSO_4$ @ 1% in groundnut

Situation: Mid season drought

At Patameghpar, a dry spell of 29 days occurred coinciding with the pegging and pod development stage of groundnut and flowering stage of cotton. Supplemental irrigation from harvested rainwater through sprinklers in groundnut gave 8.6% higher pod yield (2156 kg/ha) with higher net returns (Rs.75204/ha), B:C ratio (2.45) and WUE (3.59 kg/ha-mm) compared no supplemental irrigation (1984 kg/ha). Similarly, supplemental irrigation in cotton through drip system gave 4.5% higher yield (2042 kg/ha) with higher net returns (Rs.62860/ha), B:C ratio (2.56) and WUE (3.40 kg/ha-mm) compared no supplemental irrigation (1955 kg/ha) (Table 59).

Sprinkler irrigation in groundnut

Table 59: Effect of supplemental irrigation on crop yield and economics

Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed /medium black soil	Groundnut	Supplemental irrigation	2156	3.59	75204	2.45
		Farmers' practice (no supplemental irrigation)	1984	3.30	65056	2.25
	Cotton	Supplemental irrigation	2042	3.40	62860	2.56
		Farmers' practice (no supplemental irrigation)	1955	3.26	58179	2.23

At Dangarvada, during dry spell, supplemental irrigation through sprinkles gave 11.1% higher pod yield (2210 kg/ha) with higher net returns (Rs.78390/ha), B:C ratio (2.51) and WUE (3.68 kg/ha-mm) compared no supplemental irrigation (1990 kg/ha). Similarly, supplemental irrigation through drip system in cotton gave 8.0 % higher yield (2145 kg/ha) with higher net returns (Rs.68401/ha), B:C ratio (2.69) and WUE (3.57 kg/ha-mm) compared no supplemental irrigation (1986 kg/ha) (Table 60).

Table 60: Effect of supplemental irrigation on crop yield and economics

Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed/medium black soil	Groundnut	Supplemental irrigation	2210	3.68	78390	2.51
		Farmers' practice (no supplemental irrigation)	1990	3.31	65410	2.26
	Cotton	Supplemental irrigation	2145	3.57	68401	2.69
		Farmers' practice (no supplemental irrigation)	1986	3.31	59847	2.26

Preparedness

Rainwater management

Opening of dead furrows between two rows for *in-situ* moisture conservation in cotton recorded 14.5% higher seed cotton yield (2240 kg/ha) compared to farmers' practice (1956 kg/ha) with higher net returns (Rs.66700/ha), B:C ratio (2.47) and RWUE kg/ha-mm (3.73) (Table 61).

Table 61: Effect of furrow opening 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)
		2018-19	Mean (3 years)				
Rainfed/ medium black	Furrow opening	2240	2433	45300	66700	2.47	3.73
	Farmers' practice	1956	2044	42600	55200	2.30	3.26

Cropping systems

Cotton + sesame intercropping system (1:1) gave higher seed cotton equivalent yield (2850 kg/ha), LER (1.29), net returns (Rs 80670/ha), B:C ratio (2.47) and RWUE (4.52 kg/ha-mm) compared to farmers' practice of sole cotton (2213 kg/ha) (Table 62).

Table 62: Performance of cotton + sesame (1:1) intercropping system

Farming situation/ soil type	Intervention	CEY		LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2018-19	Mean (5 years)				
Rainfed/ medium black	Cotton + sesame (1:1)	2850	2711	1.29	80670	2.47	4.52
	Farmers' practice (sole cotton)	2213	2195	-	63150	2.36	3.66

CEY: Cotton 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). Centre for Natural Resource Management, S. D. Agricultural University, Sardarkrushinagar, Taluka – Dantiwada, District – Banaskantha, geographically located in North Gujarat at 24°19' North latitude, 72°19' East longitude and 154.52 meter above mean sea level. The overall climate varies from arid to semi-arid. Summer is very hot and winter is cool and dry. The mean annual rainfall ranges from 328 mm (2018) to 2083 mm (2017) with an average annual rainfall is 692.8 mm. Rainfall is inadequate, uncertain and erratic as well as the soil is loamy sand in texture with low moisture retention capacity. The dry farming in such soils of North Gujarat is unassured and unpredicted.

b. On-station experiments

Experienced weather conditions during 2018-19

During 2018, the onset of monsoon was delayed by 5 days (30th June). A rainfall of 327.9 mm was received which was deficit by 364.9 mm (52.7%) compared to normal (692.8 mm) (Fig.18). During south-west monsoon, a rainfall of 327.9 mm was received which was deficit by 52.7% mm than normal crop seasonal rainfall. Terminal drought in different crops occurred due to early withdrawal of monsoon.

Normal onset of monsoon	25 June
Onset of monsoon during 2018	30 June
Annual mean rainfall	692.8 mm
Annual rainfall during 2018-19	327.9 mm
Mean crop seasonal rainfall	625.2 mm
Crop seasonal rainfall during 2018-19	327.9 mm

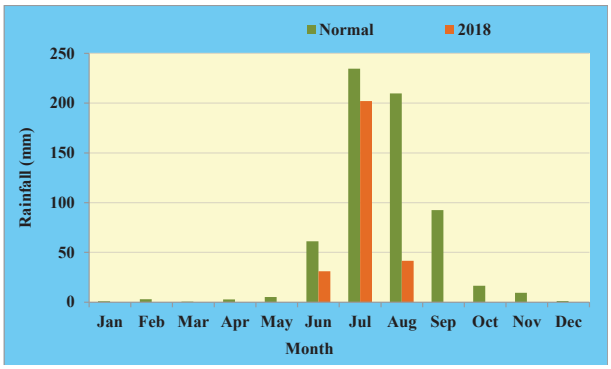


Fig.18: Normal and actual (2018) monthly rainfall at SK Nagar

Dry spells during crop growing season (2018-19)

Dry spell		Crops	Stage of the crop
Duration (days)	Dates & months		
23	24 July - 16 August	Cereals, pulses and castor	Tillering and flowering
62	30 August onwards	Cereals, pulses and castor	Flowering, pod filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Midseason drought	Pearlmillet	Flowering	Foliar spray
Terminal drought	Castor	Flowering till maturity	Life saving irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During 2018, a dry spell of 23 days occurred during 24 July to 16 August and again no rainfall from 30 August till harvesting of the crop affecting flowering and grain filling of pearlmillet. Foliar application of water soluble complex fertilizer (19:19:19) @ 0.5% + foliar spray of $ZnSO_4$ @ 0.5% recorded significantly higher grain yield (1383 kg/ha), net returns (Rs. 25411/ha), B:C ratio (3.03) and RWUE (4.22 kg/ha-mm) both during tillering and flowering stages as compared to other treatments (Table 63).

Table 63: 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)
	Grain	Dry fodder				
Time of foliar sprays						
Tillering stage	1107	2462	12153	18451	2.52	3.37
Flowering stage	1019	2309	12153	16189	2.33	3.11
Tillering and flowering stages	1300	2945	12153	23762	2.92	3.96
CD at 5%	178.48	343.13				
Nutrients						
Urea @ 2.0%	998	2303	11996	15928	2.32	3.04
Water soluble complex fertilizer (19:19:19) @ 0.5%	1026	2389	12345	16448	2.33	3.13
Foliar spray of $ZnSO_4$ @ 0.5%	1161	2597	12079	20077	2.66	3.54
Water soluble complex fertilizer (19:19:19) @ 0.5% + foliar spray of $ZnSO_4$ @ 0.5%	1383	2998	12512	25411	3.03	4.22
CD at 5%	206	396				

Pearlmillet with spray of water soluble complex fertilizer (19:19:19) and ZnSO4 @ 0.5% at tillering and flowering stages

Situation: Terminal drought

During 2018, terminal drought occurred due to early withdrawal of monsoon affecting the seed filling and maturity of castor affecting the branching and flowering stages of castor. Application of two lifesaving irrigations (50 mm each) from harvested rainwater from farm pond to castor during flowering to capsule development recorded significantly highest seed and stalk yields (1093 and 2475 kg/ha) with maximum net returns (Rs.41628/ha), B:C ratio (2.92) and RWUE (3.33 kg/ha-mm) followed by two lifesaving irrigations (25 mm each) (995 and 2251 kg/ha) compared to control (Table 64).

Table 64: Effect of supplemental irrigation on yield and economics of castor (GCH 7)

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2018-19)	Mean seed (2017-19)	Stalk				
Control (no life saving irrigation	721	823	1618	10350	26486	2.56	2.20
One life saving irrigation (25 mm)	869	987	1959	11850	32557	2.75	2.65
Two lifesaving irrigations (25 mm each)	995	1127	2251	13250	37640	2.84	3.04
One life saving irrigation (50 mm)	920	1037	2022	12350	34676	2.81	2.81
Two lifesaving irrigations (50 mm each)	1093	1260	2475	14250	41628	2.92	3.33
Alternate furrow irrigation (50 mm)	873	1007	1984	11800	32819	2.78	2.66
CD at 5%	162.6	-	436.9	-			

Two life saving irrigations (25 mm each)

Two life saving irrigations (50 mm each)

Control

Performance of castor under different treatments

c. On farm demonstrations

Village profile

The program is being implemented in Kalimati/ Dholiya village, taluka Amirgadh, Banaskantha district, Gujarat located in North Gujarat at 24°36'7.40'' North latitude, 72°59'33.65'' East longitude and 216 meter above mean sea level. The overall climate varies from arid to semi-arid. The rainfall is inadequate, uncertain and erratic in nature. The average annual rainfall varies from 383 mm (2018) to 1393 mm (2017). 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. The new village is Ghanghu, District Banaskanta, located in North Gujarat at 24°35'6.94'' North latitude, 72°60'78.71'' East longitude and 225 meter above mean sea level.

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, cluster bean, maize, castor, cotton etc.

Experienced weather conditions during 2018-19

During 2018, in Kalimati village, onset of monsoon was 2 days early (22nd June). A total rainfall of 383 mm was received which was deficit by 480.0 mm (55.6%) compared to normal (863.8 mm). Out of total rainfall, crop seasonal rainfall was 383.0 mm which was deficit by 477.4 mm (55.5%) than normal of 860.4 mm (Fig 19).

Normal onset of monsoon	25 June
Onset of monsoon during 2018	22 June
Annual mean rainfall	863.8 mm
Annual rainfall during 2018-19	383.0 mm
Mean crop seasonal rainfall	860.4 mm
Crop seasonal rainfallduring2018-19	383.0 mm

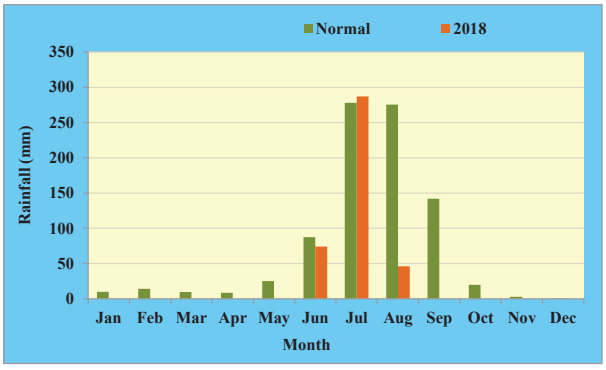


Fig.19: Normal and actual (2018) monthly rainfall at Kalamati

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
23	23 July - 14 August	Pearlmillet, sorghum, maize	Vegetative and flowering
57	4 September onwards	Pulses, castor	Flowering, pod filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	Crop	RTCP implemented
Kalimati/Dholiya village			
Terminal drought	Sandy loam to clay	Castor	Supplemental irrigation
Ghanghuvillage			
Terminal drought	Sandy loam to clay	Castor	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

Terminal drought occurred at Kalimati/Dholiya village due to early withdrawal of monsoon affecting branching and flowering of castor. Supplemental irrigation (30 mm depth each) twice (on 18.10.2018 & 14.12.2018) through micro-irrigation (MIS) after flowering to capsule development in castor from harvested rainwater in farm pond gave 27.1% higher seed yield (1134 kg/ha) and stalk yield (2555 kg/ha) compared to farmers' practice of no supplemental irrigation (892 kg/ha), with highest net returns (Rs. 41528/ha), B:C ratio (2.52) and WUE (2.96 kg/ha-mm) (Table 65).

Table 65: Effect of supplemental irrigation on yield and economics of castor

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Seed (2018)	Mean seed (2014-19)	Stalk			
Supplemental irrigation	1134	1445	2555	41528	2.52	2.96
No supplemental irrigation	892	949	1916	32108	2.39	2.33

Castor with supplemental irrigation

Castor without supplemental irrigation

Terminal drought occurred at Ghanghu village due to early withdrawal of monsoon affecting branching and flowering of castor. Supplemental irrigation (30 mm depth each) twice (on 18.10.2018 & 14.12.2018) through micro-irrigation (MIS) after flowering to capsule development in castor from harvested rainwater in farm pond recorded 29.4% significantly higher seed and stalk yields (1109 & 2519 kg/ha, respectively) compared to farmers' practice of no supplemental irrigation (857 kg/ha), with highest net returns (Rs. 40260/ha), B:C ratio (2.45) and WUE (2.90 kg/ha-mm) (Table 66).

Table 66: Effect of supplemental irrigation on yield and economics of castor

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Seed (2018)	Mean seed (2017-19)	Stalk			
Supplemental irrigation	1109	1526	2519	40260	2.45	2.90
Local practice	857	1126	1884	30342	2.26	2.24

Castor with supplemental irrigation

Castor without supplemental irrigation

Preparedness

Rainwater management

At Kalimati/Dholiya village, *in-situ* moisture conservation in castor with ridge and furrow system recorded higher grain and stalk yield (1029 and 2377 kg/ha) compared to flat bed method (816 kg/ha) with higher net returns (Rs. 40009/ha), B:C ratio (3.17) and RWUE (2.69 kg/ha-mm) (Table 67).

Table 67: Effect of *in-situ* moisture conservation on yield and economics of castor

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2018)	Mean seed yield (2011-19)	Stalk			
Ridge & furrow method	1029	1224	2377	40009	3.17	2.69
Flat bed method	816	874	1797	30249	2.64	2.13

Castor under ridge & furrow method

Castor under flat bed method

At Kalimati/Dholiya village, *in-situ* moisture conservation in pearlmillet with compartmental bunding recorded higher grain and fodder yield (962 and 2639 kg/ha) compared to no compartmental bunding (718 kg/ha), with higher net returns (Rs. 18844/ha), B:C ratio (1.93) and RWUE (2.51 kg/ha-mm) (Table 68).

Table 68: Effect of *in-situ* moisture conservation on yield and economics of pearlmillet

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain (2018)	Mean grain (2011-19)	Fodder			
Compartmental bunding	962	1465	2639	18844	1.93	2.51
No compartmental bunding	718	1025	1907	12041	1.33	1.87

Pearlmillet under compartmental bunding

Pearlmillet under flat bed method

At Ghanghu village, *in-situ* moisture conservation with ridge and furrow system in castor recorded higher seed and stalk yield (1080 and 2598 kg/ha) compared to local practice of flat bed method (798 kg/ha) with higher net returns (Rs. 42669/ ha), B:C ratio (3.38) and RWUE (2.82 kg/ha-mm) (Table 69).

Table 69: Effect of *in-situ* moisture conservation on yield and economics of castor

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2018)	Mean seed yield (2017-19)	Stalk			
Ridge & furrow method	1080	1292	2598	42669	3.38	2.82
Flat bed method	798	1049	2111	29506	2.58	2.08

Castor under ridge & furrow method

Castor under flat bed method

At Ghanghu village, *in-situ* moisture conservation in pearlmillet with compartmental bunding recorded higher grain and fodder yield (958 and 2595 kg/ha) compared to local practice of no compartmental bunding (888 kg/ha), with higher net returns (Rs. 18593/ha), B:C ratio (1.91) and RWUE (2.50 kg/ha-mm) (Table 70).

Table 70: Effect of *in-situ* moisture conservation on yield and economics of pearlmillet

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain (2018)	Mean grain (2017-19)	Fodder			
Compartmental bunding	958	1099	2595	18593	1.91	2.50
Local practice	888	986	2394	17176	1.90	2.32

Cropping systems

At Kalimati/Dholiya village, castor hybrid GCH 7 recorded higher seed (908 kg/ha) and stalk (1443 kg/ha) yields over GCH 5 and local variety (GHC 4), withhigher net returns (Rs.31362/ha), B:C ratio (2.12) and RWUE (2.37 kg/ha-mm). Pearlmillet hybrid GHB 558 recorded higher grain (558 kg/ha) and stover (2666 kg/ha) yields over GHB 538 and local variety (GHB 744), with higher net returns (Rs.16858/ha), B:C ratio (1.75) and RWUE (2.21 kg/ha-mm). Greengram variety GM4 recorded higher seed (474 kg/ha) and stover (1043 kg/ha) yields over local variety (K 851), with higher net returns (Rs.18179/ha), B:C ratio (2.10) and RWUE (1.24 kg/ha-mm). Cluster bean variety Gujarat Guar 2 recorded higher seed (457kg/ha) and stover (1106 kg/ha) yields over local variety (GG 1), with higher net returns (Rs.14348/ha), B:C ratio (1.98) and RWUE (1.19 kg/ha-mm). Black gram variety GU 1 recorded higher seed (515 kg/ha) and stover (1457 kg/ha) yields over local variety (T9), with higher net returns (Rs.16321/ha), B:C ratio (1.89) and RWUE (1.34 kg/ha-mm). Sorghum fodder variety GJ 39 recorded higher fodder yield (6995 kg/ha) over

local variety (Sindhiya), with higher net returns (Rs.13635/ha), B:C ratio (1.86) and RWUE (18.26 kg/ha-mm) (Table 71).

Table 71: Performance of varieties/hybrids of different crops

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain/seed	Fodder/stalk			
Castor	GCH 5	736	1257	1.92	22669	1.54
	GCH 7	908	1443	2.37	31362	2.12
	Local (GHC 4)	602	903	1.57	16102	1.11
Pearl millet	GHB 558	845	2666	2.21	16858	1.75
	GHB 538	711	2359	1.86	13117	1.36
	Local (GHB 744)	638	2081	1.67	10937	1.17
Green gram	GM 4	474	1043	1.24	18179	2.10
	Local (K851)	365	862	0.95	12486	1.50
Cluster bean	GG 2	457	1106	1.19	14348	1.98
	Local (GG1)	316	889	0.83	8637	1.29
Black gram	GU 1	515	1457	1.34	16321	1.89
	Local (T9)	404	1209	1.05	11957	1.53
Sorghum	GJ 39	-	6995	18.26	13635	1.86
	Local (Sindhiya)		5821	15.20	9903	1.31

Castor cv. GCH 5

Castor cv. GCH 7

Local variety (GCH 4)

Greengram var. GM 4

Local check (K 851)

Blackgram var. GU 1

Local check (T 9)

Intercropping system (1:1) of castor + greengram (GCH 7 + Gujarat Mung 4) at Kalimati Dholiya recorded 44.4% higher castor equivalent yield (1232 kg/ha), with higher net returns (Rs. 43060 kg/ha) B:C ratio (2.32) and RWUE (3.22 kg/ha-mm) compared to sole castor (815 kg/ha) (Table 72).

Table 72: Performance of castor + greengram intercropping system (1:1)

Farming situation/ soil type	Intervention	CEY		LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2018-19	Mean (2011-19)				
Loamy sand	Castor + greengram (1:1)	1232	1599	1.44	43060	2.32	3.22
	Castor sole	815	1079	-	27375	1.79	2.23

CEY: Castor equivalent yield

Castor + greengram intercropping (1:1)

Castor sole

At Ghanghu village, pearlmillet hybrid GHB 558 recorded higher grain (884 kg/ha) and fodder (2457 kg/ha) yields over GHB 538 and local variety (GHB 744), with higher net returns (Rs.16753/ ha), B:C ratio (1.74) and RWUE (2.31 kg/ha-mm). Greengram variety Gujrat Mung (GM4) recorded higher seed (517 kg/ha) and stover (1202 kg/ha) yields over local variety (K 851), with higher net returns (Rs.20506/ha), B:C ratio (2.41) and RWUE (0.91 kg/ha-mm). Cluster bean variety Gujarat Guar 2 variety recorded higher grain (398 kg/ha) and stover (1053 kg/ha) yields over local variety (GG 1), with higher net returns (Rs.11829/ha), B:C ratio (1.63) and RWUE (1.04 kg/ha-mm). Black gram variety GU1 recorded higher seed (590 kg/ha) and stover (1222 kg/ha) yields over local variety (T9), with higher net returns (Rs.18616/ha), B:C ratio (2.15) and RWUE (1.54 kg/ha-mm) (Table 73).

Table 73: Performance of varieties of different crops

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain/seed	Fodder/stalk			
Pearl millet	GHB 558	884	2457	2.31	16753	1.74
	GHB 538	691	2276	1.80	12410	1.29
	Local (GHB744)	604	1882	1.58	9503	1.02
Green gram	GM 4	517	1202	1.35	20806	2.41
	Local (K851)	364	890	0.95	12520	1.50
Cluster bean	GG 2	398	1053	1.04	11829	1.63
	Local (GG1)	291	710	0.76	7100	1.06
Black gram	GU 1	590	1222	1.54	18616	2.15
	Local (T 9)	368	1015	0.96	9935	1.27

Clusterbean var.GG 2

Local check (GG 1)

Blackgram var. GU 1

Local check (T 9)

Intercropping system (1:1) of castor + greengram (GCH 7 + Gujarat Mung 4) at Ghanghu village recorded 33.1% higher castor equivalent yield (1122 kg/ha), with higher net returns (Rs. 37584 kg/ha), B:C ratio (2.03), RWUE (2.93 kg/ha-mm) compared to sole crop of castor (804 kg/ha) (Table 74)

Table 74: Performance of castor + greengram intercropping system (1:1)

Farming situation/ soil type	Intervention	CEY		LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2018-19	Mean (2017-19)				
Loamy sand	Castor + greengram (1:1)	1122	1470	1.33	37584	2.03	2.93
	Castor sole	843	1031		26853	1.76	2.20

CEY: Castor equivalent yield

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 2018-19

During 2018, the onset of monsoon was normal (3 June). An annual rainfall of 626.6 mm was received which was deficit by 94.8 mm (13.1%) compared to normal rainfall of 721.4 mm. During *kharif*, 479.0 mm rainfall was recorded against normal of 535.1 mm. *Rabi* season recorded 78.6 mm, which was deficit by 46.9 mm compared to normal rainfall of 125.5 mm (Fig.20)

Normal onset of monsoon	7 June
Onset of monsoon during 2018	3 June
Annual mean rainfall	721.4 mm
Annual mean rainfall during 2018-19	626.6 mm
Mean crop seasonal rainfall during	535.1mm &125.5mm during *kharif* & *rabi*, respectively
Crop seasonal rainfall during 2018-19	479.0 mm & 78.6 mm during *kharif* & *rabi*, respectively

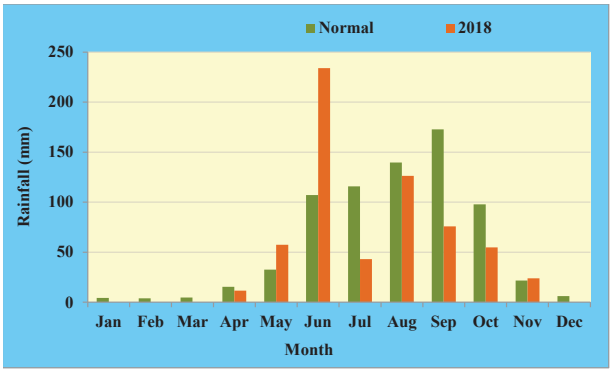


Fig. 20: Normal and actual (2018) monthly rainfall at Solapur

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
9	31 June - 8 July	Pigeonpea, sunflower, pearlmillet, blackgram	Early growth
15	29 July - 12 August	Pigeonpea, sunflower, pearlmillet, blackgram	Vegetative
12	04-15 September	Pigeonpea	Flowering & pod development
9	18-26 September	Sorghum, chickpea	Early growth
11	06-16 October	Sorghum, chickpea	Vegetative
26	25 October - 19 November	Sorghum, chickpea	Flowering & grain development

Real time contingency practices (RTPC) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Sunflower	Flowering	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

A dry spell occurred during 29 July to 12 August (15 days) coinciding with flowering stage in sunflower. Foliar sprays in sunflower (var. Phule Bhaskar) during dry spell recorded significantly higher seed (1613 kg/ha) and stalk (3868 kg/ha) yields with higher net returns (Rs.29101/ha), B:C ratio (2.81) and RWUE (5.87 kg/ha-mm) as compared to the foliar sprays after relieving dry spells. Among different foliar sprays in sunflower, water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 0.5% recorded significantly higher seed (1745 kg/ha) and stalk (4999 kg/ha) yield, net returns (Rs.32639/ha), B:C ratio (3.01) and RWUE (6.35 kg/ha-mm) as compared to other treatments (Table 75).

Table 75: Effect of foliar spray on yield and economics of sunflower

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Main plot						
Foliar spray during dryspell	1613	3868	16072	29101	2.81	5.87
Foliar spray after relieving dryspell	1028	3664	16072	12715	1.79	3.74
CD at 5%	459	100	-	6170	-	-
Sub plot						
Urea @ 1%	1249	3368	16030	18956	2.18	4.55
Urea @ 2%	1224	3706	16060	18207	2.13	4.45
Water soluble complex fertilizer (19:19:19) @ 0.5%	1417	4086	16069	23597	2.47	5.15

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 0.5%	1745	4999	16207	32639	3.01	6.35
$FeSO_4$ @ 0.5%	1383	4261	16138	22577	2.39	5.03
Water spray	1192	3013	16000	17352	2.08	4.33
Control (no spray of any material/water)	1036	2929	16000	13026	1.81	3.77
CD at 5%	198	169	-	5568	0.35	-

Recommended dose of 50:25:25, N: P_2O_5: K_2O kg/ha + 2.5 t FYM/ha given at the time of sowing to all treatments

c. On-farm demonstrations

Village profile

The programme is being implemented in Narotewadi village, North Solapur Tehsil in Solapur district. The total cultivated area is 560.7 ha out of which 450 ha is rainfed. The mean annual rainfall is 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 clay loam. 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 semiarid. 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 southwest 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 2018-19

During 2018, in Narotewadi village, the onset of monsoon was timely and a rainfall of 256.6 mm was received which was deficit by 466.9 mm compared to normal (723.5 mm) (Fig.21). During *kharif* and *rabi* seasons, 204.4 mm and 32.5 mm of rainfall was recorded which was deficit by 216.3 and 205.3 mm as compared to normal rainfall (420.7 and 237.8, mm respectively).

Normal onset of monsoon	7 June
Onset of monsoon during 2018	3 June
Annual mean rainfall	723.5 mm
Annual mean rainfall during 2018-19	256.6 mm
Mean crop seasonal rainfall during	420.7 mm and 237.8 mm *kharif* & *rabi*, respectively
Crop seasonal rainfall during 2018-19	204.4 mm and 32.5 mm *kharif* & *rabi*, respectively

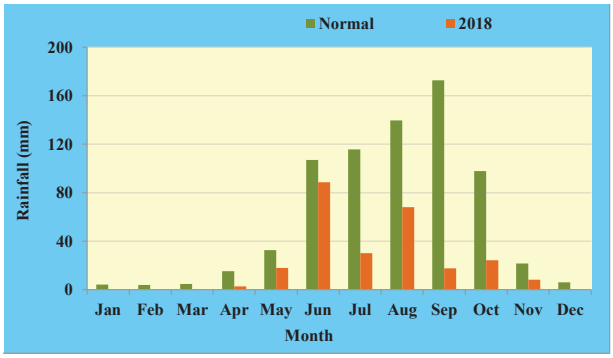


Fig. 21: Normal and actual (2018) monthly rainfall at Narotewadi

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	28 June - 09 July	Blackgram, pearlmillet & pigeonpea	Early vegetative
22	18 July - 09 August	Blackgram, pearlmillet & pigeonpea	Flowering
17	28 August - 13 September	Blackgram, pearlmillet & pigeonpea	Seed filling and maturity
71	21 September - 30 November	Chickpea, *rabi* sorghum	All stages of crop
		pigeonpea	Seed filling

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Blackgram	Vegetative	Intercultivation
Mid season & terminal drought	Sorghum, chickpea	Flowering & seed filling	Supplemental irrigation, foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

Intercultivation with cycle hoe at 30 DAS increased the yield of blackgram (TPU-1) by 23.8% with higher net returns (Rs. 22850/ha), B:C ratio (2.42) and RWUE (4.72 kg/ha-mm) over farmers' practice of no weeding and intercultural operations (Table 76).

Table 76: Effect of weeding / intercultivation on yield and economics of blackgram

Farming situation/ soil type	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium black soil	Weeding/ interculture	925	4.72	22850	2.42
	Farmers' practice	710	3.62	14820	1.98

Farmers' practice: No weeding/interculture

Two supplemental irrigations of 6 cm depth at primordial (28-30 DAS) and grain filling stages (90-95 DAS) increased the grain yield (1320 kg/ha) of sorghum (cv. PhuleVasudha) by 34.9% with higher net returns (Rs.23800/ha), B:C ratio (1.82) and WUE (8.56 kg/ha-mm) over farmers' practice of no supplemental irrigation (Table 77).

Table 77: Effect of supplemental irrigation on yield and economics of *rabi* sorghum

Farming situation	Intervention	Seed yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium black soil	Supplemental irrigation at critical growth stages	1320	8.56	23800	1.82
	Farmers' practice (no supplemental irrigation)	860	5.58	5400	1.80

Chickpea without supplemental irrigation

Two supplemental irrigations of 6 cm depth at branching(30-35 DAS) and pod filling stages (60-65 DAS) increased the seed yield (911kg/ha) of chickpea (cv. Phule Digvijay) by 53.8% with higher net returns (Rs.24995/ha), B:C ratio (2.56) and WUE (5.35 kg/ha-mm) over farmers' practice of no supplemental irrigation (Table 78).

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

Farming situation/ soil type	Intervention	Seed yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium black soil	Supplemental irrigation	911	5.35	24995	2.56
	Farmers' practice (no supplemental irrigation)	421	2.73	18945	1.35

Chickpea with two supplemental irrigations

Foliar application of potassium nitrate @ 1% at flowering stage during dry spells increased the seed yield (675 kg/ha) of chickpea (Digvijay) by 37.8% with higher net returns (Rs.14375/ha), B:C ratio (1.89) and RWUE (13.47 kg/ha-mm) over farmers' practice of no foliar spray (Table 79).

Table 79: Effect of foliar spray of potassium nitrate on yield and economics of chickpea

Farming situation	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium black soil	Foliar spray of potassium nitrate @ 1%	675	13.47	14375	1.89
	Farmers' practice (no foliar spray)	422	8.42	4990	1.35

Preparedness

Rainwater management

Opening of ridges and furrows in *kharif* followed by *rabi* sorghum increased the grain yield of *rabi* sorghum (880 kg/ha) by 35.4% with higher net returns (Rs.17450/ha), B:C ratio (1.69) and RWUE (5.71 kg/ha-mm) over farmers' practice of two harrowings during *kharif* season followed by *rabi* sorghum (650 kg/ha) (Table 80).

Table 80: Effect of *in-situ* moisture conservation on yield and economics of *rabi* sorghum

Farming situation	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain	Stover				
Medium to deep black soil	Ridges and furrows in *kharif* followed by *rabi* sorghum	880	1980	25100	17450	1.69	5.71
	Two harrowings (Farmers' practice)	650	1220	24600	5937	1.24	4.22

Opening of ridges and furrows on fallow land in *Kharif*

Rabi sorghum (Cv.Phule Vasudha)

Cropping systems

Intercropping of pigeonpea + soybean (1:3) recorded higher pigeonpea equivalent yield (2977 kg/ha), net returns (Rs.23095/ha), B:C ratio (1.52) and RWUE of 6.62 kg/ha-mm with higher LER (1.24) compared to sole pigeonpea (Table 81).

Table 81: Performance of pigeonpea + soybean intercropping system (1:3)

Farming situation/ soil type	Intervention	Yield (kg/ha)			LER	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Intercrop	MCEY					
Medium black soil	Pigeonpea + soybean (1:3)	735	889	2977	1.24	44000	23095	1.52	6.62
	Sole pigeonpea (farmers' practice)	1002	-	1002	1.00	40000	15110	1.37	4.08

LER: Land equivalent ratio; MCEY: Main crop equivalent yield

Double cropping system of blackgram followed by *rabi* sorghum recorded main crop equivalent yield of 1666 kg/ha as compared to farmers practice of sole cropping (610 kg/ha), with higher net returns (Rs.39620/ha), B:C ratio (2.23) and RWUE (3.56 kg/ha-mm) (Table 82).

Table 82: Performance of blackgram – *rabi* sorghum double cropping system

Farming situation/ soil type	Intervention	Yield (kg/ha)		MCEY	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Crop 1	Crop 2					
Medium black soil	Blackgram - sorghum	810	940	1666	32000	39620	2.23	3.56
	Blackgram sole	610	-	610	14000	11620	1.83	2.48

MCEY: Main crop equivalent yield (blackgram)

Energy management

Sowing of *rabi* sorghum with two bowl fertilizer seed drill gave 18% higher grain yield compared to farmers' practice of sowing with single bowl seed drill, with higher net returns (Rs. 6940/ha) and B:C ratio (1.27). The energy use efficiency was also higher (1.89) due to sowing with two bowl fertilizer seed drill over farmers' practice i.e., sowing with single bowl seed drill in *rabi* sorghum (Table 83).

Sowing of *rabi* sorghum with two bowl ferti-seed drill

Table 83: Effect of two bowl fertilizer seed drill on crop yield and economics of *rabi* sorghum

Farming situation	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Field efficiency (hr/ha)	Energy		Energy use efficiency
		Grain	Stover						Input	Output	
Medium black soil	Sowing with two bowl fertilizer seed drill	720	1368	25100	6940	1.27	4.67	5.5	14652	27684	1.89
	Sowing with local seed drill	610	1040	24600	1950	1.07	3.96	5.0	14172	21967	1.55

Alternate land use

Anola + pearlmillet system recorded higher anola fruit yield (2000 kg/ha) and pearlmillet grain yield (1139 kg/ha) with net returns of Rs. 27229/ha, B:C ratio of 1.87 and RWUE of 8.14 kg/ha-mm as compared to farmers' practice (sole anola) (1500 kg/ha) (Table 84).

Table 84: Performance of anola + pearlmillet system

Farming situation	Intervention	Yield (kg/ha)				Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Aonla	Inter crop	Stover yield	MCEY				
Medium Black Soil	Anola + pearl-millet	2000	1139	2562	2511	31000	27229	1.87	8.14
	Farmers' practice* (Sole anola)	1500	-	-	1500	18000	15000	1.66	6.10

MCEY: Main crop equivalent yield

Anola + pearlmillet system

Sole pearlmillet

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 2018-19

During 2018, the onset of monsoon was normal (7th June), and a rainfall of 466.3 mm was received which was deficit by 128.0 mm (21.5%) compared to normal (594.3 mm). Out of total rainfall, *kharif* season (June- September) recorded 295.5 mm which was deficit by 92 mm (23.7%) than seasonal normal of 387.5 mm. During *rabi*, it was 37.8 mm which was deficit by 96.2 mm (71.8%) than normal (134.0 mm) (Fig.22).

Normal onset of monsoon	7 June
Onset of monsoon during 2018	7 June
Annual mean rainfall	594.3 mm
Annual rainfall during 2018-19	466.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	*kharif* 387.5 mm and *rabi* 134.0 mm
Crop seasonal rainfall during 2018-19 (*kharif* & *rabi*)	*kharif* 295.5 mm and *rabi* 37.8 mm

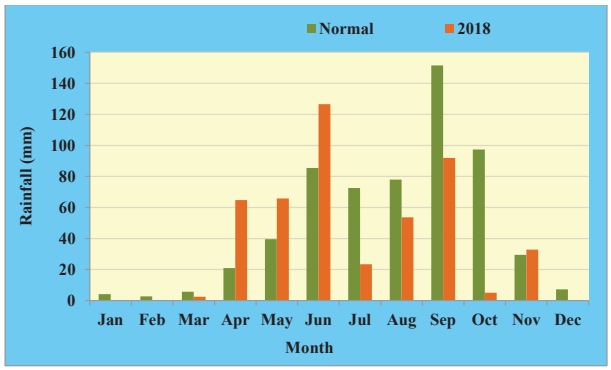


Fig.22: Normal and actual (2018) monthly rainfall at Vijayapura

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
19	10–28 June	Pigeonpea, pearl millet and greengram	Seedling and vegetative
11	2 – 12 July	Pigeonpea, pearlmillet and greengram	Vegetative
15	21 July - 1 August	Pigeonpea, pearlmillet and greengram	Vegetative, grand growth and flowering
50	30 September - 18 November	Sunflower, pigeonpea, *rabi* sorghum,chickpea and safflower	Seedling , vegetative and flowering
42	20 November - 31 December	Sunflower, pigeonpea , *rabi* sorghum,chickpea and safflower	Flowering and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season and terminal drought	Chickpea	Foliar spray, supplemental irrigation and mulching

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During 2018, a dry spell of 50 days occurred during 30 September -18 November affecting the vegetative and flowering stage of chickpea. Foliar application of water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% recorded significantly higher seed yield (511 kg/ha), net returns (Rs. 9572/ha), B:C ratio (1.71) and RWUE (6.38 kg/ha-mm compared to control (Table ….). There was no significant difference between foliar spray during dry spell and after relieving of stress / dry spell on crop yield (Table 85).

Table 85: Effect of foliar spray on chickpea yield and economics

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2018-19)	Mean seed (2 years)	Stover (2018-19)				
Main plot							
Foliar spray during dry spell	409	863	916	13212	5176	1.39	5.11
Foliar spray after relieving of stress / dry spell	441	911	963	13212	6631	1.50	5.51
CD at 5%	NS	NS	NS	-	NS	NS	NS
Sub-plot							
Urea @ 1%	413	837	946	13145	5414	1.41	5.16
Urea @ 2%	401	847	902	13245	4794	1.36	5.01
Water soluble complex fertilizer (19:19:19) @ 0.5%	463	983	1033	13245	7584	1.57	5.78
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	511	1051	1147	13605	9572	1.71	6.38
$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	434	939	917	13405	6207	1.47	5.42
Water spray	382	802	836	13045	4069	1.31	4.78
Control (no spray of any material/water)	371	751	795	12795	3684	1.28	4.64
CD at 5%	66	118	96	-	2950	0.22	0.82

Chickpea with water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%

Chickpea under control (no spray)

Situation: Terminal drought

During 2018, a dry spell of 50 days occurred during 30 September to 18 November and 20 November to 31 December affecting the flowering and maturity stage of chickpea. Application of one irrigation of 3 cm with sprinklers at critical stage (flowering) along with pearlmillet straw mulching recorded significantly higher seed yield (510 kg/ha), net returns (Rs.22967/ha) and B:C ratio (2.30) compared to other treatments (Table 86).

Table 86: Effect of critical irrigation and mulching on chickpea yield and economics

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Seed	Stover			
Irrigation at critical stage + mulch	510	806	12952	2.30	4.77
Irrigation at critical stage	330	473	5828	1.65	3.08
Irrigation after more than 20 days dry spell + mulch	377	521	7966	1.89	3.52
Irrigation after more than 20 day dry spell	340	448	6810	1.80	3.18
Control	218	265	1793	1.22	2.03
CD at 5%	87	125	3903	0.44	0.81

Irrigation at critical stage + mulching in chickpea

Control

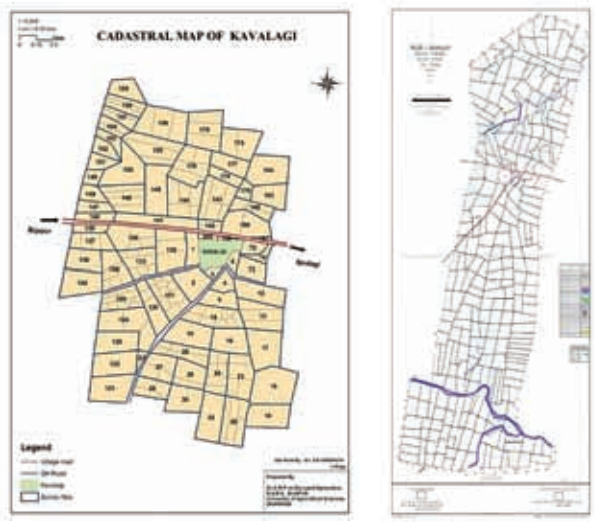
c. On-farm demonstrations

Village profile

The program is being implemented in Kavalagi village, Vijayapura tehsil and Honnutagi Vijayapura 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.

The village Kavalagi is located 15 km East of Vijayapura town (16^{0}48' N and 75^{0}45' E). The new village Honnutagi is located 17 km East of Vijayapura town (75^0 50' 11.3'' to 75^0 52' 52.5''E and 16^o 45' 46.5" to 16^0 51' 18.6'' N).



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 2018-19

During 2018, in Kavalagi village the onset of monsoon was early by 3 days (4 June). An annual rainfall of 270.3 mm was received which was deficit by 324.1 mm (54.5%) than normal (594.3 mm). During *kharif*, there was a rainfall of 180.2 mm, deficit by 207.3 mm (53.5%) than normal (387.5 mm) and in *rabi* season 80 mm rainfall was recorded which was deficit by 4.0 mm (97.0%) against normal of 134.0 mm (Fig.23).

Normal onset of monsoon	7 June
Onset of monsoon during 2018	4 June
Annual mean rainfall (mm)	594.3 mm
Annual mean rainfall (mm) during 2018-19	270.3 mm
Mean crop seasonal rainfall (mm) during *kharif* and *rabi*	387.5 mm &134.0 mm, respectively
Crop seasonal rainfall (mm) during *kharif* and *rabi* 2018-19	180.2 mm & 4.0 mm, respectively

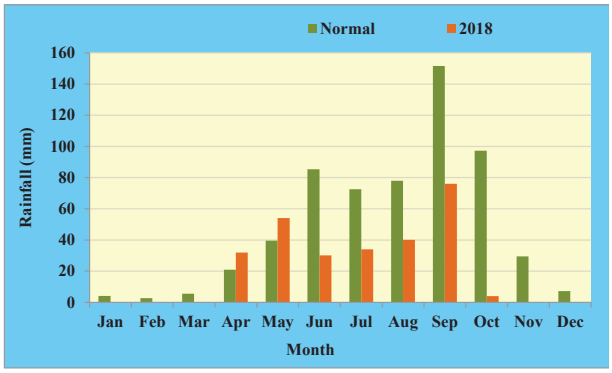


Fig.23: Normal and actual (2018) monthly rainfall at Kavalagi

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
23	9 June - 1 July	Pigeonpea, greengram and pearlmillet	Vegetative
40	7 July - 15 August	Pigeonpea	Vegetative
		Greengram and pearlmillet	Vegetative to flowering
10	17 August - 26 August	Pigeonpea	Vegetative
20	28 August - 16 September	Pigeonpea	Vegetative
21	26 September - 16 October	Pigeonpea	Vegetative – flowering
74	18 October - 31 December	Pigeonpea	Flowering – maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	Crop	RTCP implemented
Village: Honnutagi			
Early season drought	Rainfed/shallow and medium black soil	Pigeonpea	Thinning
			Intercultivation
		Greengram	Intercultivation
	Rainfed/ medium deep black soil	Chickpea, sorghum	Intercultivation
Mid season drought	Rainfed/shallow and medium black soil	Pigeonpea, greengram	Foliar spray of KNO_3 @ 0.5%
	Rainfed/ medium deep black soil	Chickpea, sorghum	Foliar spray of KNO_3 @ 0.5%
	Rainfed/shallow and medium black soil	Pigeonpea, greengram	Protective irrigation
Village: Kavalagi			
Early season drought	Rainfed/shallow and medium black soil	Pigeonpea, greengram	Intercultivation
	Rainfed/ medium deep black soil	Chickpea	Intercultivation
Mid season drought	Rainfed/shallow and medium black soil	Pigeonpea, greengram	Foliar spray of KNO_3 @ 0.5%
	Rainfed/ medium deep black soil	Chickpea	Foliar spray of KNO_3 @ 0.5%
	Rainfed/shallow and medium black soil	Chickpea	Protective irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During 2018, a dry spell of 23 days occurred during 9 June - 1 July coinciding with vegetative stage of *kharif* crops. Further, a dry spell of 20 days during 26 September – 16 October occurred during early vegetative stage of *rabi* crops. Weeding and Intercultivation with bullock drawn hoe increased the yield of pigeonpea, chickpea, safflower and *rabi* sorghum by 16 to 23% as compared to farmers' practice of no weeding and intercultivation. Among the crops, chickpea gave higher net returns (Rs.14469/ha), RWUE (6.80 kg/ ha-mm) and B:C ratio (2.45) compared to other crops (Tables 87 & 88).

Table 87: Effect of weeding / intercultivation on pigeonpea yield and economics

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Honnutagi	Rainfed / medium deep black soil	Weeding / interculture	625	3.39	22000	2.42
		Farmers' practice*	513	2.78	16250	2.12
	Rainfed / shallow black soil	Weeding / interculture	588	3.19	19525	2.24
		Farmers' practice*	483	2.62	14450	2.00
Kavalagi	Rainfed / medium deep black soil	Weeding / interculture	738	4.00	28750	2.85
		Farmers' practice*	600	3.26	21500	2.32

*Farmers' practice: No interculture operation

Weeding/interculture in pigeonpea

Farmers' practice (no weeding/ intercultivation)

Table 88: Effect of weeding / interculture on yield and economics of different crops

Crop	Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Greengram	Honnutagi	Rainfed / medium deep black soil	Weeding / interculture	215	2.06	4400	1.52
			Farmers' practice*	185	1.78	2600	1.31
	Kavalagi	Rainfed / medium deep black soil	Weeding / interculture	225	2.16	5000	1.59
			Farmers' practice*	188	1.80	2750	1.32
Chickpea	Honnutagi	Rainfed / medium deep black soil	Weeding / interculture	544	6.80	14469	2.45
			Farmers' practice*	456	5.70	9250	2.03
	Kavalagi	Rainfed / medium deep black soil	Weeding / interculture	388	4.84	7438	1.74
			Farmers' practice*	330	4.13	4200	1.47
Rabi sorghum	Honnutagi	Rainfed / medium deep black soil	Weeding / interculture	546	6.83	5795	1.61
			Farmers' practice*	448	5.59	4030	1.47
Safflower	Honnutagi	Rainfed / medium deep black soil	Weeding / interculture	613	7.66	8875	1.93
			Farmers' practice*	488	6.09	5625	1.63

*Farmers' practice: No weeding / interculture

Safflower with weeding / interculture

Farmers' practice

Situation: Mid season drought

At Honnutagi and Kavalagi villages, a long dry spell of 74 days occurred during 18 October to 31 December coinciding with flowering and maturity stage of pigeonpea and chickpea. Two supplemental irrigations of 40 mm each with MIS (sprinklers) from harvested rainwater recharged and stored in open wells gave an average of 86 and 53% higher yields in pigeonpea and chickpea respectively, over farmers' practice of no supplemental irrigation, with higher net returns, B:C ratio and RWUE (Table 89).

Table 89: Effect of supplement irrigation on yield and economics of pigeonpea and chickpea

Village	Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Honnutagi	Rainfed / medium deep black soil	Pigeonpea	Supplemental irrigation	1250	6.79	58000	4.41
			Farmers' practice	675	3.66	26000	2.79
Honnutagi	Rainfed / medium black soil	Chickpea	Supplemental irrigation	613	7.66	17563	2.76
			Farmers' practice	400	5.00	7000	1.78

Farmers' practice: No supplemental irrigation

Pigeonpea with supplemental irrigation

Pigeonpea under farmers' practice

At Honnutagi and Kavalagi villages, a dry spell of 20 days from 28 August to 16 September and a long dry spell of 74 days occurred during 18 October to 31 December coinciding with vegetative and flowering stages of pigeonpea, chickpea, greengram and *rabi* sorghum. Foliar application of KNO_3 @ 0.5% gave an average of 20-25% higher yields in pigeonpea, chickpea and *rabi* sorghum over farmers' practice of no foliar spray and recorded higher net returns, B:C ratio and RWUE (Table 90).

Table 90: Effect of foliar application of KNO_3 on yield and economics of different crops

Crop	Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Pigeonpea	Honnutagi	Rainfed / medium deep black soils	Foliar spray	717	3.89	27442	2.77
			Farmers' practice	571	3.10	19750	2.36
	Kavalagi	Rainfed / medium deep black soils	Foliar spray	748	4.06	29350	2.89
			Farmers' practice	600	3.26	21500	2.32
Greengram	Honnutagi	Rainfed / medium deep black soils	Foliar spray	255	2.45	6575	1.75
			Farmers' practice	213	2.04	4025	1.50
	Kavalagi	Rainfed / medium deep black soils	Foliar spray	233	2.23	5225	1.60
			Farmers' practice	193	1.85	2825	1.36
Chickpea	Honnutagi	Rainfed / medium deep black soils	Foliar spray	498	6.23	12675	2.76
			Farmers' practice	407	5.08	7267	1.78
	Kavalagi	Rainfed / medium deep black soils	Foliar spray	513	6.41	13313	2.37
			Farmers' practice	413	5.16	7500	1.83
Rabi sorghum	Honnutagi	Rainfed / medium deep black soils	Foliar spray	556	6.95	6325	1.68
			Farmers' practice	463	5.78	4450	1.52

*Foliar spray: KNO_3 @ 0.5%; Farmers' practice: No foliar spray

Preparedness

Rainwater management

In-situ moisture conservation through deep ploughing in chickpea recorded 21.2 and 21.6% higher mean seed yield of 394 and 415 kg/ha over farmers' practice at Honnutagi and Kavalagi villages, respectively (Table). Similarly, in *rabi* sorghum, deep ploughing recorded 21.1% higher mean grain yield of 639 kg/ha over farmers' practice in Honnutagi village with higher net returns of Rs. 18244/ha and B:C ratio (2.74) (Table 91).

Table 91: Effect of *in-situ* moisture conservation (deep ploughing) on yield and economics of chickpea and *rabi* sorghum

Crop	Village	Farming situation/ soil type	Intervention	Seed/ grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Chickpea	Honnutagi	Rainfed / medium black soil	Deep ploughing	394	10500	8963	1.85	5.41
			Farmers' practice	325	9500	6363	1.67	4.41
	Kavalagi	Rainfed / medium black soil	Deep ploughing	415	10500	8175	1.78	5.19
			Farmers' practice	341	9500	5856	1.62	4.27
Rabi sorghum	Honnutagi	Rainfed / medium black soil	Deep ploughing	639	10500	18244	2.74	7.98
			Farmers' practice	528	9500	14238	2.50	6.59

*Farmers' practice: No deep ploughing.

In chickpea, compartment bunding recorded 24.9 and 25.3% higher seed yield (476 and 499 kg/ha) with higher net returns over farmers' practice in Honnutagi and Kavalagi villages, respectively (Table 92).

Table 92: Effect of compartment bunding on yield and economics of chickpea

Village	Farming situation/ soil type	Intervention	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Honnutagi	Rainfed / medium black soil	Compartment bunding	476	10500	10931	2.04	5.95
		Farmers' practice	381	9500	7656	1.81	4.77
Kavalagi	Rainfed / medium black soil	Compartment bunding	499	10500	11,958	2.14	6.24
		Farmers' practice	398	9500	8,430	1.89	4.98

*Farmers' practice: No compartment bunding

In chickpea, ridge and furrow method of sowing recorded higher seed yield of 433 and 415 kg/ha as compared to farmers practice in Honnutagi and Kavalagi villages, respectively. Similarly, in *rabi* sorghum, ridge and furrow method of sowing recorded higher grain yield of 620 kg/ha with higher net returns (Rs. 17400/ha) and B:C ratio (2.66) over farmers' practice in Honnutagi village (Table 93).

Table 93: Effect of *in-situ* moisture conservation on yield and economics of chickpea and *rabi* sorghum

Crop	Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Chickpea	Honnutagi	Rainfed / medium black soil	Ridge and furrow	433	10500	8963	1.85	5.41
			Farmers' practice*	353	9500	6363	1.67	4.41
	Kavalagi	Rainfed / medium black soil	Ridge and furrow	415	10500	8175	1.78	5.19
			Farmers' practice	341	9500	5856	1.62	4.27
Rabi sorghum	Honnutagi	Rainfed / medium black soil	Ridge and furrow	20	10500	17,400	2.66	7.75
			Farmers' practice	513	9500	13,563	2.43	6.41

Farmers' practice: flat bed sowing

Cropping systems

In *rabi* season, sorghum and safflower based intercropping systems were demonstrated in the farmers' fields. Among the intercropping systems, sorghum + chickpea intercropping (2:4) gave higher sorghum equivalent yield (673 and 646 kg/ha), net returns (Rs.9354 and 8600/ha), B:C ratio (1.98 and1.91), RWUE (8.42 and 8.08 kg/ha-mm) and LER(1.33 and 1.29) respectively (Table 94) in Honnutagi and Kavalagi villages, respectively compared to sole sorghum and chickpea (455 and 476 kg/ha, respectively) (Table .). Safflower + chickpea (2:4) intercropping system gave higher safflower equivalent yield of 731 and 675 kg/ha, net returns (Rs.9500 and 9500/ha), RWUE (9.14 and 4.37 kg/ha-mm), B:C ratio (2.31 and 2.13) and LER (1.48 and 1.36) compared to sole safflower and chickpea (351 and 385 kg/ha, respectively) (Table 95).

Table 94: Performance of *rabi* sorghum + chickpea (2:4) intercropping system

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)		MCEY (kg/ha)	LER	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			Main crop	Inter crop						
Honnutagi	Rainfed / medium black soil	*Rabi* sorghum + chickpea	314	224	673	1.33	9500	9354	1.98	8.42
		Farmers' practice	455	-	455	-	8500	4240	1.50	5.69
Kavalagi	Rainfed / medium black soil	*Rabi* sorghum + chickpea	325	200	646	1.29	9500	8,600	1.91	8.08
		Farmers' practice	476	-	476	-	8500	4828	1.57	5.95

Farmers' practice: Sole *rabi* sorghum; LER: Land equivalent ratio; MCEY: Main crop equivalent yield

***Rabi* sorghum + chickpea intercropping (2:4)**

Sole *rabi* sorghum

Table 95: Performance of safflower + chickpea (2:4) intercropping system

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)		MCEY	LER	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			Main crop	Inter-crop						
Honnutagi	Rainfed / medium black soil	Safflower + chickpea	375	238	731	1.48	9500	12438	2.31	9.14
		Farmers' practice	350		350		9000	6734	1.75	8.44
Kavalagi	Rainfed / medium black soil	Safflower + chickpea	338	225	675	1.36	9500	10750	2.13	4.37
		Farmers' practice	381		381		9000	8138	1.90	4.70

Farmers' practice: Sole chickpea; LER: Land equivalent ratio; MCEY: Main crop equivalent yield

Safflower + chickpea intercropping (2:4)

Sole chickpea

Among *rabi* sorghum varieties, BJV-44 and M35-1 recorded highest grain yield of 543 and 575 kg/ha compared to local variety in Honnutagi village under medium black soils with higher net returns and B:C ratio (Table 96).

Table 96: Yield and economics of improved *rabi* sorghum varieties

Farming situation/ soil type	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed / medium deep black soil	BJV-44	543	6.79	5880	1.63
	M35-1	575	7.19	6600	1.69
	Farmers' practice (local variety)	455	5.69	4240	1.50

Rabi sorghum var. BJV-44

Rabi sorghum var. M35-1

Similarly, improved drought tolerant variety of safflower, A-1 recorded seed yield of 575 kg/ha with net returns of Rs. 800/ha and B:C ratin of 1.86 compared to local variety (469 kg/ha) at Honnutagi village in the medium black soils (Table 97).

Table 97: Performance of improved safflower variety under deficit rainfall conditions

Farming situation/ soil type	Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rainfed / medium deep black soil	A-1	575	7.19	8000	1.86
	Farmers' practice (local variety)	469	5.86	5063	1.56

Energy management

During *Kharif*, compartmental bunding helped in moisture conservation and gave higher seed yield of chickpea (476-499 kg/ha) compared to famers' practice. On an average, energy input for chickpea cultivation was 4924 and 4876 MJ/ha

with compartment bunds and without compartment bunds, respectively with energy use efficiency of 4.84 to 3.91, respectively at Honnutagi village while it was 5.07 and 4.09, respectively at Kavalagi village (Table 98).

Table 98: Effect of compartmental bunding on energy use efficiency in chickpea

Village	Farming situation/ soil type	Intervention	Seed yield (kg/ha)	Energy (MJ/ha)		Energy use efficiency
				Input	Output	
Honnutagi	Rainfed / medium black soil	Compartment bunding	476	4924	23813	4.84
		Farmers' practice	381	4876	19063	3.91
Kavalagi	Rainfed / medium black soil	Compartment bunding	499	4924	24953	5.07
		Farmers' practice	398	4876	19922	4.09

*Farmers' practice: No compartment bunding

Land management units (LMU) based crop planning

On the basis of soil conservation unit (SCU) and soil quality units (SQU) 14 land management units (LMU) have been derived (Fig.24). However the results of four LMUs (I, III, V and VII) revealed that higher chickpea and sorghum yields were recorded in LMU-I followed by LMU-III, LMU-V and LMU-VII. Further, net returns and benefit cost ratio were also high in LMU-I. (Table 99).

Table 99: Performance of chickpea and *rabi* sorghum under different LMUs

Crop/ variety	Land management unit (LMU)	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Chickpea (JG-11)	LMU-I	578	16988	2.89	7.22
Chickpea (JG-11)	LMU-III	523	14513	2.61	6.53
Chickpea (JG-11)	LMU-V	420	9900	2.10	5.25
Chickpea (JG-11)	LMU-VII	300	4500	1.50	3.75
Sorghum (BJV-44)	LMU-I	588	17438	2.94	7.34
Sorghum (M 35-1)	LMU-I	623	19013	3.11	7.78
Sorghum (BJV-44)	LMU-III	473	12263	2.36	5.91
Sorghum (M 35-1)	LMU-III	520	14400	2.60	6.50
Sorghum (BJV-44)	LMU-V	425	10125	2.13	5.31
Sorghum (M 35-1)	LMU-V	403	9113	2.01	5.03
Sorghum (BJV-44)	LMU-VII	325	5625	1.63	4.06
Sorghum (M 35-1)	LMU-VII	338	6188	1.69	4.22

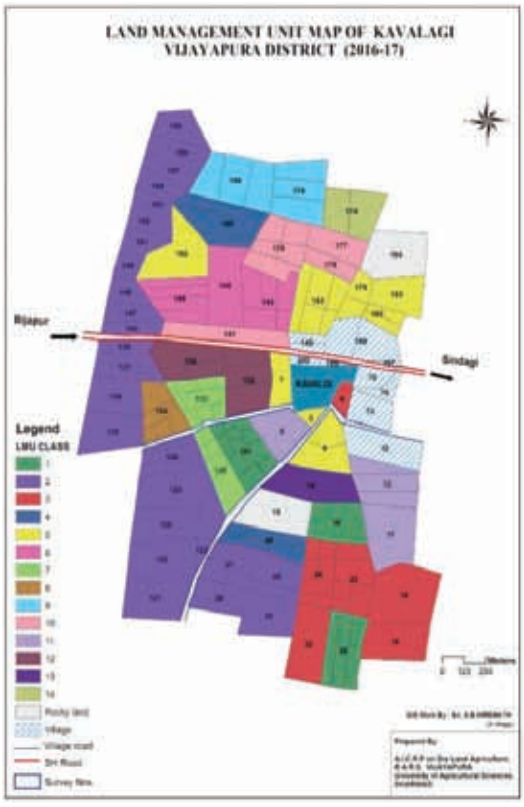


Fig.24: Land management units of Kavalagi village

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 2018-19

During 2018, the onset of monsoon was early (6 June) and an annual rainfall of 836.5 mm was received which was excess by 61.7 mm (7.9%) compared to normal (774.8 mm) (Fig.25). Out of total rainfall received, 836.5 mm was received during *kharif* season which was excess by 103.4 mm compared to normal of 733.1 mm.

Normal onset of monsoon	11-17 June
Onset of monsoon during 2018	6 June
Annual mean rainfall	774.8 mm
Annual rainfall during 2018-19	836.5 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	733.1 mm
Crop seasonal rainfall during 2018-19 (*kharif* & *rabi*)	836.5 mm

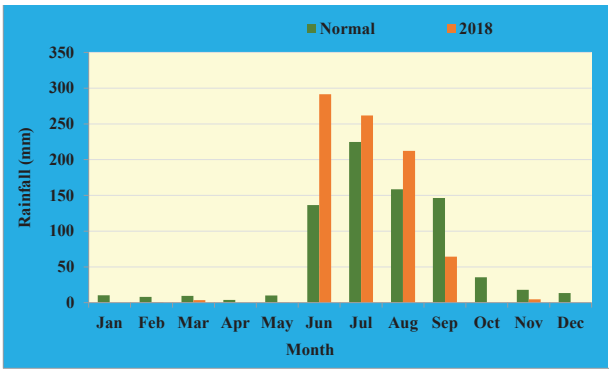


Fig. 25: Normal and actual (2018) monthly rainfall at Akola

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
20	27 July -15 August	Soybean, greengram	Flowering
		Cotton, pigeonpea	Vegetative
27	23 August -18 September	Soybean, greengram	Pod initiation and development
		Cotton	Square formation and boll initiation
		Pigeonpea	Vegetative
96	24 September - 31 December	Cotton	Maturity
		Pigeonpea	Flowering and pod development
		Chickpea	Vegetative and flowering.

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early and mid season drought	Cotton	Vegetative	Opening of furrows after each row at 30-35 DAS and foliar sprays
Mid season drought	Cotton	Square formation	Foliar sprays

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

During *kharif* 2018, a dry spells of 20 days occurred during 27 July to 15 August at vegetative stage in cotton. Opening of furrows at 30-35 DAS recorded higher seed cotton yield (1278 kg/ha) net returns (Rs. 32325/ha), B:C ratio (1.8) and RWUE (1.25 kg/ha-mm) followed by foliar spray of 2% water soluble complex fertilizer (19:19:19) at flowering and boll development stage (1274 kg/ha) compared to control (1107 kg/ha) (Table 100).

Table 100: Effect of *in-situ* moisture conservation and foliar spray on *Bt.* cotton (Balwan) yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton	Stalk				
Opening of furrow at 30-35 DAS	1278	2326	40164	32325	1.80	1.53
Foliar spray of 2% urea at flowering (75-80 DAS)	1219	2218	40447	28679	1.71	1.46
Foliar spray of 2% KCl at BDS	1219	2218	40447	28679	1.71	1.46
Foliar spray of 2% urea and 2% KCl at flowering and BDS	1270	2312	41287	30782	1.75	1.52
Foliar spray of 2% 19:19:19 at flowering	1226	2231	40584	28962	1.71	1.47
Foliar spray of 2% 19:19:19 at BDS	1204	2191	40473	27813	1.69	1.44
Foliar spray of 2% 19:19:19 at flowering and BDS	1274	2319	41505	30773	1.74	1.52
Control (no spray)	1107	2015	39312	23511	1.60	1.32

BDS: Boll development stage

Cotton with opening of furrow and foliar sprays

Cotton without opening of furrow and foliar sprays

Situation: Mid season drought

During *kharif* 2018, a dry spell of 27 days occurred during 23 August to 18 September at vegetative, square formation and boll initiation stage in cotton. Opening of furrows at 30-35 DAS and foliar spray of 2% water soluble complex fertilizer (19:19:19) at flowering and boll development stage (BDS) recorded higher seed cotton yield (1326 kg/ha), net returns (Rs. 42654/ha), B:C ratio (2.37) and RWUE (1.59 kg/ha-mm) followed by opening of conservation furrow (30-35 DAS) compared to control (1148 kg/ha) (Table 101).

Table 101: Effect of *in-situ* moisture conservation and foliar spray under HDPS on *arboreum* cotton (AKA-7) yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton	Stalk				
Opening of furrow at 30-35 DAS	1293	1357	29474	42362	2.44	1.55
Foliar spray of 2% urea at flowering (75-80 DAS)	1256	1318	29832	39946	2.34	1.50
Foliar spray of 2% KCl at BDS	1248	1311	29787	39579	2.33	1.49
Foliar spray of 2% urea and 2% KCl at flowering and BDS	1304	1369	30701	41753	2.36	1.56
Foliar spray of 2% 19:19:19 at flowering	1256	1318	29932	39846	2.33	1.50
Foliar spray of 2% 19:19:19 at BDS	1263	1326	29976	40213	2.34	1.51
Foliar spray of 2% 19:19:19 at flowering and BDS	1326	1392	31034	42654	2.37	1.59
Control (no spray)	1148	1206	28607	35201	2.23	1.37

BDS: Boll development stage

Cotton with furrow opening and foliar spray

Cotton without furrow opening and foliar spray

c. On-farm demonstrations

Village profile

The old village Warkhed (Bk) and new village Kajleshwar in Barshitakli tahsil of Akola district is situated between77^{0}7'00'' to 77^{0}10'00'' E longitude and 20^{0}32' 30'' to 20^{0}35' 00'' N latitude and covers an area of 198 ha. The mean elevation of the area is about 325 m above MSL. It is about 32 km south-east of Akola city. The mean annual rainfall is 796.0 mm with seasonal rainfall of 743 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, sorghumand 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 up to 25th SMW and 26th SMW and early withdrawal observed during 39th SMW. The soil moisture status was often deficit during the reproductive stages of major rainfed 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 2018-19

During 2018, the onset of monsoon was on 14th June. A rainfall of 905.4 mm was received which was excess by 98.4 mm compared to normal (807.0 mm). During *kharif* season (June to September), 905.4 mm of rainfall was received which was excess by 217.4 mm as compared to normal (688.0 mm). During *rabi* season (October-December), no rainfall was received against the normal (82.0 mm). During summer, 1.7 mm rainfall was received which was deficit by 21.1 mm compared to normal (22.8 mm) (Fig.26).

Normal onset of monsoon	11-17 June
Onset of monsoon during 2018	14 June
Annual mean rainfall	807.0 mm
Annual rainfall during 2018-19	905.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	688.0 and 82.0 mm, respectively
Actual crop seasonal rainfall during (2018-19)	905.4 mm and 0.0 mm, respectively

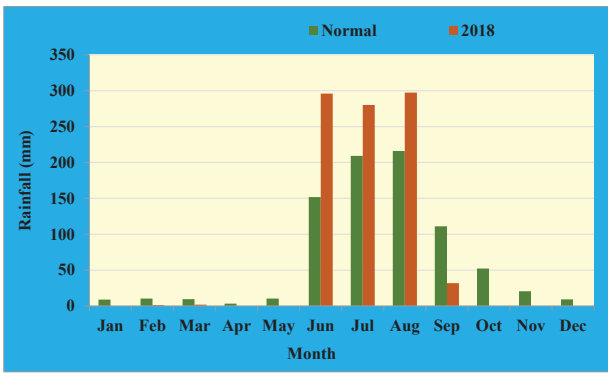


Fig. 26: Normal and actual (2018) monthly rainfall at Warkhed

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Soybean, cotton	Vegetative	Opening of furrow in each row
Mid season drought	Cotton	Boll development	Foliar spray
	Soybean	Pod initiation	Protective irrigation, foliar spray
	Chickpea	Flowering and pod development	Protective irrigation

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
08	13-20 June	Soybean, cotton, pigeonpea, greengram	Vegetative
13	28 July - 10 August	Soybean, greengram	Flowering
		Cotton, pigeonpea	Vegetative
23	28 August - 21 September	Soybean	Pod initiation and development
		Cotton	Square formation and boll initiation
		Pigeonpea	Vegetative

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During *kharif*, a dry spell of 13 days occurred during 28 July-10 August coinciding with pod development stage of soybean (JS-335) *in-situ* moisture conservation through openingof furrows in each row after 30-35 DAS of soybean recorded higher seed yield (1875 kg/ha), net returns (Rs.33120/ha), B:C ratio (2.4) and RWUE (1.86 kg/ha-mm) at Warkhed village as compared to farmers' practice of without furrow opening (1536 kg/ha) (Table …). At new village, Kajleshwar, *in-situ* moisture conservation through openingof furrows in each row after 30-35 DAS of soybean recorded higher seed yield (1570 kg/ha), net returns (Rs.29381/ha), B:C ratio (2.21) and RWUE (1.73 kg/ha-mm) compared to farmers' practice of without furrow opening (1427 kg/ha) (Table 102)

Conservation furrow in soybean

Soybean under farmers' practice

Table 102: Effect of conservation furrow on yield and economics of soybean

Village	Farming situation/soil type	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Warkhed	Medium deep black soils	Opening of furrow (30-35 DAS)	1875	1.86	33120	2.4
		Farmers' practice (without furrow)	1536	1.7	25869	2.07
Kajleshwar	Medium deep black soils	Opening of furrow (30-35 DAS)	1570	1.73	29381	2.21
		Farmers' practice (without furrow)	1427	1.57	22448	1.93

In cotton, *in-situ* moisture conservation through opening of furrows in each row after 30-35 DAS recorded higher seed cotton yield (1776 kg/ha), net returns (Rs.54051/ha), B:C ratio (2.16) and RWUE (1.56 kg/ha-mm) at Warkhed village as compared to farmers' practice of without furrow opening (1622 kg/ha) (Table 103).

Table 103: Effect of conservation furrow on yield and economics of cotton

Farming situation/soil type	Intervention	Seed yield (kg/ha)	RWUE (kg/ ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium deep black soils	Opening of furrow (30-35 DAS)	1776	1.56	54051	2.16
	Farmers' practice (without furrow)	1622	1.79	45262	1.99

Cotton with conservation furrow

Cotton without conservation furrow

Situation: Mid season drought

At Warkhed village, a dry spell of 23 days occurred during 28 August- 21 September coinciding with pod development stage of soybean (JS-335). Application of one protective irrigation (25 mm) from harvested rainwater in farm pond recorded higher seed yield (1952 kg/ha), net returns (Rs. 41905/ha), B:C ratio (2.70) and WUE (2.16 kg/ha-mm) over farmers' practice of no protective irrigation (1726 kg/ha) (Table 104).

Farm pond at Warkhed village

Soybean with protective irrigation

Soybean without protective irrigation

Table 104: Effect of protective irrigation on yield and economics of soybean

Farming situation/soil type	Intervention	Yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium deep black soil	Protective irrigation	1952	2.16	41905	2.70
	Farmers' practice	1726	1.91	31783	2.31

At Warkhed village, foliar spray of KCl @ 2% at boll development stage in cotton recorded higher seed cotton yield (1810 kg/ha), net returns (Rs. 55806/ha), B:C ratio (2.2) and RWUE (2.0 kg/ha-mm) compared to farmers' practice of no foliar spray (1628 kg/ha) (Table 105).

Table 105: Effect of foliar spray on yield and economics of cotton

Farming situation/ soil type	Intervention	Seed cotton yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium deep black soil	Foliar spray KCl @ 2%	1810	2.00	55806	2.20
	Farmers' practice	1628	1.80	45522	1.99

At Warkhed village, foliar spray of complex fertilizer (19:19:19) @ 2% at pod initiation stage in soybean recorded higher seed yield (3848 kg/ha), net returns (Rs. 34643/ha), B:C ratio (2.42) and RWUE (1.91 kg/ha-mm) over the farmers' practice of no foliar spray (3408 kg/ha) (Table 106). At Kajleshwar village, foliar spray of complex fertilizer (19:19:19) @ 2% at pod initiation stage in soybean recorded higher seed yield (3557 kg/ha), net returns (Rs. 29992/ha), B:C ratio (2.33) and RWUE (1.75 kg/ha-mm) over the farmers' practice of no foliar spray (3136 kg/ha)

Table 106: Effect of foliar spray on yield and economics of soybean

Village	Farming situation/ soil type	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Warkhed	Medium deep black soil	Foliar spray	3848	1.91	34643	2.42
		Farmers' practice	3408	1.68	25530	2.06
Kajleshwar	Medium deep black soil	Foliar spray	3557	1.75	29992	2.33
		Farmers' practice	3136	1.55	21727	1.98

At Warkhed village, two protective irrigations from harvested rainwater in farm pond at flowering and pod development stage in chickpea recorded higher seed yield (1862 kg/ha), net returns (Rs. 41959/ha) and B:C ratio (2.30) compared to farmers' practice (18369 kg/ha) (Table 107).

Chickpea with two protective irrigations

Chickpea without protective irrigation

Table 107: Effect of protective irrigations on yield and economics of chickpea

Farming situation/ soil type	Intervention	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Medium deep black soil	Two protective irrigations	1862	41959	2.64
	One protective irrigation	1604	32860	2.30
	Farmers' practice (no irrigation)	1369	13333	1.55

Preparedness

Cropping systems

Soybean + pigeonpea (4:2) intercropping system recorded 10.3% higher soybean equivalent yield (2562 kg/ha) as compared to farmers' practice of soybean + pigeonpea (6:1) system (2323 kg/ha), with higher net returns (Rs. 38735/ha), B:C ratio (2.31) and RWUE (2.30 kg/ha-mm) (Table 108).

Table 108: Performance of soybean + pigeonpea (4:2) intercropping system

Farming situation/ soil type	Intervention	Yield (kg/ha)		MCEY(kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Soybean	Pigeonpea	2018-19	Mean (6 years)			
Medium deep black soils	Soybean + pigeonpea (4:2)	1369	740	2562	2078	38735	2.31	2.30
	Soybean + pigeonpea (6:1) (Farmers' practice)	1465	533	2323	1537	20999	1.71	1.70

Cotton + greengram (1:1) intercropping system gave 30.8% higher cotton equivalent yield (2046 kg/ha), with higher net returns (Rs. 45273/ha), B:C ratio (1.90) and RWUE (1.89 kg/ha-mm) compared to sole cotton (1564 kg/ha) (Table 109).

Table 109: Performance of cotton + greengram (1:1) intercropping system

Farming situation/ soil type	Cropping system	Yield (kg/ha)		MCEY (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Cotton	Green gram	2018-19	Mean (6 years)			
Medium deep black soils	Cotton + greengram (1:1)	1452	697	2046	1709	45273	1.90	1.89
	Farmers' practice (sole cotton)	1564	--	1564	1365	35222	1.79	1.51

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 2018-19

During 2018, the onset of monsoon was timely (2nd June). A rainfall of 727.8 mm was received which was deficit by 192.9 mm (21%) compared to normal (920.0 mm) (Fig.27). During *kharif* season

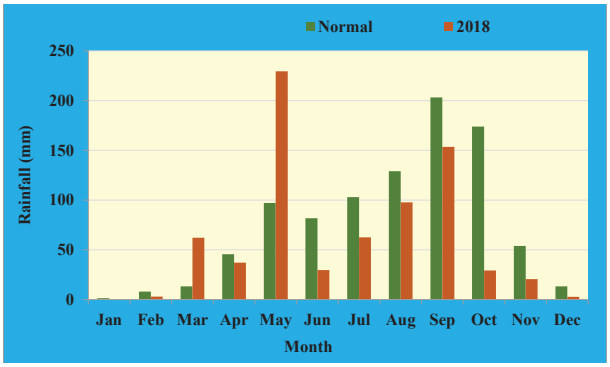


Fig.27: Normal and actual (2018) monthly rainfall at Bengaluru

(June-September), 337.6 mm rainfall was recorded which was deficit by 170.7 mm (33.6%) against normal of 508.3 mm. In *rabi* season, rainfall was 51.8 mm which was deficit by 182.1 mm (77.8%) than the normal of 233.9 mm and in summer, 269.4 mm rainfall was recorded and was excess by 94.6 mm (54.0%) than normal of 174.8 mm.

Normal onset of monsoon	2 June
Onset of monsoon during 2018	2 June
Annual mean rainfall	920.4 mm
Annual rainfall during 2018-19	727.8 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	508.3 & 233.9 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* & *rabi*)	337.60 & 51.8 mm, respectively

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
12	6-17 October	Fingermillet	Flag leaf

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Fingermillet	Flag leaf	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

Foliar spray in fingermillet during dry spell recorded numerically higher grain (1550 kg/ha) and straw yield (1677 kg/ha) compared to foliar spray after relieving of stress/dry spell (1386 and 1685 kg/ha). Among different sources of nutrients, foliar spray of 0.5% water soluble complex fertilizer (19:19:19) recorded numerically higher grain yield (1920 kg/ha) with higher net returns (Rs. 36386/ha) and B:C ratio (2.52) compared to control (1050 kg/ha). The interaction effect among different foliar sprays on grain yield of finger millet was found non-significant (Table 110).

Table 110: Performance of fingermillet under different foliar sprays during mid season drought

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2018	Pooled (2 years)	2018	Pooled (2 years)			
Main plot							
M_1: Foliar spray during dry spell	1550	1030	1677	3090	24760	2.02	5.72
M_2: Foliar spray after relieving of stress/ dry spell	1386	942	1685	2842	19857	1.82	3.91
CD at 5%	NS	NS	NS	NS	-	-	-
Sub plot							
T_1:Urea @1%	1350	944	1898	3010	19709	1.83	4.96
T_2:Urea @ 2%	1729	1162	1747	2951	30815	2.30	6.37
T_3:Water soluble complex fertilizer (19:19:19) @ 0.5%	1920	1242	1825	3329	36386	2.52	7.08
T_4:T_3+ rec. dose of micronutrient as foliar spray*	1650	876	1277	3116	25768	2.00	6.08
T_5:Rec. dose of micronutrient as foliar spray	1226	1103	1690	3192	14030	1.56	3.09
T_6:Water spray	1354	808	1658	2638	19038	1.79	3.19
T_7:Control (no spray of any nutrient/ water)	1050	767	1672	2528	10415	1.44	2.90
CD at 5%	NS	NS	NS	NS	-	-	-

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

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 (Standard meteorological week, 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 2018-19

During 2018, in Chikkamaranahalli village, the onset of monsoon was timely (2nd June). A rainfall of 609.0 mm was received which was deficit by 144.4 mm (23.9%) compared to normal (753.4 mm). Out of total rainfall, *kharif* season received 327.0 mm, which was deficit by 88.1 mm (21.23%) compared to normal of 415.1 mm (Fig.28). *Rabi* season received 64.0 mm which was deficit by 177.6 mm (73.5%) compared to normal of 241.6 mm and in summer, it was 218.0 mm against normal of 95.6 mm which was excess by 122.4 mm (128%).

Normal onset of monsoon	2 June
Onset of monsoon during 2018	2 June
Annual mean rainfall	753.4 mm
Annual rainfall during 2018-19	609.0 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	415.1 & 241.6 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* & *rabi*)	327.0 mm & 64.0 mm, respectively

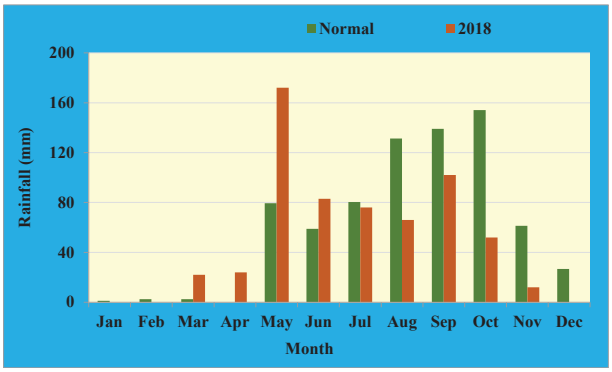


Fig.28: Normal and actual (2018) monthly rainfall at Chikkamaranahalli

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
33	7 June - 8 July	Cowpea, Groundnut	Germination
24	14 July - 6 August	Fingermillet, Pigeonpea	Germination stage
		Field bean, cowpea	Pod filling
10	17 August - 26 August	Fingermillet, pigeonpea	Germination to establishment
		Groundnut	Flowering to peg initiation

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
16	30 August – 14 September	Fingermillet	Seedling to tillering
		Pigeonpea	Vegetative to flowering
		Groundnut	Pod formation to maturity
15	30 September- 14 October	Fingermillet	Tillering to flag leaf
		Pigeonpea	Flowering to pod formation
		Groundnut	Harvesting
		Horse gram	Germination to establishment
39	16 October- 23 November	Fingermillet	Flowering
		Pigeonpea	Grain filling
43	24 November- 5 January	Fingermillet	Maturity/ harvest
		Pigeonpea	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	Crop	RTCP implemented
Early season drought	Upland-loamy sand	Fingermillet, groundnut pigeonpea	Fingermillet (MR-1) + pigeonpea (BRG-5) (8:2) with conservation furrow

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

Intercropping of fingermillet (MR-1) + pigeonpea (BRG-5) (8:2) with conservation furrow between paired rows of pigeonpea recorded higher fingermillet grain equivalent yield, net returns and B:C ratio compared to farmers' practice of growing fingermillet + mixed cropping (*Akkadi)* with an yield advantage ranging from 34 to 44.7% in different cluster villages (Table 111).

Table 111 : Performance of *in-situ* moisture conservation in fingermillet + pigeonpea (8:2) intercropping system

Village	Farming situation/ soil type	Intervention	Fingermillet equivalent yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Mudalapalya	Upland-loamy sand	Fingermillet + pigeonpea (8:2) with *in-situ* moisture conservation	2298	42200	2.36	7.46
		Fingermillet + *akkadi*	1344	9601	1.30	4.36
Hosapalya	Upland-loamy sand	Fingermillet + pigeonpea (8:2) with *in-situ* moisture conservation	2136	37223	2.20	6.93
		Fingermillet + *akkadi*	1409	11551	1.36	4.57
Chikkamaranahalli	Upland-loamy sand	Fingermillet + pigeonpea (8:2) with *in-situ* moisture conservation	2141	36715	2.19	6.95
		Fingermillet + *akkadi*	1485	13831	1.43	4.82
Chikkamaranahalli colony	Upland-loamy sand	Fingermillet + pigeonpea (8:2) with *in-situ* moisture conservation	2139	37427	2.21	6.94
		Fingermillet + *akkadi*	1182	4741	1.15	3.83
Chikkaputtayyana-palya	Upland-loamy sand	Fingermillet + pigeonpea (8:2) with *in-situ* moisture conservation	2348	43852	2.42	7.62
		Fingermillet + *akkadi*	1328	9121	1.28	4.31
Chikkahosapalya	Upland-loamy sand	Fingermillet + pigeonpea (8:2) with *in-situ* moisture conservation	2019	33390	2.08	6.55
		Fingermillet + *akkadi*	1264	7201	1.22	4.10

Preparedness

Cropping systems

Among different varieties of fingermillet, long duration variety (MR-6) recorded higher grain yield, net return and B: C ratio (2400 kg/ha, Rs. 53862/ ha and 3.29, respectively) compared to medium duration (GPU-28) and short duration varieties (GPU-48) (Table 112).

Table 112: Performance of different fingermillet varieties

Farming situation/ soil type	Variety	Duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Grain	Straw			
Upland-loamy sand	MR-6	117	2400	3612	9.67	53862	3.29
	GPU-28	103	1700	2040	9.34	30522	2.30
	GPU-48	98	1420	1633	7.80	21512	1.91

Among the pulse based intercropping systems at Chikkamaranahalli village, pigeonpea (BRG-1) + field bean (HA-4) recorded higher pigeonpea equivalent yield (872 kg/ha), RWUE (2.20 kg/ha-mm), net returns (Rs. 20012/ha) and B:C ratio (1.72) compared to the farmers' practice of sole pigeonpea (523 kg/ha) (Table 113).

Table 113: Yield and economics of pulse based intercropping systems

Farming situation/ soil type	Crop	PEY (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		2018-19	Mean (7 years)			
Upland-loamy sand	Pigeonpea + cowpea (1:1)	678	1059	1.71	13357	1.49
	Pigeonpea + field bean (1:1)	872	1142	2.20	20012	1.72
	Sole pigeonpea	523	615	1.32	3210	0.94

PEY: Pigeonpea equivalent yield

Pigeonpea + cowpea intercropping (1:1)

Pigeonpea + field bean (1:1)

Fingermillet (MR-1) + pigeonpea (BRG-5) (8:2) intercropping system recorded higher fingermillet equivalent yield, net return and B:C ratio as compared to farmers' practice of fingermillet + *akkadi* (multiple crops) at all the cluster villages (Table 114).

Table 114: Yield and economics of fingermillet + pigeonpea (8:2) intercropping system

Village	Farming situation/ soil type	Intervention	FEY (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			2018-19	Mean (7 years)			
Mudalapalya	Upland-loamy sand	Fingermillet + pigeonpea (8:2)	2395	2728	31418	2.13	4.88
		Fingermillet + *akkadi*	1409	1763	13646	3.48	3.48

Village	Farming situation/ soil type	Intervention	FEY (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			2018-19	Mean (7 years)			
Hosapalya	Upland-loamy sand	Fingermillet + pigeonpea (8:2)	2236	2567	42815	2.46	7.25
		Fingermillet + *akkadi*	1670	1744	17607	1.54	5.42
Chikkamaranahalli	Upland-loamy sand	Fingermillet + pigeonpea (8:2)	2310	2836	46069	2.57	7.49
		Fingermillet + *akkadi*	1758	1842	20247	1.63	5.70
Chikkamaranahalli colony	Upland-loamy sand	Fingermillet + pigeonpea (8:2)	2502	2682	51571	2.76	8.12
		Fingermillet + *akkadi*	1985	1693	27057	1.83	6.44
Chikkaputtayyanapalya	Upland-loamy sand	Fingermillet + pigeonpea (8:2)	2445	2574	49226	2.68	7.93
		Fingermillet + *akkadi*	1758	1678	20247	1.62	5.70
Chikkahosapalya	Upland-loamy sand	Fingermillet + pigeonpea (8:2)	2224	-	43730	2.49	7.22
		Fingermillet + *akkadi*	1585		15.057	1.46	5.14

FEY=Fingermillet equivalent yield

Fingermillet + pigeonpea (8:2)

Fingermillet + *akkadi* system

Nutrient management

Application of 100% RDF+12.5 kg/ha of $ZnSO_4$ in fingermillet (MR-1) + pigeonpea (BRG-5) (8:2), intercropping system recorded higher grain equivalent yield, net returns and B:C ratio compared to application of 100% RDF alone in Mudalpalya, Chikkamaranhalli and Chikkaputtayyanapalya villages (Table 115).

Table 115: Effect of nutrient management in fingermillet + pigeonpea (8:2) intercropping system

Village	Farming situation/ soil type	Intervention	FEY (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			2018-19	Mean (7 years)			
Mudalapalya	Upland-loamy sand	100% RDF + $ZnSO_4$ @ 12.5 kg/ha	2702	2960	59473	3.24	8.77
		100% RDF	2395	2728	31418	2.13	4.88
Chikkamara-nahalli	Upland-loamy sand	100% RDF + $ZnSO_4$ @ 12.5 kg/ha	2677	2807	59173	3.22	8.69
		100% RDF	2502	2682	51571	2.76	8.12
Chikkaput-tayyanapalya	Upland-loamy sand	100% RDF + $ZnSO_4$ @ 12.5 kg/ha	2663	2884	58521	3.20	8.64
		100% RDF	2445	2574	49226	2.68	7.93

FEY: Fingermillet equivalent yield; 100% RDF: 50:40:37.5 kg NPK/ha

Application of 100% RDF+12.5 kg/ha of $ZnSO_4$ in groundnut (GKVK-5) + pigeonpea (BRG-1) (8:2) intercropping system recorded higher groundnut equivalent yield (1792, 1758 and 1611 kg/ha), net returns (Rs. 34941, 33573 and 27675/ha) and B:C ratio (2.08, 2.04 and 1.87) compared to application of 100% RDF alone in Hosapalya, Chikkaputtayyanapalya and Chikkahosapalya villages (Table 116).

Table 116: Effect of nutrient management on yield and economics of groundnut + pigeonpea (8:2) intercropping system

Village	Crop	Intervention	GNEY (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			2018-19	Mean (3 years)			
Hosapalya	Groundnut + pigeonpea (8:2)	100% RDF + $ZnSO_4$ @ 12.5 kg/ha	1792	1752	34941	2.08	4.65
		100% RDF	1434	1553			
Chikkaputtayanapalya	Groundnut + pigeonpea (8:2)	100% RDF + $ZnSO_4$ @ 12.5 kg/ha	1758	2121	33573	2.04	4.56
		100% RDF	1511	1855			
Chikkahosapalya	Groundnut + pigeonpea (8:2)	100% RDF + $ZnSO_4$ @ 12.5 kg/ha	1611		27675	1.87	4.18
		100% RDF	1213				

GNEY: Groundnut equivalent yield; 100% RDF: 25:50:25 kg NPK/ha

1.2.3 INDORE

a. Agro-ecological setting

Indore centre is located in Central highlands (Malwa) Gujarat plain Kathiawar peninsula semiarid 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 2018-19

During 2018, the onset of monsoon was normal (18 June), and an annual rainfall of 756.7 mm was received which was deficit by 201.3 mm compared to normal (958.0 mm). During south-west monsoon (*kharif),* the rainfall received was 756.7 mm against the normal (854.5 mm) which was deficit by 97.8 mm. During *rabi* (October-December), no rainfall was received compared to normal (64.5 mm). During summer, no rainfall was received compared to normal (30.6 mm) (Fig.29).

Normal onset of monsoon	12-18 June
Onset of monsoon during 2018	18 June
Annual mean rainfall	958 mm
Annual rainfall during 2018-19	756.7 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	854.5 and 64.5 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi)*	756.7 and 0.0 mm, respectively

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
7	30 July - 05 August	Soybean, maize, pigeonpea	Vegetative
7	10-16 September	Soybean, maize, pigeonpea	Seed filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Soybean	Vegetative	Foliar spray

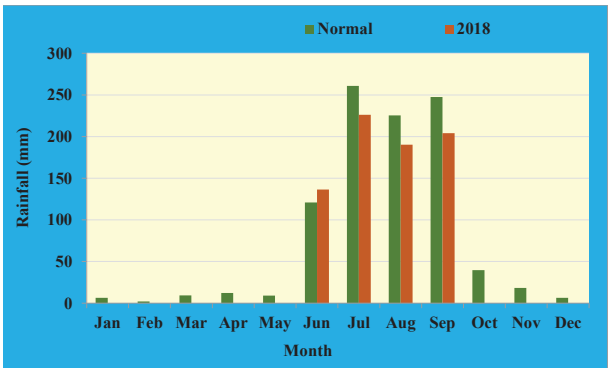


Fig.29 : Normal and actual (2018) monthly rainfall at Indore

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

Foliar spray of urea @ 2% in soybean during branching and initiation of flowering recorded highest seed yield (1222 kg/ha), net returns (Rs. 17889/ha) and B:C ratio (1.89) followed by foliar spray of water soluble NPK (19:19:19) @ 0.5% (1204 kg/ha) (Table 117).

Table 117: Effect of foliar spray on soybean (JS-20-34) yield and economics

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio
	Seed	Stalk		
Urea 2%	1222	2019	17889	1.89
NPK (19:19:19) @ 0.5% + insecticide	1162	1894	16023	1.80
NPK (19:19:19) @ 0.5%	1204	2037	17315	1.87
Chlormequat chloride @ 375 ml/ha	1157	1991	15880	1.79

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 semiarid. 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 2018-19

During 2018, the onset of monsoon was normal (17 June) and annual rainfall of 645.9 mm was received which was deficit by 312.1 mm compared to normal (958.0 mm) (Fig.). During

south-west monsoon (*kharif*), 645.9 mm of rainfall was received against the normal of 854.5 mm, and was deficit by 208.6 mm (24.4%). During *rabi*, no rainfall was received against the normal of 64.5 mm and in summer also no rainfall was received against normal rainfall of 30.7 mm (Fig.30).

Normal onset of monsoon	12-18 June
Onset of monsoon during 2018	17 June
Annual mean rainfall	958.0 mm
Annual rainfall during 2018-19	645.9 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	854.5 and 64.5, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	645.9 and 0.0 mm, respectively

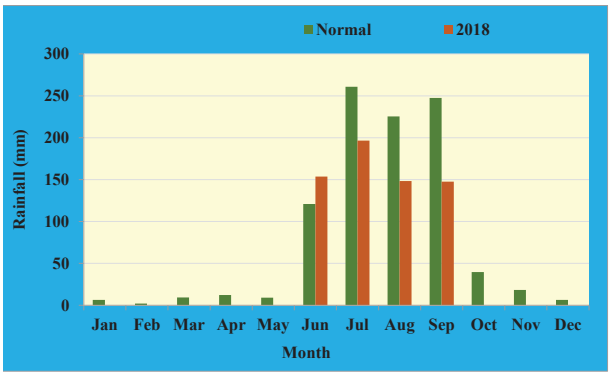


Fig.30: Normal and actual (2018) monthly rainfall at Nignoti

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
15	26 July-09 August	Soybean, maize, pigeonpea	Vegetative, early flowering
16	22 August - 06 September	Soybean, maize, pigeonpea	Late maturity, vegetative (pigeonpea)
12	09 - 20 September	Soybean, maize, pigeonpea	Late maturity, vegetative (pigeonpea)
-	23 September onwards	Soybean, maize, pigeonpea	Maturity

Real time contingency practices (RTCP) implemented: Nil

Salient achievements of on-farm demonstrations

Preparedness

Rainwater management

Construction of five excavated tanks during 2018-19 helped in storing huge amount of runoff water in these tanks and decreased the offsite damage and erosion from the lower fields due to retarded runoff amount and velocity (Table 118).

Table 118: Details of new tanks constructed during 2018-19

Farmers' name	Village	Tank dimension(m)					Capacity (m^3)	Land holding (ha)
		Top		Bottom		Depth		
		L	W	L	W			
Goutam Singh	Ningnoti	21.5	14.5	15	9	4	893.5	4.25
Abhay Singh	Ningnoti	15	11	11.2	10.3	4.5	630.81	0.87
Ishwar Singh	Ningnoti	57.5	15.5	53.5	11.5	2	1506.5	5.00
Raju Upmanyu	Bisakhedi	33	11	29.7	6.3	2	550.11	3.00
Pawan	Bisakhedi	26	14.5	17.5	15.6	2.7	877.5	4.25

During *rabi*, one supplemental irrigation from harvested rainwater increased the yield of chickpea by 23.7, 15.6 and 5.5 % in Vishal, Jaki-9218 and Dollar varieties, respectively with higher net returns and B:C ratio compared to no supplemental irrigation (Table 119).

Table 119: Effect of supplemental irrigation from harvested rainwater on yield and economics of chickpea

Variety	Seed yield (kg/ha)		WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With supplemental irrigation	Without supplemental irrigation			
Vishal	862	1130	1.75	19180	0.89
Jaki-9218	760	900	1.39	10900	0.51
Dollar	1040	1100	1.70	42600	1.82

Cropping systems

During *kharif* 2018, new soybean variety JS-2034 produced higher seed yield (1975 kg/ha), net returns (Rs. 40238/ha), B:C ratio (2.01) and RWUE (3.06 kg/ha-mm) followed by JS 95-60 (1706 kg/ha, Rs. 32033/ha and 1.60) compared to RVS-6124 (1587 kg/ha) (Table 120).

Table 120: Performance of new soybean varieties

Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
JS 95-60	1706	2.64	32033	1.60
JS-2034	1975	3.06	40238	2.01
RVS-6124	1587	2.46	28404	1.42

During *rabi*, potato variety ALR produced higher tuber yield (14160 kg/ha), net returns (Rs. 118200/ha) and B:C ratio (4.73) compared to Jyoti (13800 kg/ha) and Chipsona (12240 kg/ha) (Table 121).

Table 121: Performance of potato varieties

Variety	Tuber yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Jyoti	13800	114600	4.58
ALR	14160	118200	4.73
Chipsona	12240	99000	3.96

During *rabi*, wheat variety Tejas produced 28.1% higher grain yield (5350 kg/ha), with higher net returns (Rs. 81050/ha) and B:C ratio (3.12) with improved practice compared to farmers' practice (4175kg/ha). Other varieties, Lok 1 and Anmol also produced 14.4 and 8.4% higher grain yield (4175 and 4854 kg/ha) over farmers' practice (3650 and 4479 kg/ha) respectively (Table 122).

Table 122: Performance of new wheat varieties

Variety	Yield without intervention (kg/ha)	Yield with improved practice (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Anmol	4479	4854	6.1	71121	1.44
Tejas	4175	5350	6.7	81050	3.12
Lok 1	3650	4175	5.2	57550	2.22

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 2018-19

During 2018, the onset of monsoon was normal (9th June). A rainfall of 812.1 mm was received which was deficit by 68.6 mm (7.8%) compared to normal (880.9 mm). During *kharif* 802.4 mm rainfall was recorded which was deficit by 32.6 mm (3.9%) than normal rainfall of 835.0 mm (Fig.31).

Normal onset of monsoon	10 June
Onset of monsoon during 2018	9 June
Annual mean rainfall	880.9 mm
Annual mean rainfall during 2018-19	812.1 mm
Mean crop seasonal rainfall during *kharif*	835.0 mm
Crop seasonal rainfall during 2018 (*kharif*)	802.4 mm

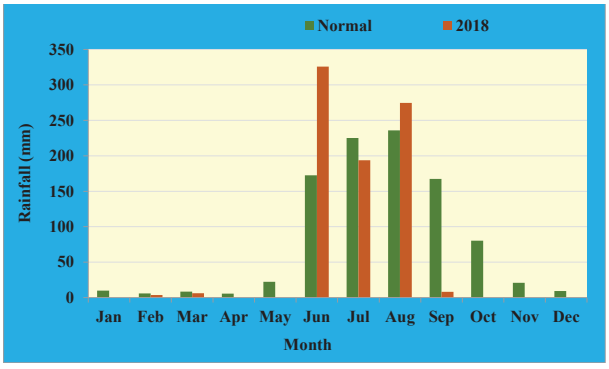


Fig. 31 : Normal and actual (2018) monthly rainfall at Parbhani

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
25	22 July - 15 August	Soybean, pigeonpea, cotton	Flowering & pod formation
33	28 August - 30 September	Soybean, pigeonpea, cotton	Grain filling and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Cotton, soybean,	Vegetative	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* 2018, a dry spell of 33 days occurred (28August to 30 September) at boll development of cotton. Foliar spray of KNO_3 @ 1.5% recorded significantly higher seed cotton yield (1659 kg/ha), net returns (Rs. 53759/ha), B:C ratio (2.46) and RWUE (2.94 kg-mm/ha) compared to other treatments. Foliar spray during dry spell recorded significantly higher seed cotton yield (1580 kg/ha) with higher net returns (Rs.49566/ha) and B:C ratio (2.35) compared to foliar spray after relieving of stress (Table 123). Foliar spray of water soluble complex fertilizer (19:19:19) at 0.5% + $ZnSO_4$ @ 0.5% also recorded higher relative water content (RWC) and chlorophyll content (Table 124).

Table 123: Effect of foliar spray on cotton yield and economics

Treatment	Seed cotton yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Main plot					
Foliar spray during dry spell	1580	36539	49566	2.35	2.80
Foliar spray after relieving of stress /dry spell	1307	36539	34708	1.94	2.32
CD at 5%	15		799		-
Sub plot					
Urea @ 1%	1385	35280	40202	2.13	2.46
Urea @ 2%	1399	35360	40886	2.15	2.48
Water soluble complex fertilizer (19:19:19) @ 0.5%	1449	36740	42203	2.14	2.57
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5%	1551	38270	46250	2.20	2.75
$ZnSO_4$ @ 0.5%	1500	39800	41941	2.05	2.66
Water spray	1325	35200	36994	2.05	2.35
KNO_3 @ 1.5%	1659	36665	53759	2.46	2.94
Control (no spray of any material/water)	1282	35000	34860	1.84	2.27
CD at 5%	100	-	5466	-	-

Table 124: Effect of foliar spray on RWC, chlorophyll content and NDVI values in cotton

Treatment	% RWC		Chlorophyll content		NDVI	
	T_1	T_2	T_1	T_2	T_1	T_2
Urea @ 1%	102.8	127.6	41.9	42.2	0.782	0.826
Urea @ 2%	108.9	129.8	41.9	42.4	0.780	0.814
Water soluble complex fertilizer (19:19:19) @ 0.5%	112.9	135.5	42.9	42.9	0.804	0.818
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5%	156.2	156.2	43.4	42.7	0.800	0.822
$ZnSO_4$ @ 0.5%	146.9	150.0	41.5	41.6	0.832	0.814
Water spray	107.1	118.8	40.9	41.0	0.786	0.782
KNO_3 @ 1.5%	176.2	158.6	44.3	43.2	0.838	0.856
Control (no spray of any material/water)	91.1	89.2	40.4	40.6	0.796	0.776

T_1: Foliar spray during dryspell; T_2: Foliar spray after relieving of dryspell

Foliar sprays of KNO_3 @ 1.5% recorded significantly higher soybean seed yield (1075 kg/ha), net returns (Rs. 13203/ha), B:C ratio (1.56) and RWUE (1.91 kg-mm/ha) compared to other treatments (Table 125). Foliar spray during dry spell recorded higher seed yield (1026 kg/ha), net returns (Rs. 12865/ha) and B:C ratio (1.58) compared to foliar spray after relieving of stress/dry spell.

Table 125: Effect of foliar spray on soybean (MAUS 158) seed yield and economics

Treatment	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Main plot				
Foliar spray during dry spell	1026	12865	1.58	1.82
Foliar spray after relieving of stress /dry spell	829	6161	1.27	1.47
CD at 5%	44.1	1499.3	-	-
Sub plot:				
Urea @ 1%	871	9048	1.44	1.54
Urea @ 2%	894	6970	1.46	1.58
Water soluble complex fertilizer (19:19:19) @ 0.5%	960	9143	1.38	1.70
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5%	1001	10335	1.43	1.77
$ZnSO_4$ @ 0.5%	986	9457	1.39	1.75
Water spray	837	8046	1.39	1.48
KNO_3 @ 1.5%	**1075**	**13203**	**1.56**	**1.91**
Control (no spray of any material/water)	798	7183	1.35	1.41
CD at 5%	102.3	3479.4	-	-

c. On-farm demonstrations

Village profile

The program is being implemented in Babulgaon village in Jintur Taluka, and new village Ujalamba, Parbhani Taluka and district, Maharashtra. The total cultivated area is 951.06 ha out of which 880.00 ha is rainfed. The mean annual rainfall is 880 mm with seasonal rainfall of 812.1 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 source of irrigation is open 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 880mm, 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 (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
9	12-20 June	Soybean, pigeonpea, greengram, blackgram and cotton	Vegetative
25	22 July – 15 August	Soybean, pigeonpea, greengram, blackgram and cotton	Flowering and Pod formation
33	28 August - 30 September	Soybean, pigeonpea, greengram, blackgram and cotton	Grain filling stage and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Soybean, pigeonpea	Vegetative	Weeding and intercultivation
Mid season drought	Soybean, pigeonpea	Flowering	Furrow opening, supplemental irrigation, foliar spray
Terminal drought	Soybean, pigeonpea	Seed filling and maturity	Supplemental irrigation, foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

In Babulgaon village, a dry spell of 9 days occurred during 12-20 June at vegetative stage of crops. *In-situ* moisture conservation through dust mulching and straw mulching @ 5 t/ha produced 13.5 (1010 kg/ha) higher yield compared to without mulching with higher net returns (Rs 14340/ha) (Table 126).

Table 126: Effect of mulching on soybean seed yield and economics

Farming situation/ soil type	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium black soil	Straw mulching @ 5 t/ha	1010	1.79	14340	1.71
	Farmers' practice (no mulching)	890	1.58	10260	1.51

Weeding with hoe at 21-25 DAS in soybean produced 14.7% higher seed yield (1100 kg/ha) compared to without weeding and intercultural operations, with higher net returns (Rs 17400/ha) (Table 127).

Table 127: Effect of weeding/interculture on soybean yield and economics

Farming situation/ soil type	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium black soil	Weeding/interculture	1100	1.95	17400	1.87
	Farmers' practice (no weeding)	959	1.70	12606	1.63

In Ujalamba village, a dry spell of 9 days occurred during 12-20 June at vegetative stage of crops. *In-situ* moisture conservation with dust mulching and straw mulching @ 5 t/ha produced 11.8% higher yield compared to without mulching, with higher net returns (Rs 15360/ha) and B:C ratio (1.76) (Table 128).

Table 128: Effect of mulching on soybean yield and economics

Farming situation/ soil type	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium black soil	Straw mulching @ 5 t/ha	1040	1.79	15360	1.76
	Farmers' practice (no mulching)	930	1.65	11620	1.58

In Ujalamba village, weeding with hoe and interculture at 21-25 DAS produced 11 to 12% higher seed yield compared to without weeding and interculture operations. Among the crops soybean produced higher seed yield (1085 kg/ha) with higher net returns (Rs 16890/ha) compared to pigeonpea (Table 129).

Table 129: Effect of weeding/interculture on soybean and pigeonpea yields and economics

Farming situation	Crop	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium black soil	Soybean	Weeding/interculture	1085	1.92	16890	1.84
		Farmers' practice	990	1.76	13660	1.68
	Pigeonpea	Weeding/interculture	600	1.06	12700	1.67
		Farmers' practice	515	0.91	8068	1.40

Farmers' practice: No weeding/interculture

Situation: Mid season drought

During *kharif* 2018, a dry spell of 25 days occurred (22 July to 15 August) at flowering and pod formation stage of crops. *In-situ* moisture conservation through opening of furrows after every 4 rows in soybean and after every 2 rows in pigeonpea enhanced yield by 13.0 and 17.9%, respectively. Among the crops, pigeonpea recorded highest net returns (Rs.18352/ha), RWUE (2.0 kg/ha-mm) and B:C ratio (1.9) with improved practice of opening of furrows (Table 130).

Table 130: Effect of *in-situ* moisture conservation on yield and economics of soybean and pigeonpea

Farming situation	Crop	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium black	Soybean- (MAUS 71)	Opening of furrows	1128	2.0	18352	1.9
		Farmers' practice	998	1.77	13932	1.69
	Pigeon pea (BDN 711)	Opening of furrows	802	1.42	15513	1.51
		Farmers' practice	680	1.20	9060	1.32

Farmers' practice: No furrow opening

One supplemental irrigation of 5 cm with sprinkler system from harvested rainwater in farm pond at pod formation stage of soybean increased the seed yield by 67.5% (1410 kg/ha), with higher net returns (Rs.27869/ha), B:C ratio (2.39) and WUE (1.63 kg/ha-mm) compared to farmers' practice of no supplemental irrigation (842 kg/ha) (Table 131).

Table 131: Effect of supplemental irrigation on soybean yield and economics

Farming situation/ soil type	Intervention	Seed yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium Black	Supplemental irrigation	1410	1.63	27869	2.39
	Farmers' practice (no supplemental irrigation)	842	1.49	8628	1.43

Foliar spray of both KNO_3 (1% & 2%) and water sprays (35 & 60 DAS) at pod filling stage increased the yield of soybean and pigeonpea by 9.8 to 33.2% compared to farmers' practice of no foliar spray. In both crops, foliar spray of KNO_3 (1% & 2%) gave higher yields and net returns compared to water spray (Table 132).

Table 132: Effect of foliar sprays on soybean and pigeonpea on yields and economics

Farming situation/ soil type	Crop	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium black soil	Soybean	KNO_3 @ 1%	1070	2.08	19780	1.81
		Water spray	988	1.75	16380	1.67
		Farmers' practice	810	1.44	7540	1.37
	Pigeonpea	KNO_3 @ 2%	810	1.44	15968	1.53
		Water spray	730	1.29	11427	1.38
		Farmers' practice	665	1.18	8243	1.29

Demonstration of foliar spray (KNO_3) for dry spell mitigation in soyabean

In Ujalamba village, one supplemental irrigation of 5 cm with sprinkler system, from harvested rainwater in farm pond, at pod formation stage of soybean increased the seed yield by 58.9% (1430 kg/ha), with higher net returns (Rs.28620/ha), B:C ratio (2.43) and WUE (1.63 kg/ha-mm) compared to farmers' practice of no supplemental irrigation (842 kg/ha) (Table 133).

Table 133: Effect of supplemental irrigation on soybean yield and economics

Farming situation/ soil type	Intervention	Seed yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium black	Supplemental irrigation	1430	1.63	28620	2.43
	Farmers' practice (no supplemental irrigation)	900	1.60	10600	1.53

Situation: Terminal drought

During *kharif* 2018, a dry spell of 33 days occurred (28 August to 30 September) coinciding with seed filling and harvesting stages of soybean. Supplemental irrigation from harvested rainwater in farm pond with a depth of 5 cm in soybean (MAUS-158) gave highest seed yield (1410 kg/ha), net returns (Rs.27869/ha), B:C ratio (2.39) and WUE (2.50 kg/ha-mm) compared to farmers' practice of no supplemental irrigation (840 kg/ha) (Table. 134). In Ujalamba village, supplemental irrigation in soybean (MAUS-158) gave highest soybean yield (1430 kg/ha), net returns (Rs.28620/ha), B:C ratio (2.43) and WUE (2.54 kg/ha-mm) compared to farmers' practice of no supplemental irrigation (900 kg/ha)

Table 134: Effect of supplemental irrigation on soybean yield and economics

Village	Farming situation/ soil type	Intervention	Seed yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Babhulgaon	Light to medium black soil	Supplemental irrigation	1410	2.50	27869	2.39
		Farmers' practice	840	1.49	8560	1.42
Ujalamba	Light to medium black soil	Supplemental irrigation	1430	2.54	28620	2.43
		Farmers' practice	900	1.60	10600	1.53

Foliar spray of KNO_3 @ 1% in soybean & @ 2% in pigeonpea at pod filling stage increased the yield of soybean and pigeonpea by 14.3 to 15.4% compared to farmers' practice of no foliar spray, and gave higher net returns and B:C ratio (Table 135).

Table 135: Effect of foliar sprays on soybean and pigeonpea yield and economics

Farming situation/ soil type	Crop	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Light to medium black soil	Soybean	KNO_3 @ 1%	1165	2.07	19610	1.98
		Farmers' practice	1025	1.82	14850	1.74
	Pigeon pea	KNO_3 @ 2%	768	1.36	13584	1.45
		Farmers' practice	665	1.18	9243	1.34

Preparedness

Rainwater management

In Babhulgaon village, *in-situ* moisture conservation in soybean with broad bed and furrow (BBF) method resulted in higher seed yield (1200 kg/ha), net returns (Rs. 20180/ha), B:C ratio (2.02) and RWUE of 2.13 kg/ha-mm compared to farmers' practice (flat bed). Similarly, in Ujalamba village, *in-situ* moisture conservation in soybean with broad bed and furrow (BBF) method gave higher seed yield (1185 kg/ha), net returns (Rs. 20990/ha), B:C ratio (1.99) and RWUE of 2.10 kg/ha-mm compared to farmers' practice (flat bed) (Table 136).

Table 136: Effect of *in-situ* moisture conservation on yield and economics of soybean

Village	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	Stalk				
Babhulgaon	Light to medium black soil	BBF	1200	2120	20180	20620	2.02	2.13
		Farmers' practice	995	1975	19000	14830	1.78	1.76
Ujalamba	Light to medium black soil	BBF	1185	-	20180	20990	1.99	2.10
		Farmers' practice	1005	-	19000	15170	1.79	1.78

Soybean under BBF method

Cropping systems

Intercropping of soybean + pigeonpea (4:2) gave higher soybean equivalent yield (SEY) (1312 kg/ha), net returns (Rs.18608/ha), B:C ratio (1.71) and RWUE (2.33 kg/ha-mm) compared to farmers' practice of sole soybean (965 kg/ha). Similarly sorghum + pigeonpea intercropping system (4:2) gave higher soybean equivalent yield (1547 kg/ha) and net returns (Rs. 22692/ha) compared to farmers practice of sole sorghum (850 kg/ha) (Table 137).

Soybean + pigeonpea intercropping system (4:2)

Table 137: Performance of soybean + pigeonpea (4:2) and sorghum + pigeonpea (4:2) intercropping systems

Farming situation	Intervention	SEY (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2018-19	Mean (2 yrs)				
Light to medium black soil	Soybean + pigeonpea (4:2)	1312	1553	26000	18608	1.71	2.33
	Farmers' practice (sole soybean)	965	983	20100	12710	1.63	1.71
	Sorghum + pigeonpea (4:2)	1547	1723	14900	22692	2.5	2.75
	Farmers practice (sole sorghum	850	925	12250	8405	1.68	1.51

SEY: Soyabean equivalent yield

In Ujalamba village, during *rabi*, chickpea + safflower (6:2) intercropping system gave higher chickpea equivalent yield (CEY) (579 kg/ha), net returns (Rs.6588/ha), B:C ratio (1.32) and RWUE (1.02 kg/ha-mm) compared to farmers' practice of sole chickpea (500 kg/ha) (Table 138).

Table 138: Performance of chickpea + safflower (6:2) intercropping system

Farming situation	Intervention	CEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Light to medium black soil	Chickpea+ safflower intercropping (6:2)	579	20162	6588	1.32	1.02
	Farmers' practice (sole chickpea)	500	19100	4000	1.20	0.88

CEY: Chickpea equivalent yield

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 2018-19

During 2018, the onset of monsoon was early (10th June). A rainfall of 1054.2 mm was received which was excess by 236.7 mm (28.9%) compared to normal (817.5 mm). During *kharif*, 1037.2 mm rainfall was received which was excess by 294.9 mm than normal (742.3 mm). During *rabi* (October-December), no rainfall was received against normal rainfall of 29.8 mm and during summer (March-May), 8.0 mm of rainfall was received which was deficit by 16.2 mm compared to normal (24.2 mm) (Fig.32).

Normal onset of monsoon	3rd week of June
Onset of monsoon during 2018	10 June
Annual mean rainfall	817.5 mm
Annual mean rainfall during 2018-19	1054.2 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	742.3 and 29.8 mm, respectively
Crop seasonal rainfall during 2018 (*kharif* & *rabi*)	1037.2 and 0.0 mm during *kharif* and *rabi*, respectively

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
16	24 September – 10 October	Groundnut	Pod development

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Groundnut	Pod development	Foliar spray
	Sorghum	Boot stage	Foliar spray

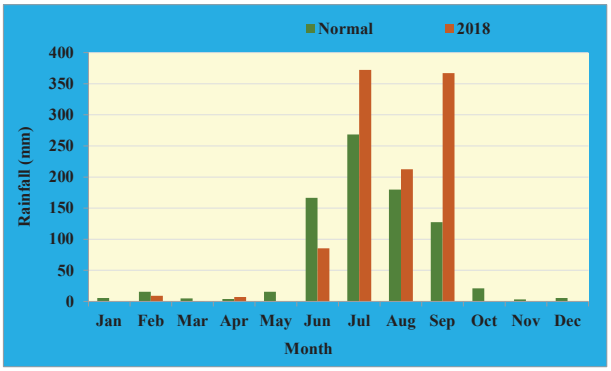


Fig.32: Normal and actual (2018) monthly rainfall at Jhansi

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* 2018, a dry spell of 16 days occurred at vegetative stage of sorghum. Among different foliar sprays, water soluble complex fertilizers (19: 19: 19) @ 0.5 % + zinc and iron @ 0.5% each (Zn through zinc sulphate and Fe through iron sulphate) produced higher green and dry fodder yield (19333 and 9217 kg/ha) which was at par with treatment recommended dose of micronutrients for foliar spray (Zinc, boron, iron & Mn @ 0.5% each) (17633 and 8400 kg/ha) compared to other treatments (Table 139).

Table 139: 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	16.42	6.95	118	17033	8114
F_2: Foliar spray after relieving of stress/ dry spell	15.23	7.00	122	15690	7471
CD at 5%	0.96	NS	NS	NS	NS
Sub plot					
S_1 : Urea 1%	16.50	7.17	121	17617	8383
S_2 : Urea 2%	15.67	7.17	119	17250	8200
S_3: Water soluble complex fertilizers (19:19:19) @ 0.5%	15.83	7.50	129	17350	8283
S_4: S_3 + foliar spray of zinc and iron @ 0.5% each	15.50	7.83	129	19333	9217
S_5: Foliar spray of zinc, boron, iron & Mn @ 0.5% each	15.67	7.33	124	17633	8400
S_6: Water spray	15.50	5.67	111	13783	6567
S_7: Control	16.16	6.17	105	11567	5500
CD at 5%	NS	1.02	7.8	2832	1349

GFY: Green fodder yield; DFY: Dry fodder yield

Similarly, in groundnut, foliar spray of water soluble complex fertilizers (19:19:19) @ 0.5% and recommended dose of micronutrients for foliar spray (zinc, boron, iron & Mn @ 0.5% each) being par with each other recorded significantly higher pod yield (409 and 400 kg/ha) and haulm yield (799 and 782 kg/ha) respectively over other treatments (Table 140).

Table 140: Effect of different foliar sprays on growth and yield of groundnut

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						
F_1: Foliar spray during dry spell	6.14	75.38	27.00	16.57	358	698
F_2: Foliar spray after relieving of stress/ dry spell	6.04	76.42	25.90	16.23	348	679
CD at 5%	NS	NS	NS	NS	9.6	18
Sub plot						
S_1 : Urea 1%	5.50	77.50	27.00	16.50	331	646
S_2 : Urea 2%	5.83	75.16	28.00	16.33	328	640
S_3: Water soluble complex fertilizers (19:19:19)@ 0.5%	6.00	75.16	28.50	16.33	409	799
S_4: S_3 + foliar spray of zinc and iron @ 0.5% each	6.67	78.83	25.83	16.83	399	779
S_5: Foliar spray of zinc, boron, iron & Mn @ 0.5% each	6.00	75.50	26.33	16.67	400	782
S_6: Water spray	6.67	73.50	24.00	15.83	301	588
S_7: Control	6.00	73.67	25.50	16.33	300	586
CD at 5%	NS	NS	NS	Ns	18	34.9

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 2018-19

During 2018, in Kadesara kalan village, the onset of monsoon was normal (27th June). A rainfall of 943.8 mm was received which was deficit by 78.3 mm compared to normal of 1022.0 mm. During south-west monsoon (*kharif*), 937.6 mm rainfall was received which was 195.3 mm excess compared to normal of 742.3 mm and during *rabi* (October to December), there was 6.1 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.33).

Normal onset of monsoon	25 June (26th SMW)
Onset of monsoon during 2018	27 June (26th SMW)
Annual mean rainfall	1022.0 mm
Annual mean rainfall during 2018-19	943.8 mm
Mean crop seasonal rainfall during *kharif*	742.3 and 29.8 mm, during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018 (*kharif*)	937.6 and 6.1 mm, during *kharif* and *rabi*, respectively

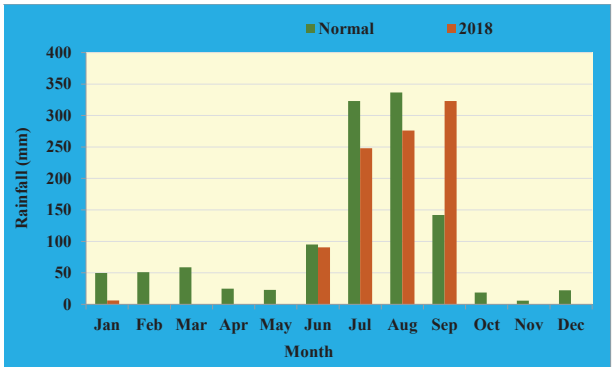


Fig. 33: Normal and actual (2018) monthly rainfall at Kadesara Kalan

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
20	10 - 30 September	Groundnut, blackgram	Pod development

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of the crop	RTCP implemented
Terminal drought	Groundnut	Pod development	Supplemental irrigation
	Blackgram	Pod filling	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

At Kadesara Kalan village, supplemental irrigation (40 mm) from harvested rainwater increased the pod yield of groundnut by 49.0% (1078 kg/ha) with higher net returns (Rs.38448/ha) and B:C ratio (2.35) compared to without supplemental irrigation (708 kg/ha). Similarly, at Hanauta village, supplemental irrigation (40 mm) from harvested rainwater increased the pod yield of groundnut by 46.0% (1037 kg/ha) with higher net returns (Rs.36331/ha) and B:C ratio (2.22) compared to without supplemental irrigation (708 kg/ha) (Table 141).

Groundnut under supplemental irrigation

Table 141: Effect of supplemental irrigation on yield and economics of groundnut

Village	Farming situation/ soil type	Intervention	Pod yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Kadesara Kalan	Medium deep black soil	Supplemental irrigation	1078	1.15	38448	2.35
		Farmers' practice (no supplemental irrigation)	708	0.76	19773	1.21
Hanauta	Medium deep black soil	Supplemental irrigation	1037	1.11	36331	2.22
		Farmers' practice (no supplemental irrigation)	708	0.76	19773	1.21

At Kadesara Kalan village, *in-situ* moisture conservation through weeding and interculture increased blackgram seed yield by 33.5% (517 kg/ha) with higher net returns (Rs.14260/ha) and B:C ratio (1.87) compared to farmers' practice of no weeding and interculture (387 kg/ha). At Hanauta village, *in-situ* moisture conservation practice of weeding and interculture increased blackgram seed yield by 37.0% (531 kg/ha) with higher net returns (Rs.14859/ha) and B:C ratio (1.43) compared to farmers' practice of no weeding and interculture (387 kg/ha) (Table 142).

Table 142: Effect of intercultural operations on performance of blackgram

Village	Farming situation/ soil type	Intervention	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Kadesara Kalan	Shallow alluvial soils	Weeding/ interculture	517	0.55	14260	1.87
		Farmers' practice	387	0.41	6465	1.39
Hanauta	Shallow alluvial soils	Weeding/ interculture	531	0.57	14859	1.43
		Farmers' practice	387	0.41	6465	1.39

At Kadesara Kalan village, foliar spray of 2% urea at branching and pod formation stage of blackgram increased the seed yield by 52.2% (589 kg/ha), with higher net returns (Rs.18252/ha) and B:C ratio (2.11) compared to farmers' practice of no foliar spray (387 kg/ha). Similarly, at Hanauta village, foliar spray of 2% urea solution at increased the seed yield by 27.0% (495 kg/ha), with higher net returns (Rs.12850/ha) and B:C ratio (1.78) compared to farmers' practice of no foliar spray (387 kg/ha) (Table 143).

Table 143: Effect of foliar spray on yield and economics of blackgram

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Kadesara Kalan	Medium black soil	Foliar spray of 2% urea	589	0.62	18252	2.11
		Farmers' practice (no foliar spray)	387	0.41	6465	1.39
Hanauta	Medium black soil	Foliar spray of 2% urea	495	0.52	12850	1.78
		Farmers' practice (no foliar spray)	387	0.41	6465	1.39

Preparedness

Rainwater management

At Kadesara Kalan village, use of herbicide for weed control and dust mulching at 30 DAS in groundnut increased pod yield by 55.8% (1025 kg/ha), with higher net returns (Rs.35564/ha) and B:C ratio (1.09) compared to farmers' practice of no herbicide use and dust mulching (708 kg/ha) (Table 144).

Table 144: Effect of sowing time, herbicide spray and dust mulching on performance of groundnut

Farming situation/ soil type	Intervention	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Pod	Haulm			
Shallow alluvial soils	Improved practice	1025	1196	35564	2.17	1.09
	Farmers' practice	708	1012	19773	1.21	0.76

*Improved practice: Timely sowing, spray of herbicide to control weeds, dust mulch at 30 DAS

Cropping systems

At Kadesara Kalan village, among different double cropping systems in medium black soils, groundnut (Amber)-wheat (HI-1418) system gave higher main crop equivalent yield (7375 kg/ha), net returns (Rs.103389/ha), B:C ratio (3.97) and RWUE (7.81 kg/ha-mm) when compared to farmers' practice. Similarly, in medium black soil, blackgram (Azad-2)-wheat (HI-1605) system gave higher main crop equivalent yield (6622 kg/ha) and net returns (Rs.90552/ha) and B:C ratio (3.60) compared to farmers' practice. In shallow alluvial soils, sesame (Shekhar)-wheat (Raj-3765) system gave higher main crop equivalent yield (5471 kg/ha), net returns (Rs.69746/ha) and B:C ratio (3.01) compared to farmers practice (Table 145)

Table 145: Yield and economics of double cropping systems

Farming situation/ soil type	Cropping system	Yield (kg/ha)		MCEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Crop 1	Crop 2				
Medium black soil	Groundnut (Amber) -Wheat (HI-1418)	1044	4430	7375	103389	3.97	7.81
	Farmers' practice	708	2760	4756	59176	2.92	5.04
Medium black soil	Blackgram (Azad-2) -Wheat (HI-1605)	527	4920	6622	90552	3.60	7.01
	Farmers' practice	387	2760	4010	45869	2.49	4.24
Shallow alluvial soils	Sesame (Shekhar)-Wheat (Raj-3765	394	4050	5471	69746	3.01	4.70
	Farmers' practice	297	2760	3831	42685	1.39	3.23

MCEY: Main crop equivalent yield; Farmers' practice: Groundnut-wheat double cropping with local varieties

Energy management

At Kadesara Kalan village, sowing of wheat with bullock drawn seed drill gave higher grain yield (4230 kg/ha) net returns (Rs.65018/ha) and B:C ratio (4.43) compared to farmers' practice (2760 kg/ha). Similarly, sowing of blackgram with bullock drawn seed drill gave higher seed yield (499 kg/ha), net returns (Rs.13946/ha) and B:C ratio (1.91) compared to farmers' practice (387 kg/ha) (Table 146).

Table 146: Yield and economics of wheat and blackgram as affected by sowing method

Farming situation/ soil type	Intervention	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio
		Seed/grain	Stover/stalk		
Medium black soil	Wheat sowing with bullock drawn seed drill	4230	5320	65018	4.43
	Farmers' practice	2760	3890	35339	1.92
Medium black soil	Black gram sowing with bullock drawn seed drill	499	911	13946	1.91
	Farmers' practice	387	776	6465	1.39

Farmers' practice: Broadcasting

1.2.6 RAKH DHIANSAR

a. Agro-ecological setting

Rakh Dhiansar is situated at 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: Nil

Experienced weather conditions during 2018-19

During 2018, the onset of monsoon was delay by 2 days (29 June). The annual rainfall recorded during the year was 768.1 mm which was deficit by 382.8 mm than the normal (1150.9 mm). Out of the total rainfall received, 631.8 mm was received during the *kharif* season (June to September) which was deficit by 254.0 mm (28.7%) as against normal of 885.8 mm. In *rabi*, 43.2 mm rainfall was received which was deficit by 4.4 mm (9.2%) than normal of 47.6 mm. In summer season, 48.9 mm rainfall was received which was deficit by 65.2 mm as against normal of 114.1 mm (Fig.34.).

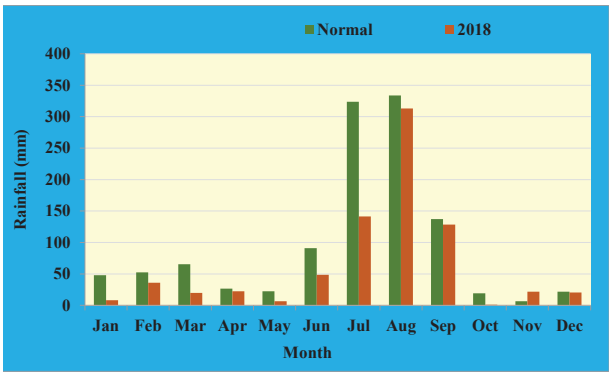


Fig.34: Normal and actual (2018) monthly rainfall at Rakh Dhiansar

Normal onset of monsoon	27 June
Onset of monsoon during 2018	29 June
Annual mean rainfall	1150.9 mm
Annual rainfall during 2018-19	768.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	885.8 and 47.6 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif & rabi)*	631.8 and 43.2 mm, respectively

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
18	14 December-31 December	Wheat	Germination

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% of the 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 is 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 2018-19

During 2018, the onset of monsoon was normal (29 June). The annual rainfall recorded during the year was 768.1 mm, which was deficit by 383.0 mm than the normal rainfall of 1151.1 mm. Out of total rainfall, 631.8 mm was received during the *kharif* season (June to September) as against normal of 668.5 mm. In *rabi*, 43.2 mm rainfall was received which was 65.5 mm deficit than normal of 108.7 mm (Fig.35).

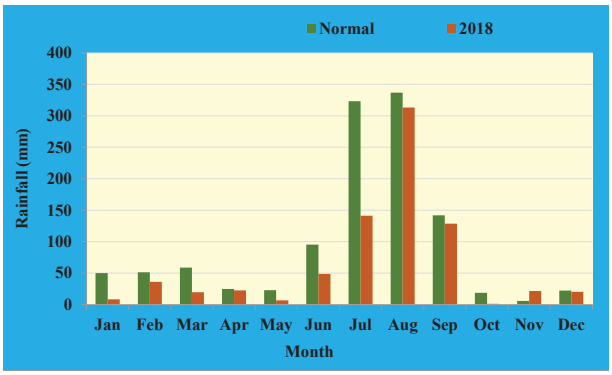


Fig. 35: Normal and actual (2018) monthly rainfall at Khaner

Normal onset of monsoon	27 June
Onset of monsoon during 2018	29 June
Annual mean rainfall	1150.9 mm
Annual rainfall during 2018-19	768.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	668.5 mm and 108.7 mm, respectively
Crop seasonal rainfall during 2018 (*kharif* and *rabi*)	631.8 mm and 43.2 mm, respectively

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
33	30 September - 01 November 2018	Maize	Maturity & harvesting
18	14 December-31 December 2018	Wheat	Germination

Real time contingency practices (RTCP) implemented: Nil

Salient achievements of on-farm demonstrations

Preparedness

Rainwater management

At Kahner village, maize hybrid Double dekalb sown across the slope gave 15.1% higher maize grain yield (2360 kg/ha) with higher net returns (Rs. 29532/ha), B:C ratio (2.4) and RWUE (4.28 kg/ha-mm) as compared to farmers' practice of sowing along the slope (2050 kg/ha) (Table 147).

Table 147: Effect of sowing methods on yield and economics of maize

Intervention	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sowing across the slope	2360	20500	4.28	29532	2.4
Sowing along the slope (Farmers' practice)	2050	19700	3.71	21505	2.1

Cropping systems

At Khaner village an intercropping system of maize + blackgram (1:1) (additive series) gave 21% higher maize equivalent yield (2748 kg/ha) with higher net returns (Rs. 34533/ha), B:C ratio (2.53) and RWUE (4.98 kg/ha-mm) as compared

to farmers' practice of sole maize (1900 kg/ha). Similarly, at Madana village, intercropping system of maize + blackgram (1:1) gave 19.1% higher maize equivalent yield (2609 kg/ha) with higher net returns (Rs.31993/ha), B:C ratio (2.42) and RWUE (4.73 kg/ha-mm) as compared to farmers' practice of sole maize (2190 kg/ha) (Table 148).

Table 148: Performance of maize + blackgram (1:1) intercropping system

Village	Farming situation/soil type	Intervention	MEY (kg/ha)	Cost of cultivation (Rs/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Khaner	Medium deep soils	Maize + blackgram (1:1)	2748	22500	4.98	34533	2.53
		Sole maize (farmers' practice)	1900	19700	3.44	18870	1.95
Madana	Medium deep soils	Maize + blackgram (1:1)	2609	22500	4.73	31993	2.42
		Sole maize (farmers' practice)	1850	19700	3.40	18400	1.93

MEY: Maize equivalent yield

Energy management

Sowing of maize with maize planter gave 17.5 and 21.1% higher grain yield over farmers' practice in Khaner and Madana villages respectively with net returns of Rs. 35198 and 35319/ha, B:C ratio (2.72 each) and RWUE (4.54 and 4.60 kg/ha-mm). The energy use input and output ranged from 6905-6893 MJ/ha and 115298-114951 MJ/ha respectively with energy use efficiency of 16.70 and16.68 in Khaner and Madana villages (Table 149).

Table 149: Effect of maize planter for sowing on yield and economics of maize

Farming situation/ soil type	Village	Mean yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	Energy (MJ/ha)		Energy use efficiency
		Improved	Farmers' practice				Input	Output	
Medium deep soils	Khaner	2509	2134	4.54	35198	2.72	6905	115298	16.70
	Madana	2521	2082	4.60	35319	2.72	6893	114951	16.68

Farmers' practice: Broadcasting

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 conditions during 2018-19

During 2018, the onset of monsoon was normal (27th June). The annual rainfall during the year was 1357.7 mm, which was excess by 263.4 mm than the normal annual rainfall of 1094.3 mm. Out of the total rainfall, 1203.5 mm was received during the *kharif* season (June to September) which was excess by 341.5 mm (39.6%) as against normal of 862.0 mm. In *rabi*, 240.2 mm rainfall was received which was 49.7 mm excess (26.1%) than normal of 190.5 mm. In summer season, 56.5 mm rainfall was received which was deficit by 25.6 mm as against normal of 82.1 mm (Fig.36).

Normal onset of monsoon	1 July
Onset of monsoon during 2018	27 June
Annual mean rainfall	1094.3 mm
Annual rainfall during 2018-19	1357.7 mm
Mean crop seasonal rainfall	862.0 and 190.5 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018-19	1203.5 and 240.2 mm during *kharif* and *rabi*, respectively

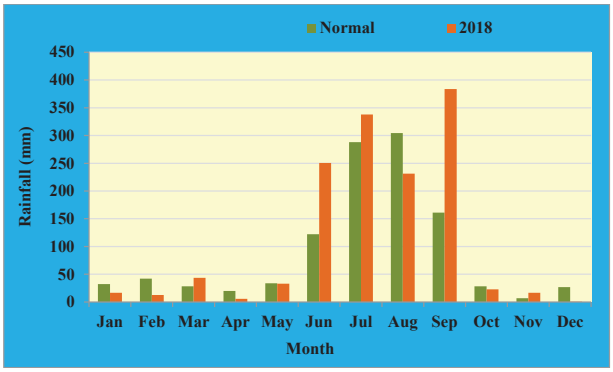


Fig. 36: Normal and actual (2018) monthly rainfall at Ballowal Saunkhri

There were no dry spells during crop growing season (2018-19) and therefore real time contingency practices (RTCP) were not implemented

Salient achievements of on-station experiments

Preparedness

Rainwater management

During *kharif* 2018, 39.6% higher rainfall was received than normal (862.0 mm). So the maize yield and other crop parameters were found to be at par with the rainfed crop compared to different drip irrigation treatments. However, scheduling irrigation through drip @ 100% of ET in maize using harvested rainwater gave marginally higher grain yield (4231 kg/ha) as compared to rainfed crop (4198 kg/ha) (Table 150).

Table 150: 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	Mean grain (2 yrs)	Straw				
Rainfed	4198	3754	7514	35832	34652	1.87	3.48
50% ET	4210	4053	7621	37512	33259	1.89	3.49
75 % ET	4208	4227	7959	37551	33393	1.89	3.49
100 % ET	4231	4311	7869	37529	33805	1.90	3.51
CD at 5%	NS	-	NS	-	-	-	-

In maize foliar spray of 2% urea resulted in highest grain yield (3764 kg/ha) which was statistically at par with foliar spray of urea @ 1%, 19:19:19 @ 1% and 19:19:19 @ 1% + $ZnSO_4$ @ 0.5% but was significantly higher compared to $ZnSO_4$ @ 0.5%, KCl @ 2%, water spray and no spray treatments. Foliar spray of urea @ 2% also recorded higher net returns (Rs. 41496/ha), B:C ratio (2.36) and RWUE (4.24 kg/ha-mm) compared to other treatments (Table 151).

Table 151: Effect of foliar application of different fertilizers on maize yield and economics

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
No spray	3005	5446	3.39	26610	1.85
Water spray	3290	5914	3.71	33268	2.11
Urea @ 1%	3594	6662	4.05	39146	2.30
Urea @ 2%	3764	6674	4.24	41496	2.36
KCl @ 2%	3411	6186	3.84	35242	2.16
Water soluble complex fertilizer (19:19:19) @ 1%	3541	6493	3.99	37410	2.22
Water soluble complex fertilizer (19:19:19) @ 1% + $ZnSO_4$ @ 0.5%	3711	6815	4.18	40552	2.31
$ZnSO_4$ @ 0.5%	3258	2843	3.67	27834	1.92
CD at 5%	345	616	-	-	-

Maize with urea spray @ 2%

Maize with no foliar spray

c. On-farm demonstrations

Village profile

The program is being implemented 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 south-west 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 2018-19

During 2018, the onset of monsoon was normal (27th June). The annual rainfall during the year was 1265.9 mm, which was 171.6 mm excess than the normal annual rainfall of 1094.3 mm. Out of total rainfall, 1142.4 mm was received during the *kharif* season (June to September) which was excess by 280.4 mm (32.5%) as against normal of 862.0 mm. In *rabi*, 17.8 mm rainfall was received which was 44.1 mm deficit than normal of 61.9 mm and in summer season, it was 56.5 mm which was deficit by 25.6 mm as against normal of 82.1 mm (Fig.37)

Normal onset of monsoon	1 July
Onset of monsoon during 2018	27 June
Annual mean rainfall	1094.3 mm
Annual mean rainfall during 2018-19	1265.9 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	862.0 and 61.9 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	1142.4 and 17.8 mm, respectively

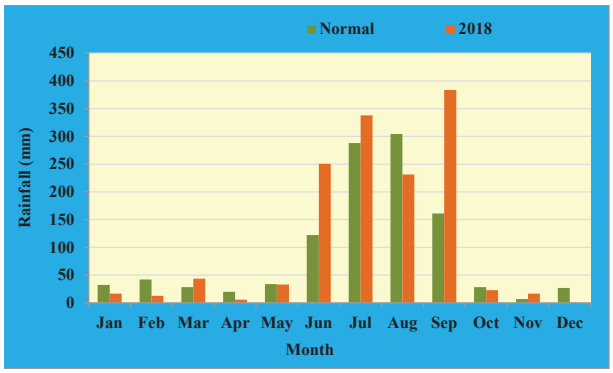


Fig.37 : Normal and actual (2018) monthly rainfall at Achalpur

There were no dry spells during crop growing season (2018-19) and therefore real time contingency practices (RTCP) were not implemented

Salient achievements of on-farm demonstrations

Preparedness

Rainwater management

Sowing of maize on ridges recorded higher grain and stover yield (4270 and 7771 kg/ha), net returns (Rs.39190/ha), B:C ratio (2.20) and RWUE (3.73 kg/ha-mm) followed by bed sowing (4010 and 7258 kg/ha) compared to flat bed sowing (3415 kg/ha) (Table 152).

Table 152: Effect of planting methods on yield and economics of rainfed maize

Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Grain	Mean (2 yrs)	Stover				
Ridge planting	4270	4058	7771	32629	39190	2.20	3.73
Bed planting	4010	3946	7258	32408	35000	2.08	3.51
Flat bed sowing (Farmers' practice)	3415	3289	6249	33138	24336	1.73	2.99

At villages Achalpur and Nainwan, *in-situ* moisture conservation through summer ploughing immediately after harvest of wheat gave higher maize grain yield of 3993 and 3872 kg/ha with net return of Rs. 29433 and 36118/ha and B:C ratio of 1.77 and 1.94, respectively as compared to sowing without summer ploughing. In the newly adopted village Bhawanipur, summer ploughing gave grain yield of 4370 kg/ha with net returns of Rs.45255/ha and B:C ratio of 2.17 compared to sowing of crops without summer ploughing (Table). At village Achalpur and Nainwan, *in-situ* moisture conservation through sowing of maize across the slope gave grain yield of 3556 and 3530 kg/ha with net returns of Rs. 27162 and 34615/ha compared to sowing of maize along the slope. In Bhawanipur village also, sowing of maize across the slope gave higher grain yield (3593 kg/ha) and net returns (Rs.35771/ha) compared to sowing of maize along the slope.

Similarly, earthing up in maize gave grain yield of 3852 and 4341 kg/ha with higher net returns

of Rs.31308 and 48870/ha, respectively at both Achalpur and Nainwan villages compared to over without earthing up. In Bhawanipur village also, earthing up in maize gave higher grain yield (4524 kg/ha) and net returns (Rs.52227/ha) compared to no earthing up (Table 153).

Table 153: Effect of *in-situ* moisture conservation on yield and economics of maize

Intervention	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Achalpur village				
Summer ploughing	3993	4.49	29433	1.77
Farmers' practice (without summer ploughing)	3480	3.91	25937	1.78
Sowing across slope	3556	4.00	27162	1.82
Farmers' practice (Sowing along the slope)	3204	3.60	21489	1.65
Earthing up	3852	4.33	31308	1.92
Farmers' practice (without earthing up)	2795	3.14	22011	1.69
Nainwan village				
Summer ploughing	3872	4.35	36118	1.94
Farmers' practice (without summer ploughing)	3319	3.73	30744	1.93
Sowing across slope	3530	3.97	34615	2.04
Farmers' practice (Sowing along the slope)	3239	3.64	29276	1.89
Earthing up	4341	4.88	48870	2.41
Farmers' practice (without earthing up)	3284	3.69	29893	1.92
Bhawanipur village				
Summer ploughing	4370	4.91	45255	2.17
Farmers' practice (without summer ploughing)	3854	4.33	40560	2.21
Sowing across slope	3593	4.04	35771	2.07
Farmers' practice (Sowing along the slope)	3161	3.55	27845	1.85
Earthing up	4524	5.08	52227	2.50
Farmers' practice (without earthing up)	3496	3.93	33310	2.02

Cropping systems

At Achalpur, Maize hybrid PMH 1 gave higher grain yield (4229 kg/ha) compared to Prakash and local cultivar, with higher net returns (Rs.43774/ha), B:C ratio (2.16) and RWUE (4.8 kg/ha-mm). Similar results were recorded at village Nainwan and Bhawanipur villages (Table). At Achalpur, blackgram variety Mash 114 gave highest seed yield of 626 kg/ha compared to KUG 725 and local cultivars. Similarly at villages Nainwan and Bhawanipur, Mash 114 gave highest seed yield (723 and 696 kg/ha, respectively) compared to other varieties. At Achalpur, greengram variety ML 2056 gave higher seed yield (648 kg/ha) and net returns (Rs.12849/ha) over local cultivar. Similar results were recorded at Nainwan and Bhawanipur.

At Achalpur, sesame variety Punjab Til No. 2 gave higher seed yield (531 kg/ha) compared to RT 346 (354 kg/ha) and local cultivar (231 kg/ha), with higher net returns of Rs.31660/ha and B:C ratio (2.48). Similarly at village Nainwan and Bhawanipur, Punjab Til No 2 performed better than other varieties (Table 154).

Table 154: Performance of improved varieties of different crops

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C	RWUE (kg/ha-mm)
	Grain/seed	Stover/stalk				
Maize						
Achalpur village						
PMH-1	4229	9473	37592	43774	2.16	4.8
Prakash	2750	5390	36716	23674	1.64	3.1
Local	2357	5209	33821	23242	1.69	2.6
Nainwan village						
PMH-1	3890	8714	37293	37551	2.01	4.4
Prakash	2420	4743	36374	16769	1.46	2.7
Local	3141	6942	34715	41329	2.19	3.5
Bhawanipur village						
PMH-1	4200	9408	37567	43241	2.15	4.7
Prakash	2240	4390	36187	13003	1.36	2.5
Local	2180	4818	33619	19159	1.57	2.4
Blackgram						
Achalpur village						
Mash 114	626	3906	25750	8680	1.34	0.7
KUG 725	470	2449	25750	100	1.00	0.5
Local	371	2371	22298	3672	1.16	0.4
Nainwan village						
Mash 114	723	4512	25750	14015	1.54	0.8
KUG 725	501	2610	25750	1805	1.07	0.6
Local	392	2505	22298	5142	1.23	0.4
Bhawanipur village						
Mash 114	696	4343	25750	12530	1.49	0.8
KUG 725	429	2235	25750	-2155	0.92	0.5
Local	325	2077	22298	452	1.02	0.4
Greengram						
Achalpur village						
ML 2056	648	4523	22791	12849	1.56	0.7
Local	398	2078	18656	3234	1.17	0.4
Nainwan village						
ML 2056	686	4788	22791	14939	1.66	0.8
Local	422	2203	18656	4554	1.24	0.5
Bhawanipur village						
ML 2056	742	5179	22791	18019	1.79	0.8
Local	334	1743	18656	-286	0.98	0.4
Sesame						
Achailpur village						
PB Til No 2	531	4004	21440	31660	2.48	0.6
RT 346	354	2683	21440	13960	1.65	0.4
Local	231	1642	15599	7501	1.48	0.3
Nainwan village						
PB Til No 2	409	3100	21440	19460	1.91	0.5
RT 346	354	2669	21440	13960	1.65	0.4
Local	180	1280	15599	2401	1.15	0.2
Bhawanipur village						
PB Til No 2	472	3578	21440	25760	2.20	0.5
RT 346	386	2910	21440	17160	1.80	0.4
Local	264	1877	15599	10801	1.69	0.3

Energy management

Among different sowing methods in maize, higher grain yield was recorded with manually operated seed drill in all the three villages with higher net returns, B:C ratio and RWUE compared to other sowing methods (Table 155).

Table 155: Effect of sowing implements on yield and economics of maize

Intervention	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Achalpur village				
Broadcasting	3431	3.00	29052	1.78
Tractor drawn drill	4574	4.00	49994	2.31
Kera method	3516	3.08	28248	1.71
Manually operated seed drill	5006	4.38	57475	2.48
Nainwan village				
Broadcasting	4074	3.57	40894	2.08
Tractor drawn drill	4749	4.16	53209	2.39
Kera method	3561	3.12	29076	1.73
Manually operated seed drill	4989	4.37	57163	2.47
Bhawanipur village				
Broadcasting	3608	3.16	32312	1.87
Tractor drawn drill	4880	4.27	55615	2.45
Kera method	4233	3.71	41446	2.03
Manually operated seed drill	5023	4.40	57788	2.48

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. In some parts of the region, partial waterlogging in early stages of the crop growth followed by seasonal drought during the rest of the period is observed.

b. On-station experiments

Experienced weather conditions during 2018-19

During 2018, the onset of monsoon was delayed by 15 days (24 June). The annual rainfall of 1112.0 mm was received which was deficit by 68.0 mm compared to normal (1180.0 mm) (Fig.38). During *kharif* (June–September), 1086.0 mm of rainfall was received which was excess by 48.0 mm compared to normal (1038.0 mm). During *rabi* season, 14.4 mm rainfall was received which was deficit by 51.5 mm compared to normal (65.9 mm) and in summer, rainfall was 6.8 mm which was deficit by 35.9 mm as against normal (42.7 mm).

Normal onset of monsoon	4-10 June
Onset of monsoon during 2018	24 June
Annual mean rainfall	1180.0 mm
Annual rainfall during 2018-19	1112.0 mm
Mean crop seasonal rainfall	1038.0 and 65.9 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018-19	1086.0 mm and 14.4 mm during *kharif* and *rabi*, respectively

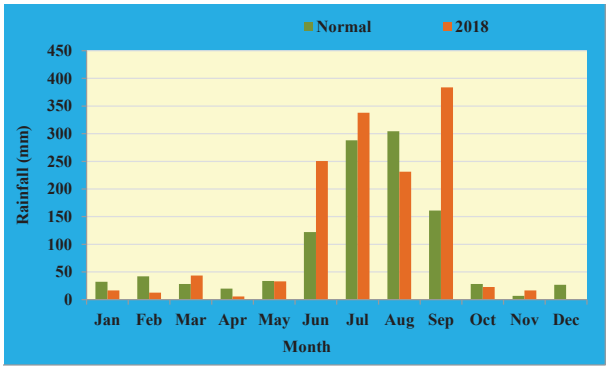


Fig.38: Normal and actual (2018) monthly rainfall at Chianki

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
21	20 September-10 October	Rice Maize Sesame Pigeonpea	Flowering Cob formation Capsule formation Vegetative
57	14 October-10 December	Pigeonpea	Flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Rice, maize, sesame	-	Improved varieties
Mid season drought	Rice	Flowering & milking	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2018, the onset of monsoon was delayed by 15 days (24th June). Among improved varieties of rainfed medium land rice, Arize-Tej recorded 47% higher grain yield (4624 kg/ha) with net returns (Rs.55284/ha) and B:C ratio (2.96) followed by PAC-801 (4151 kg/ha), MTU-1010 (3947 kg/ha) and Naveen (3619 kg/ha) compared to local varieties (3146 kg/ha) (Table 156).

Table 156: Yield and economics of medium land rice varieties

Variety	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Arize-Tej	4624	4.26	55284	2.96
PAC-801	4151	3.82	47716	2.55
MTU-1010	3947	3.63	44452	2.38
Naveen	3619	3.33	39204	2.10
PAC-807	3517	3.24	37572	2.01
Local	3146	3.00	34336	2.00

Among rainfed lowland rice varieties/hybrids, Arize-6444 gave 79% higher grain yield (5993 kg/ha) with higher net returns (Rs.77188/ha) and B:C ratio (4.13) followed by Rajshree (4758 kg/ha), CRR-2996 (4097 kg/ha) and BPT-5204 (6662 kg/ha) compared to local varieties (3348 kg/ha) (Table 157).

Table 157: Yield and economics of lowland rice varieties

Variety	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Arize- 6444	5993	5.52	77188	4.13
Rajshree	4758	4.38	57428	3.07
CRR-2996	4097	3.77	46852	2.51
BPT-5204	4005	3.69	45380	2.43
KMP-153	3891	3.58	43556	2.33
Local	3348	3.11	36568	2.15

Among maize varieties/hybrids, BAUMH2015-2 recorded higher grain yield (3178 kg/ha) with higher net returns (Rs.20194/ha) and B:C ratio (1.31) followed by Rasi-4212 (2394 kg/ha), Suwan (2359 kg/ha), BVM-2 (2292 kg/ha) and CP-848 (2458 kg/ha) while local variety (LCY) gave lowest grain yield (1921 kg/ha) and net returns (Rs.8015/ha) (Table 158).

Table 158: Yield and economics of maize varieties/hybrids

Variety/hybrid	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
BAUMH- 2015-2	3178	2.93	20194	1.31
Rasi- 4212	2394	2.20	11413	0.74
Suwan	2356	2.17	10987	0.71
BVM-2	2292	2.11	10270	0.67
CP-848	2458	2.26	12130	0.79
Local	1921	1.76	8015	0.59

Maize cv. BAUMH- 2015-2

Local variety of maize

Sesame variety Shekhar recorded 81% higher seed yield (634 kg/ha) with higher net returns (Rs.18798/ha) and B:C ratio (1.71) followed by JLT-408 (627kg/ha), JT-S-8 (572 kg/ha) and TKG-21 (566 kg/ha) compared to local variety (389 kg/ha) (Table 159).

Table 159: Yield and economics of sesame varieties

Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Shekhar	634	0.58	18798	1.71
JLT-408	627	0.58	18469	1.68
JT-S-8	572	0.53	15884	1.44
TKG-21	566	0.52	15602	1.42
JG-11	506	0.47	12782	1.16
Local	389	0.35	8283	0.82

Situation: Mid season drought

During *kharif* 2018, a dry spell of 21 days occurred during 20 September to 10 October coinciding with flowering stage in rice. Foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% recorded significantly higher grain yield (2650 kg/ha) than other treatments except foliar spray of $ZnSO_4$ @ 0.5% (2620 kg/ha) (Table 160).

Table 160: Yield and yield attributes of rice as influenced by foliar spray

Treatment	Plant height (cm)	No. of effective tillers/m²	1000 seed weight (g)	Grain yield (kg/ha)
Urea @ 1%	105	159	19.9	2180
water soluble complex fertilizer (19:19:19) @ 0.5%	106	161	21.0	2260
Urea @ 2%	106	159	20.1	2220
$ZnSO_4$ @ 0.5%	106	167	23.3	2620
water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5%	107	168	23.7	2650
Water spray	105	158	19.5	2160
No spray (control)	105	158	19.0	2040
CD at 5%	NS	NS	2.42	371

c. On-farm demonstrations

Village profile

The program is being implemented 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. The NICRA program was also expanded to adjoining village Chiraunjia, Meral block of Garhwa disrtict.

Experienced weather conditions during 2018-19

During the year 2018, the onset of monsoon was delayed by 14 days (24 June). A rainfall of 1039.6 mm was received which was deficit by 112.8 mm compared to normal of 1152.4 mm (Fig.39). During *kharif* (June - September), 1016.8 mm rainfall was

received which was excess by 109.1 mm (10.9%) compared to normal (992.5 mm). During *rabi* season, 11.7 mm rainfall was received which was deficit by 35.6 mm (45.8%) compared to normal (77.6 mm) and during summer (March-May), 7.3 mm rainfall was received which was deficit by 40.7 mm compared to normal (48.0 mm).

Normal onset of monsoon	4-10 June
Onset of monsoon during 2018	24 June
Annual mean rainfall	1152.4 mm
Annual rainfall during 2018-19	1039.6 mm
Mean crop seasonal rainfall	992.5 and 77.6 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018-19	1016.8 and 11.7 mm during *kharif* and *rabi*, respectively

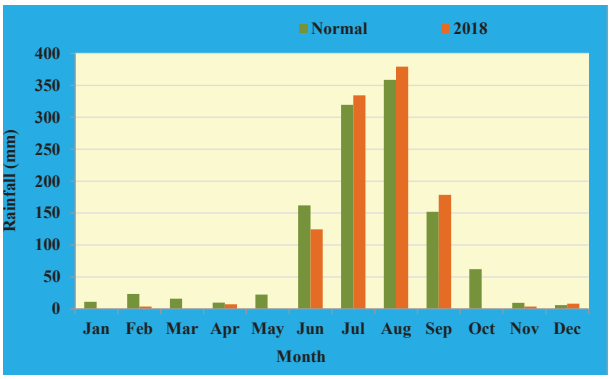


Fig.39: Normal and actual (2018) monthly rainfall at Kumbhi and Bankheta

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Delayed onset of monsoon	Rice, maize, sesame, fingermillet, sorghum, pigeonpea	Improved varieties

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
25	20 September-14 October	Rice, Maize Sesame Pigeonpea	Flowering, Cob formation Capsule formation Vegetative
65	14 October-18 December	Rice Pigeonpea	Maturity Flowering

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2018, the onset of monsoon was delayed by 15 days (24th June). High yielding drought tolerant medium duration hybrid of rice (PAC-801) yielded grain yield of 3718 kg/ha with higher RWUE (3.79 kg/ha-mm), net returns (Rs.40788/ha) and B:C ratio (2.18) as compared to local variety (2857 kg/ha) (Table...). Kanchan variety of maize gave higher grain yield of 2354 kg/ha with RWUE of 2.40 kg/ha-mm compared to local variety (1774 kg/ha) (Table...). The A-404 variety of fingermillet gave higher grain yield (1431 kg/ha) with RWUE of 1.46 kg/ha-mm over local cultivar. In sorghum, CSV-20 recorded higher grain yield (1543 kg/ha) and RWUE (1.57 kg/ha-mm) compared to local cultivar. Sesame variety Shekhar also gave higher seed yield (446 kg/ha) over local cultivar (287 kg/ha). Similarly, higher seed yield of pigeonpea (1578 kg/ha) was recorded by var. Bahar compared to local cultivar (1159 kg/ha) with higher RWUE (1.48 kg/ha-mm), net returns (Rs.53932/ha) and B:C ratio (3.47) (Table 161).

Fingermillet var. A-404

Sesame var. Shekhar

Pigeonpea var. Bahar

Table 161: Performance of drought tolerant varieties of different crops

Crop	Variety	Seed/grain yield (kg ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rice	PAC-801	3718	3.79	40788	2.18
	Local	2857	2.91	29712	1.85
	Sahbhagi Dhan	3419	3.48	37104	2.10
	Local	2741	2.79	28556	1.86
	Naveen	3374	3.44	36384	2.06
	Local	2697	2.75	27852	1.82
	Arize-6444	4457	4.54	53712	3.05
	Local	3454	3.52	39964	2.61
Maize	Kanchan	2354	2.40	10964	0.71
	Local	1774	1.81	6368	0.47
Fingermillet	A-404	1431	1.46	9320	0.84
	Local	1074	1.09	4250	0.38
Sorghum	CSV-20	1543	1.57	4781	0.38
	Local	1125	1.14	100	0.08
Sesame	Shekhar	446	0.45	9962	0.90
	Local	287	0.29	2489	0.22
Pigeonpea	Bahar	1578	1.48	53932	3.47
	Local	1159	1.08	37496	2.77

Preparedness

Cropping systems

High yielding medium duration variety of wheat (K-9107) yielded grain yield of 2748 kg/ha with higher RWUE (67.0 kg/ha-mm), net returns (Rs.27464/ha) and B:C ratio (1.28) compared to local variety (1936 kg/ha) (Table...). Chickpea var. Ujjwal gave higher seed yield (1178 kg/ha) with RWUE of 28.7 kg/ha-mm compared to local variety (712 kg/ha) (Table...). Lentil var. KLS-218 gave higher seed yield (1098 kg/ha) with RWUE of 26.78 kg/ha-mm over local cultivar. In mustard, var. Pusa Bold recorded higher seed yield (1132 kg/ha), RWUE (27.6 kg/ha-mm) and net returns (Rs.24356/ha) compared to local cultivar. Safflower variety A-1 also gave higher seed yield (1287 kg/ha) over local cultivar (987 kg/ha). Similarly, higher seed yield of linseeed (917 kg/ha) was recorded by T-397 over local cultivar (687 kg/ha) with higher RWUE (22.36 kg/ha-mm), net returns (Rs.18261/ha) and B:C ratio (1.52) (Table 162).

Table 162: Performance of drought tolerant varieties of *rabi* crops

Crop	Variety	Seed/grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Wheat	K-9107	2748	67.02	27464	1.24
	Local	1936	47.21	12848	0.58
Chickpea	Ujjwal	1178	28.73	36154	2.49
	Local	712	17.36	16116	1.11
Lentil	KLS- 218	1098	26.78	24430	1.75
	Local	813	17.36	14455	1.03
Mustard	Pusa Bold	1132	27.60	24356	1.87
	Local	878	17.36	15974	1.22
Safflower	A-1	1287	31.39	30471	2.53
	Local	987	24.03	20571	1.71
Linseed	T-397	917	22.36	18261	1.52
	Local	687	24.03	10671	0.88

Mustard var. Pusa Bold

Safflower var. A-1

Linseed var. T-397

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 2018-19

During 2018, the onset of monsoon was delayed by 18 days (12th July). A rainfall of 891.1 mm was received which was deficit by 110.6 mm compared to normal rainfall (1001.7 mm). During south-west monsoon (*kharif*), 815.8 mm rainfall was received which was deficit by 99.3 mm (9.9%) compared to normal of 915.1 mm. During *rabi*, 54.5 mm rainfall was received against the normal rainfall of 92.0 mm. During summer, 19.8 mm of rainfall was received which was deficit by 13.4 mm compared to normal rainfall (33.2 mm) (Fig.40).

Normal onset of monsoon	24 June
Onset of monsoon during 2018	12 July
Annual mean rainfall	1001.7 mm
Annual rainfall during 2018-19	891.1 mm
Mean crop seasonal rainfall	915.1 mm (*kharif*) & 92.0 mm (*rabi*)
Crop seasonal rainfall during 2018-19	815.8 mm (*kharif*) & 54.5 mm (*rabi*)

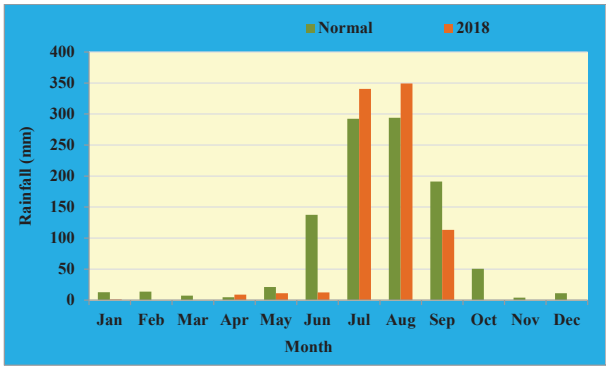


Fig.40: Normal and actual (2018) monthly rainfall at Faizabad

Dry spells during crop growing season (2018-19)

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

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Rice, maize, blackgram, sesame	-	Improved varieties
Terminal drought	Rice	Grain filling	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2018, the onset of monsoon was delayed by 18 days (12th July). Among different alternate crops, blackgram (var. NDU-1) gave higher net returns (Rs.25750/ha) and B:C ratio (2.06) followed by sesame (Rs. 19250/ha) compared to farmers' practice of rice cultivation with local variety (Rs. 4060/ha) (Table 163).

Table 163: Performance of alternate crops

Crop	Variety	Crop duration (days)	Seed/grain yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Rice	NDR-97	94	2115	2.67	20280	13560	0.67
Maize	Naveen	92	2475	3.03	20500	16625	0.81
Blackgram	NDU-1	85	765	0.94	12500	25750	2.06
Sesame	T-3	93	615	0.75	11500	19250	1.67
Farmers' practice (rice)	Local variety	115	1515	1.86	20180	4060	0.20

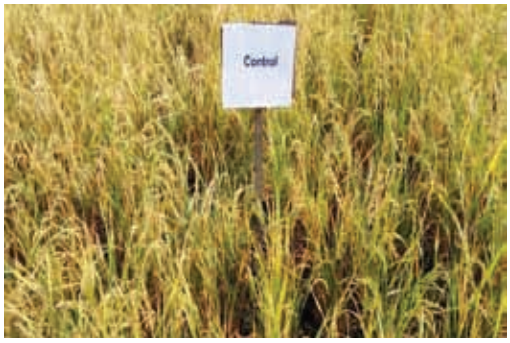
Situation: Terminal drought

During 2018, monsoon was withdrawn by 13 September affecting the grain filling in rice. Among different foliar sprays in rice, foliar spray during dry spell recorded higher grain yield (2109 kg/ha), net returns (Rs.13660 /ha), B:C ratio (0.70) and RWUE (2.56 kg/ha-mm) compared to foliar spray after relieving of stress/dry spell (1872 kg/ha). Among the different sources of foliar sprays, water soluble complex fertilizer (19: 19: 19) @ 0.5% + $ZnSO_4$ @ 0.5% recorded the highest grain yield (2220 kg/ha), net returns (Rs.15502/ha), B:C ratio (0.78) and RWUE (2.79 kg/ha-mm) compared to other treatments (Table 164).

Table 164: Effect of foliar sprays on yield and economics of rice

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain (2018-19)	Straw	Mean grain (2 yrs)				
Main plot							
Foliar spray during dry spell	2109	2413	1873	19224	13660	0.70	2.56
Foliar spray after relieving of stress (with favorable soil moisture)	1872	2533	1606	18450	10743	0.57	2.35
CD at 5%	144	-	-	-	-	-	-
Sub plot							
Urea @ 2%	1928	2413	1729	18835	11292	0.60	2.42
Urea @ 1%	2021	2533	1466	18925	12664	0.70	2.54
Water soluble complex fertilizer (19: 19: 19) @ 0.5%	2064	2583	1854	19000	13252	0.71	2.59
Water soluble complex fertilizer (19: 19: 19) @ 0.5%+ $ZnSO_4$ @ 0.5% + Borax @ 0.25 %	2220	2782	2003	19190	15502	0.78	2.79
$ZnSO_4$ @ 0.5% + Borax @ 0.25 %	2040	2553	1838	19012	12872	0.68	2.56
Water spray	1843	2304	1678	18935	9870	0.52	2.31
Control (no spray)	1818	2274	1609	18450	9957	0.53	2.28
CD at 5%	164	-	-	-	-	-	-

Rice with foliar spray of water soluble complex fertilizer (19:19:19) @ 0. 5% + $ZnSO_4$ @ 0.5% + borax @ 0.25%



Rice under control (no spray)

c. On-farm demonstrations

Village profile

The programme is being implemented in Hardoya village, Uttar Pradesh. The total cultivated area is 397 ha out of which 138 ha is rainfed. 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. The activities and interventions were extended to new village, Amavachitan, block- Haringtonganj, tehsil-Milkipur in Faizabad district.

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 1001.7 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 2018-19

The rainfall data of Faizabad centre was taken.

Dry spells during crop growing season (2018-19)

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

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Delayed on set of monsoon	Rice, maize, blackgram, sesame	Improved varieties

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2018, the onset of monsoon was delayed by 18 days (12th July). Among rice varieties, NDR-97 gave higher grain yield (1906 kg/ha) and stover yield (2426 kg/ha), net returns (Rs. 10216/ha), B:C ratio (0.50) and RWUE (2.33 kg/ha-mm) followed by var. Baranideep (1762 kg/ha) compared to local variety (1315 kg/ha) (Table 165).

Table 165: Performance of short duration varieties of rice

Variety	Grain yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
NDR-97	1906	2426	2.33	20280	10216	0.50
Baranideep	1762	2261	2.16	20280	7912	0.39
Suskasamrat	1682	2176	2.06	20280	6632	0.32
Vandna	1558	2169	1.91	20280	4648	0.23
Local variety	1315	1932	1.61	20180	860	0.04

Among the pigeonpea varieties, NDA-1 performed better and gave higher seed yield (1846 kg/ha), net returns (Rs.73250/ha), B:C ratio (3.85) and RWUE (2.27 kg/ha-mm) compared to other varieties and local variety (1250 kg/ha) (Table 166).

Table 166: Performance of short duration varieties of pigeonpea

Variety	Seed yield (kg/ha)	Stover yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
NDA-1	1846	6111	2.27	19050	73250	3.85
NDA-2	1702	5930	2.08	19050	66050	3.47
Bahar	1722	5453	2.11	19050	67050	3.52
MA-13	1470	4921	1.80	19050	54450	2.86
Local variety	1250	4380	1.53	19050	43450	2.28

Among different alternate crops, blackgram (var. NDU-1) gave higher net returns (Rs.20000/ha) and B:C ratio (1.6) followed by sesame (var.T-3) (Rs.16000/ha) compared to farmers' practice of rice cultivation with local variety (Rs.860/ha) (Table 167).

Table 167: Performance of alternate crops under delayed onset of monsoon

crop	Variety	Crop duration (days)	Seed/grain yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Rice	NDR-97	94	1906	2.33	20280	10216	0.50
Maize	Naveen	92	2250	2.76	20500	13250	0.64
Blackgram	NDU-1	85	650	0.80	12500	20000	1.6
Sesame	T-3	93	550	0.67	11500	16000	1.39
Farmers' practice (rice)	Local variety	115	1315	1.61	20180	860	0.04

Preparedness

Rainwater management

In-situ moisture conservation practice with mulching of green leaves of subabul @ 10 t/ha in maize, pigeonpea and sorghum revealed that mulching in maize (var. Naveen) recorded the highest grain yield (2377 kg/ha), net returns (Rs.15501/ha), B:C ratio (0.76) and RWUE (2.92 kg/ha-mm) compared to without mulching. Similarly in pigeonpea and sorghum, subabul green leaves mulching @ 10 t/ha recorded an increase in yield by 24.2% and 22.2%, respectively compared to no mulching (Table 168).

Table 168: Effect of mulching on yield and economics of *kharif* crops

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		With mulching	Without mulching				
Maize	Naveen	2377	1765	2.92	20154	15501	0.76
Pigeonpea	NDA-1	1950	1570	2.39	19050	78450	4.11
Sorghum	CSV-10	1650	1350	2.02	18654	6100	0.32

In-situ moisture conservation with mulching of green leaves of subabul @ 10 t/ha in mustard, chickpea and lentil recorded an increase in yield by 36.8%, 32.2% and 36.4% respectively compared to without mulching. Chickpea (var. Uday) recorded higher seed yield (2215 kg/ha), net returns (Rs.91775/ha), B:C ratio (4.83), RWUE (2.71 kg/ha-mm) compared to mustard and lentil (Table 169).

Table 169: Effect of mulching on yield and economics of *rabi* crops

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		With mulching	Without mulching				
Mustard	Varuna	1525	1115	1.87	13590	52016	3.82
Chickpea	Uday	2215	1675	2.71	18975	91775	4.83
Lentil	NDM-1	1535	1125	1.88	18975	57775	3.04

Among drought tolerant varieties of mustard, var. Varuna recorded higher seed yield (1475 kg/ha), net returns (Rs.38035/ha), B:C ratio (2.79) and RWUE (1.80 kg/ha-mm) followed by varieties NDR-1 and NDR-4 compared to farmers' practice of local variety (995 kg/ha) (Table 170).

Table 170: Performance of drought tolerant varieties of mustard

Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
NDR-1	1303	1.59	13590	32015	2.35
Varuna	1475	1.80	13590	38035	2.79
NDR-4	1195	1.47	13590	28235	2.07
Local variety	955	1.17	13590	19835	1.46

Chickpea var. Udai recorded higher seed yield (2125 kg/ha), net returns (Rs.87275/ha), B:C ratio (4.59) and RWUE (2.60 kg/ha-mm) followed by varieties Pusa-362, Avarodhi and KWR-108 compared to local variety (1350 kg/ha) (Table 171).

Table 171: Performance of chickpea varieties

Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Udai	2125	2.60	18975	87275	4.59
Pusa-362	1975	2.42	18975	79775	4.20
Avarodhi	1895	2.32	18975	75775	3.99
KWR-108	1685	2.06	18975	65275	3.44
Local variety	1350	1.66	18975	48525	2.56

1.3.4 REWA

a. Agro-ecological setting

Rewa centre is located in Keymore plateau and Satpura hill zone in Madhya Pradesh under Dry sub humid zone.

b. On-station experiments

Experienced weather conditions during 2018-19

During 2018, the onset of monsoon was delayed by 4 days (27th June). A rainfall of 894.4 mm was received which was deficit by 195.6 mm compared to normal rainfall of 1090.0 mm. The rainfall during *kharif* season was 794.4 mm as against normal rainfall of 997.0 mm. During *rabi* season, the rainfall was 29.0 mm compared to normal rainfall of 71.2 mm (Fig.41).

Normal onset of monsoon	23 June
Onset of monsoon during 2018	27 June
Normal annual rainfall	1090.0 mm
Annual rainfall during 2018-19	894.4 mm
Normal crop seasonal and rainfall during *kharif* & *rabi*	997.0 & 71.2 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* & *rabi*)	794.4 & 29.0 mm, respectively

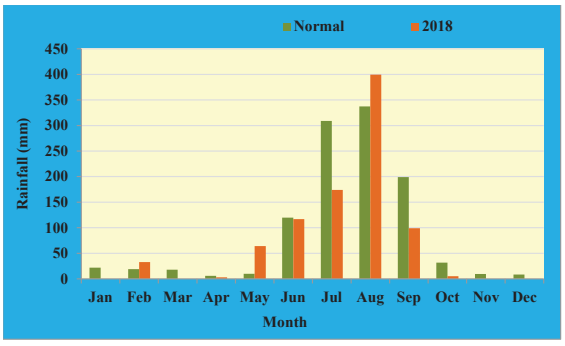


Fig.41 : Normal and actual (2018) monthly rainfall at Rewa

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
-	9 September to till harvest	Soybean	Vegetative to maturity

Real time contingency practices (RTCP) implemented

Weather aberrations	Crop	RTCP implemented
Mid season and terminal drought	Soybean	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During 2018, monsoon was withdrawn by 9 September affecting the flowering and maturity stage of soybean. Foliar application of water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrients ($ZnSO_4$ @ 100 ppm) during dry spell recorded significantly higher seed yield (749 kg/ha), stalk yield (651 kg/ha), net returns (Rs. 8807/ha), B:C ratio (1.53) and RWUE (0.95 kg/ha-mm) followed by foliar spray of urea @ 2% (717 kg/ha) compared to control (555 kg/ha) (Table 172).

Table 172: Effect of foliar sprays on yield and economics of soybean

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2018-19)	Mean seed (2 yrs)	Stalk				
During dry spell							
Urea @ 1%	702	597	1581	16330	7467	1.45	0.885
Urea @ 2%	717	727	1615	16360	7946	1.48	0.903
Water soluble complex fertilizer (19:19:19) @ 0.5%	686	515	1545	16530	6725	1.40	0.865
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 100ppm	749	651	1684	16550	8807	1.53	0.942
$ZnSO_4$ @ 100 ppm	629	450	1417	16315	5008	1.30	0.793
Water spray	563	404	1267	16100	2985	1.18	0.709
Control (no spray of any material)	555	354	1250	16065	2749	1.17	0.699
After stress relieving							
Urea @ 1%	571	563	1285	16330	3027	1.18	0.719
Urea @ 2%	563	587	1267	16360	2725	1.16	0.709
Water soluble complex fertilizer (19:19:19) @ 0.5%	567	514	1278	16530	2691	1.16	0.715
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 100 ppm	648	599	1458	16550	5417	1.32	0.816
$ZnSO_4$ @ 100 ppm	560	496	1261	16315	2669	1.16	0.705
Water spray	550	458	1240	16100	2545	1.15	0.694
Control (no spray of any material)	520	435	1170	16065	1563	1.09	0.655

Soybean with foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 100 ppm

Soybean under control (no spray)

c. On-farm demonstrations

Village profile

The program is being implemented in the village Raura and Patuna, Block and Tehsil Raipur, Karchulian in district Rewa. The total cultivated area is 643.986 ha (477.785 ha + 166.201ha) out of which 250.997 ha (129.210 ha + 121.787 ha) is rainfed. The mean annual rainfall is 1080 mm with seasonal rainfall of 950 mm during *kharif* (June-September). The major soil types are silty loam and silty clay loam. The major rainfed crops are rice, soybean, pigeonpea and blackgram in *kharif* season and wheat, chickpea, lentil and linseed in *rabi* season. The number of small, marginal, medium and large farmers are 347 (310+ 37), 192 (110 + 82) and 137 (127 +10) in Raura and Patuna villages, respectively. The programme was extended to new village Khira, Block and Tehsil Raipur, Karchulian in district Rewa. The total cultivated area is 150.350 ha out of which 80.950 is rainfed. The number small, marginal, medium and large farmers are 25, 75 and 15 in Khira villages respectively.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 85% and north-east monsoon 15% of the total annual average rainfall of 1080 mm. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 15-35% deficit of the average rainfall. The onset (south-west) of monsoon was during 25 SMW (standard meteorological week) and north-east monsoon is 47 SMW. The dry spells were experienced during the crop season for the past 10/15 years during August and September at flowering and grain formation stages of the major rainfed crops. The onset of the monsoon is normal. The soil moisture status is deficit during flowering and grain development stages of major rainfed crops.

Experienced weather conditions during 2018-19

During 2018, the onset of monsoon was delayed by 20 days (13th July). An annual rainfall of 698.6 mm rainfall was received against normal rainfall of 1050.0 mm. The rainfall was deficit by 33.5% during *kharif* season compared to seasonal rainfall (1008.6 mm). However, during *rabi*, 27.6 mm rainfall was received against normal of no rainfall (Fig.42).

Normal onset of monsoon	23 June
Onset of monsoon during 2018	13 July
Annual mean rainfall	1050.0 mm
Annual rainfall during 2018-19	698.6 mm
Mean crop seasonal rainfall (*kharif* and *rabi)*	1008.6 mm & 0.0 mm, respectively
Crop seasonal rainfall during 2018-19 *(kharif* and *rabi)*	671.0 mm & 27.6 mm, respectively

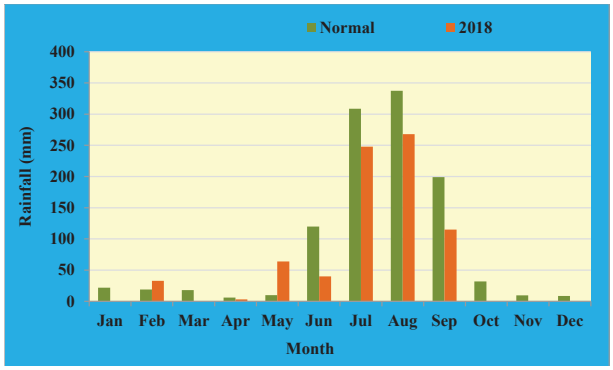


Fig.42: Normal and actual (2018) monthly rainfall at Raura and Patauna

Dry spells during crop growing season (2018-19): Nil

Real time contingency practices (RTCP) implemented

Weather aberrations	Crop	RTCP implemented
Delayed onset of monsoon	Soybean, blackgram, pigeonpea	Improved varieties

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

The onset of monsoon was delayed by 20 days during 2018. Pigeonpea var. Asha recorded higher seed yield (920 kg/ha), net returns (Rs.38600/ha), B:C ratio (4.21) and RWUE (1.26 kg/ha-mm) compared to local variety (720 kg/ha). In blackgram, variety LBG-20 gave higher seed yield (350 kg/ha), net returns (Rs. 9250/ha), B:C ratio (1.92) and RWUE (0.48 kg/ha-mm) followed by variety JU-30 (280 kg/ha) compared to local variety (220 kg/ha) (Table 173).

Table 173: Performance of improved varieties of pigeonpea and blackgram

Farming situation/soil type	Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium land black soil	Blackgram	LBG-20	350	0.48	9250	1.92
		JU-3	280	0.38	5400	1.54
		Local	220		3100	1.34
	Pigeonpea	Asha	920	1.26	38600	4.21
		Local	720	-	29600	3.96

Preparedness

Cropping systems

Among the improved varieties, wheat var. GW366 recorded higher grain yield (3450 kg/ha), straw (7250 kg/ha), net returns (Rs.51500/ha) and B: C ratio (3.94) followed by varieties HI8713, HI 3336, HI 1544, GW 322 compared to local variety (2850 kg/ha). Rice var. sahbhagi recorded higher grain yield (1250 kg/ha), straw (2510 kg/ha), net returns (Rs.5000/ha), B:C ratio (2.03) and RWUE (1.93 kg/ha-mm) followed by varieties Danteshwari, IR 64 compared to local variety (620 kg/ha) (Table 174).

Table 174: performance of improved varieties of different crops

Farming situation	Crop	Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
			Grain	Stover			
Medium land black soils	Rice	Sehbhagi	1250	2510	15000	5000	2.03
		Danteshwari	1120	2340	15000	2920	1.96
		IR 64	850	1815	15000	-1400	2.65
		Local	620	-	10200	-280	-
	Wheat	GW 366	3450	7250	17500	51500	3.94
		HI 8713	3410	7502	17500	50700	3.89
		HI 3336	3360	6888	17500	49700	3.84
		HI 1544	3125	6718	17500	45000	3.57
		GW 322	3315	6961	17500	48800	3.78
		Local	2855	-	15600	41500	-

1.3.5 VARANASI

a. Agro-ecological setting

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

b. On-station experiments: Nil

Experienced weather conditions during 2018-19

During 2018, the onset of monsoon was delayed by 5 days (27th June). A rainfall of 805.1 mm was received which was deficit by 275.8 mm (25.4%) compared to normal (1081.7 mm). During south-west monsoon (*kharif*), 780.1 mm of rainfall was received which was deficit by 164.4 mm compared to normal (944.5 mm), During *rabi*, no rainfall was received against the normal rainfall of 60.9 mm (Fig.43).

Normal onset of monsoon	22 June
Onset of monsoon during 2018	27 June
Annual mean rainfall	1081.7 mm
Annual mean rainfall during 2018-19	805.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	944.5 mm and 60.9 mm, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	780.1 mm and 0.0 mm, respectively

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
11	30 June -12 July	Rice	Seedling
11	11 - 20 September	Rice	Flowering

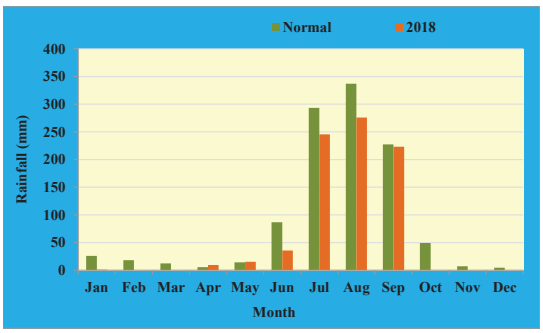


Fig.43: Normal and actual (2018) monthly rainfall at Varanasi

c. On-farm demonstrations

Village profile

The program is being implemented in Tedha 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 2018-19

During 2018, at Tedha village, the onset of monsoon was timely (11th June). A rainfall of 452.0 mm was received which was deficit by 384.7 mm (45.9%) compared to normal (836.7). During south-west monsoon (*kharif*), 424.0 mm of rainfall was received which was deficit by 275.5 mm compared to normal (699.5 mm). During *rabi*, 17.8 mm rainfall was received against the normal of 60.9 mm (Fig.44).

Normal onset of monsoon	12 June (±5 days)
Onset of monsoon during 2018	11 June
Annual mean rainfall	836.7 mm
Annual mean rainfall during 2018-19	452.0 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	699.5 mm and 60.9 mm, respectively
Crop seasonal rainfall during 2018-19 *kharif* and *rabi*	424.0 mm and 17.8 mm, respectively

Dry spells during crop growing season (2018-19)

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

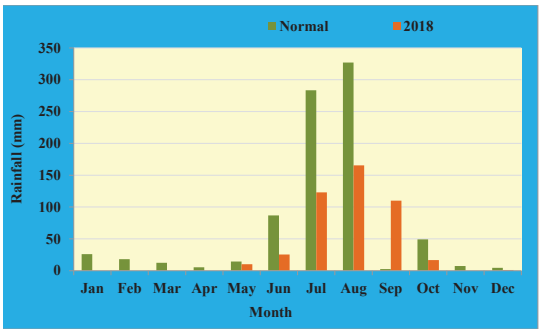


Fig .44: Normal and actual (2018) monthly rainfall at Tedha

Salient achievements of on-farm demonstrations

Preparedness

Cropping systems

Lentil var. HUL-57 gave higher seed yield (1157 kg/ha) compared to local (712 kg/ha). Similarly, chickpea var. Awrodhi gave higher seed yield (2562 kg/ha) compared to Pusa-256 (2156 kg/ha) and local variety (1512 kg/ha). In mustard, var. Varuna (T-59) gave higher seed yield (1131 kg/ha) compared to local variety (834 kg/ha) (Table 175).

Table 175: Performance of improved varieties of lentil, chickpea and mustard

Farming situation/ Soil type	Crop	Variety	Seed yield (kg/ha)
Shallow and medium alluvial soil	Lentil	HUL-57	1157
		Local	712
	Chick-pea	Awrodhi	2562
		PUSA-256	2156
		Local	1512
	Mustard	Varuna (T-59)	1131
		Local	834

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 2018-19

During 2018, the onset of monsoon was delayed by two days (7 June). A total rainfall of 1677.0 mm was received which was excess by 272.6 mm compared to normal of 1404.4 mm. During south-west monsoon (*kharif),* there was 1365.8 mm rainfall which was excess by 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.45)

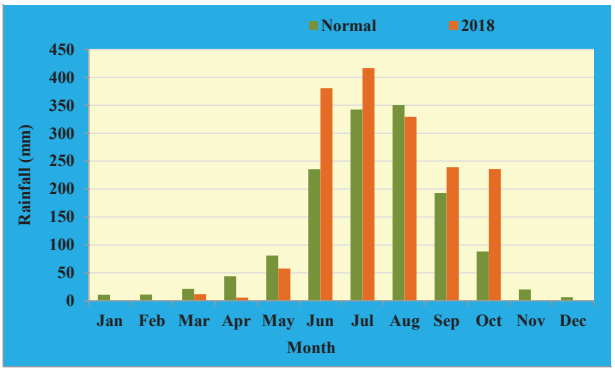


Fig.45.: Normal and actual (2018) monthly rainfall at Jagdalpur

Normal onset of monsoon	5 June
Onset of monsoon during 2018	7 June
Annual mean rainfall	1404.4 mm
Annual rainfall during 2018-19	1677.0 mm
Mean crop seasonal rainfall	1122.0 and 115.0 mm, during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018-19	1365.8 and 235.9 mm, during *kharif* and *rabi*, respectively

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
17	14 June - 31 June	Rice, maize	Tillering, vegetative
46	9 October -25 December	Rice, niger, horsegram	Milking, pod forming
29	24 January - 23 February	Chickpea, field pea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Rice	Milking	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During 2018, a dry spell of 46 days occurred during 9 October to 26 November coinciding with the milking stage of rice. During the stress condition, foliar spray of water soluble fertilizer (19:19:19) @ 0.5% along with 0.5% $ZnSO_4$ recorded significantly higher grain and straw yield (2325 and 3440 kg/ha), net returns (Rs.23203/ha), B:C ratio (1.83) and RWUE (2.74 kg/ha-mm) compared to no foliar spray (980 kg/ha) (Table 176).

Table 176: Effect of different foliar treatments on yield and economics of rice

Treatment	Yield (q/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Mean grain (2 years)	Straw			
M_1S_1	1955	1990	3330	15958	1.58	2.30
M_1S_2	2037	2070	3260	17462	1.63	2.40
M_1S_3	2153	2260	3378	19772	1.71	2.53

Treatment	Yield (q/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Mean grain (2 years)	Straw			
M_1S_4	2325	2370	3440	23203	1.83	2.74
M_1S_5	1787	1660	3078	12105	1.44	2.10
M_1S_6	1807	1590	2983	13020	1.48	2.13
M_1S_7	1198	980	2342	208	1.01	1.41
M_2S_1	1725	1600	2770	10683	1.39	2.03
M_2S_2	1753	1660	2830	11223	1.41	2.06
M_2S_3	1777	1680	2922	11593	1.42	2.09
M_2S_4	1775	1620	2800	11288	1.40	2.09
M_2S_5	1433	1280	2362	4145	1.15	1.69
M_2S_6	1370	1260	2297	3382	1.13	1.61
M_2S_7	1213	1050	2078	252	1.01	1.43

M_1: Foliar spray during dry spell; M_2: Foliar spray after relieving dry spell; S_1: Urea @ 1%; S_2: Urea @ 2%; S_3:19:19:19 @ 0.5%; S_4:19:19:19 @ 0.5% + $ZnSO_4$ @ 0.5%; S_5: $ZnSO_4$ @ 0.5%; S_6: Water spray @ 500 l/ha; S_7: Control (no spray)

c. On-farm interventions

Village profile

The program is being implemented 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 2018-19

During 2018, in Tahkapal village, onset of monsoon was delayed by 7 days (12th June). A rainfall of 1386.4 mm was received which was deficit by 18.0 mm compared to normal rainfall of 1404.4 mm. During South-west monsoon (*kharif*), 1124.8 mm rainfall was received which was 3.3 mm excess compared to normal rainfall of 1122 mm; during *rabi* (October-December), 46.7 mm of rainfall was received which was deficit by 68.1 mm compared to normal (115 mm). During summer, 212.9 mm of rainfall was received which was excess by 66.8 mm compared to normal (146.1 mm) (Fig. 46).

Normal onset of monsoon	5 June
Onset of monsoon during 2018	12 June
Annual mean rainfall	1404.4 mm
Annual rainfall during 2018-19	1386.4 mm
Mean crop seasonal rainfal during *kharif* and *rabi,* respectively	1122.0 and 115.0 mm
Crop seasonal rainfall during 2018-19 *kharif* and *rabi,* respectively	1124.8 and 46.7 mm

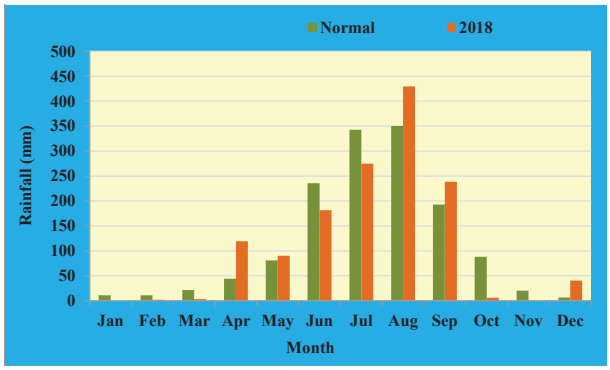


Fig.46: Normal and actual (2018) monthly rainfall at Tahkapal

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
13	14 June-27 June	Rice, maize	Tillering, vegetative
18	1-18 November	Rice, maize	Grain filling, silking
20	1-20 December	Rice, maize, niger	Grain filling

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Rice	-	*Lehi* (sprouted paddy seed) sowing on puddled field
Early season drought	Rice	Vegetative	Supplemental irrigation
Mid season drought	Rice	Flowering	Foliar spray
Terminal drought	Rice	Grain filling	Supplemental irrigation, foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

At Tahkapal village, The onset of monsoon was delayed by 7 days. *In- situ* moisture conservation by multistory techniques for seedling preparation, *Lehi* (sprouted paddy seed) sowing on puddle field, drum seeding with sprouted seeds were implemented. Among the practices, *Lehi* (sprouted paddy seed) sowing on puddle field gave highest grain yield (6557 kg/ha), net returns (Rs.98360/ha), B:C ratio (3.15) and RWUE (9.44 kg/ha-mm) compared to other treatments and control (Table 177).

Table 177: Effect of sowing methods on yield and economics of rice

Farming situation/soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Midland	Multistory techniques for seedling preparation of rice	4860	6.97	72910	2.33
	Lehi (sprouted paddy seed) sowing on puddle field	6557	9.44	98360	3.15
	Drum seeding with sprouted seeds after receipt of monsoon rains.	3192	4.57	18104	2.81
	Farmers' practice	2534	8.50	38021	1.53

Multi-storey nursery system

Drum seeder for sowing rice

Situation: Early season drought

At Tahkapal village, a dry spell of 13 days occurred during 14-17 June coinciding with early vegetative stage of rice. Life saving irrigation of 2 cm from harvested rainwater in farm pond at tillering stage gave highest grain yield (1840 kg/ha), net returns (Rs.10426/ha), B:C ratio (1.84) and WUE (2.83 kg/ha-mm) compared to control (867 kg/ha) (Table 178).

Table 178: Effect of life saving irrigation on yield and economics of rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Midland	Supplemental irrigation	1840	2.83	10426	1.84
	Farmers' practice (no supplemental irrigation)	867	1.37	1670	1.16

Rice without supplemental irrigation

Rice with supplemental irrigation

Situation: Mid season drought

At Tahkapal village, a dry spell of 18 days occurred during 1-18 November coinciding with flowering stage of rice. Foliar spray of $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha gave highest grain yield (5845 kg/ha), net returns (Rs.87688/ha), B:C ratio (2.80) and RWUE (8.41 kg/ha-mm) compared to control (1368 kg/ha) (Table 179).

Table 179: Effect of foliar spray on RWUE, yield and economics of rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Midland	Foliar spray of $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha	5845	8.41	87688	2.80
	Farmers' practice (no foliar spray)	1368	7.58	20523	2.51

Situation: Terminal drought

At Tahkapal village, a dry spell of 20 days occurred during 1-20 December coinciding with flowering stage of rice. Life saving irrigation of 2 cm from harvested rainwater gave highest grain yield (2097 kg/ha), net returns (Rs.7493/ha), B:C ratio (2.05) and WUE (3.02 kg/ha-mm) compared to control (1883 kg/ha) (Table 180).

Table 180: Effect of supplemental irrigation on yield and economics of rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Lowland	Supplemental irrigation	2097	3.02	7493	2.05
	Farmers' practice (no supplemental irrigation)	1883	2.71	6726	1.56

Preparedness

Rainwater management

At Tahkapal village, row placement of FYM along with seed sowing gave 15.3% higher grain yield (3512 kg/ha), net returns (Rs.34048/ha), B:C ratio (2.65) and RWUE (3.12 kg/ha-mm) compared to farmers' practice of broadcasting of farmyard manure @ 1 t/ha (3045 kg/ha) (Table 181).

Table 181: Effect of row placement of FYM along with seed sowing on yield and economics of rice

Farming situation/ soil type	Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain	Mean grain (3 years)	Straw			
Lowland	Row placement of FYM along with seed sowing	3512	3120	7550	34048	2.65	3.12
	Farmers' practice*	3045	2975	6547	31367	1.85	1.98

*Broadcasting of FYM @ 1 t/ha

Cropping systems

At Tahkapal village, fingermillet + pigeonpea (7:2) intercropping system gave higher net returns (Rs.37324/ha). Whereas, farmers' practice of mixing seed of fingermillet and pigeonpea together in equal amount and sowing gave higher main crop equivalent yield (1138 kg/ha), B:C ratio (2.4) and RWUE (4.9 kg/ha-mm) (Table 182).

Table 182: Yield and economics of fingermillet + pigeonpea (7:2) intercropping system

Farming situation/ soil type	Intervention	Yield (kg/ha)		MCEY (kg/ha)		LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter-crop	2018-19	Mean				
Midland	Finger millet + pigeonpea (7:2)	1440	414	829	1352	1.53	37324	2.20	4.25
	Farmers' practice	1730	569	1138	1847	0.82	22068	2.4	4.9

*Farmers' practice: Mixing seeds together in equal amount and sowing; LER: Land equivalent ratio; MCEY: Main crop equivalent yield

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 1407 mm. Annual normal potential evapotranspiration is 478 mm. Length of growing period is 180-210 days.

b. On-station experiments

Experienced weather conditions during 2018-19

During 2018, the onset of monsoon was on time (9 June). A rainfall of 1663.8 mm was received during the year which was excess by 256.5 mm than normal (1407.0 mm). Out of total rainfall, 1226.1 mm was received during *kharif* (June- September) and was excess by 75.6 mm (6.57%) than normal (1150.5 mm). In *rabi*, 290.4 mm rainfall was received which was 165.7 mm (132.8%) higher than the normal (124.7 mm). In summer 147.3 mm rainfall was received against normal of 108.4 mm rainfall (Fig.47).

Normal onset of monsoon	10 June
Onset of monsoon during 2018	9 June
Annual mean rainfall	1407.0 mm
Annual rainfall during 2018-19	1663.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	1150.5 and 124.7 mm, respectively
Crop seasonal rainfall during *kharif* and *rabi* (2018-19)	1226.1 and 290.4 mm, respectively

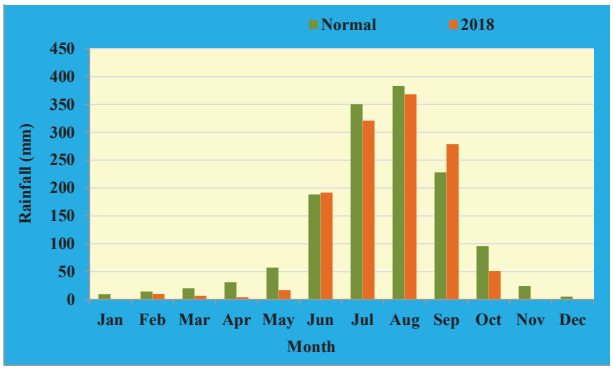


Fig.47: Normal and actual (2018) monthly rainfall at Phulbani

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
17	23 September - 10 October	Rice, maize	Milking in rice, grain filling in maize

Real time contingency practices (RTCP) implemented: Nil

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 (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
17	23 September - 10 October	Rice, maize, cowpea, pigeonpea	Grain filling & maternity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought	Rice	Life saving irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

During 2018, a dry spell of 17 days occurred during 23 September to 10 October coinciding with milking, rain filling and maturity stage in rice. Supplemental irrigation from nearby water stream given to rice varieties, Naveen and Sahabhagi resulted in 27.4 and 25.7% higher yield (2510 and 2400 kg/ha) with highest net returns (Rs.15925 and 14000/ha), B:C ratio (1.57 and 1.50) and RWUE (1.98 and 1.50 kg/ha-mm) as compared to without supplemental irrigation (1970 and 1910 kg/ha), respectively (Table 183).

Table 183: Performance of rice varieties with supplemental irrigation

Crop	Variety (duration)	Grain yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With supplemental irrigation	Without supplemental irrigation			
Rice	Sahabhagi (110 days)	2400	1910	1.90	14000	1.50
	Naveen (110 days)	2510	1970	1.98	15925	1.57

Preparedness

Rainwater management

In-situ moisture conservation through deep summer ploughing, increase in bund height, hoeing and weeding in maize + cowpea intercropping system (2:2) gave higher maize equivalent yield (4420 kg/ha), net returns (Rs.30565/ha), B:C ratio (3.49) and RWUE (3.49 kg/ha-mm) as compared to sole maize (2140 kg/ha) without *in-situ* moisture conservation (Table 184).

Table 184: Performance maize + cowpea intercropping system (2:2) under *in-situ* moisture conservation

Intercropping system/ variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With *in-situ* moisture conservation	Farmers' practice			
Maize (SA 701) + cowpea (Gomti) (2:2)	2050 (grain) + 1570 (green pods) MEY(4420)	Sole maize (2140)	3.49	30565	2.09

In- situ moisture conservation practices such as deep summer ploughing, increase in bund height, hoeing and weeding in rice var. Sahabhagi gave higher grain yield (2400 kg/ha) with higher net returns (Rs.14000/ha), B:C ratio (1.50) and RWUE (1.90 kg/ha-mm) over farmer practice of no *in-situ* moisture conservation practices (1910 kg/ha) (Table 185).

Table 185: Performance of rice under *in-situ* moisture conservation practices

Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Mean (3 yrs)	Stover				
In-situ moisture conservation	2400	2410	3100	28000	14000	1.50	1.90
Farmers' practice	1910	1920	2795	26000	7425	1.29	1.59

Cropping systems

Among maize based intercropping systems, maize + cowpea (2:2) gave higher maize equivalent yield (4420 kg/ha), net returns (Rs.30565/ha), B:C ratio (2.09) and RWUE (3.49 kg/ha-mm) followed by maize + pigeonpea (2:2) intercropping system (3776 kg/ha) while sole maize recorded lowest yield (2200 kg/ha). Similarly, pigeonpea + radish (2:2) intercropping system also gave higher pigeonpea equivalent yield (1539 kg/ha), net returns (Rs. 39100/ha), B:C ratio (2.35) and RWUE (2.35 kg/ha-mm) as compared to sole pigeonpea (850 kg/ha) (Table 186).

Table 186: performance of maize and pigeonpea based intercropping systems

Cropping system	Yield (kg/ha)			Cost of cultivation (Rs/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop	MEY/ PEY				
Maize (SA 701) + cowpea (Gomti) (2:2)	2050	1570 (green pods)	4420	28000	3.49	30565	2.09
Maize (SA 701)) + pigeonpea (NTL 724) (2:2)	2140	490	3776	30000	2.85	20032	1.67
Sole maize (Farmer's practice)	2200	-	2200	-	-	-	-
Pigeonpea (NTL 724) + radish (Pusa Chetki) (2:2)	680	7600	1539	29000	1.16	39100	2.35
Sole pigeonpea	850	-	850	-	-	-	-

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

Experienced weather conditions during 2018-19

During the year 2018, the onset of monsoon was delayed by 1week (2nd week of June). A rainfall of 1765.1 mm was received which was deficit by 99.7 mm compared to normal (1864.8 mm). During south-west monsoon (*kharif*), a rainfall of 1256.1 mm was received against a normal rainfall of 1182.2 mm. The rainfall during *rabi* was 149.4 mm which was excess by 29.4 mm compared to normal rainfall of 120.0 mm (Fig.48).

Normal onset of monsoon	1st week of June
Onset of monsoon during 2018	2nd week of June
Annual mean rainfall	1864.8 mm
Annual rainfall during 2018-19	1765.1 mm
Mean crop seasonal rainfall	1182 and 120 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018-19	1256.1 and 149.4 mm during *kharif* and *rabi*, respectively

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
32	17 November- 18 December	Toria	Flowering and siliqua formation
37	20 December -27 January, 2019	Toria	Flowering and maturity
35	28 January - 2 March, 2019	Toria	Siliqua formation to maturity

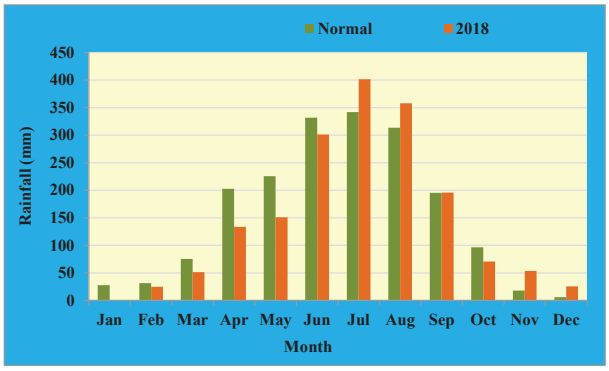


Fig.48: Normal and actual (2018) monthly rainfall at Biswanath Chariali

Real time contingency practices (RTCP) implemented

Weather abbreviation	Crop	Stage of crop	RTCP implemented
Mid season drought	Toria	Flowering	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

Foliar spray in toria (TS-38) during dry spell recorded significantly higher seed yield (948 kg/ha) with higher net returns (Rs. 21519/ha) and RWUE (12.03 kg/ha-mm) while B:C ratio (1.29) was higher with foliar spray after relieving of stress under favorable soil moisture. Among sources of nutrients, foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + borax @ 0.5% resulted in significantly higher seed yield (1027 kg/ha). However, foliar spray of urea @ 2% recorded higher net returns (Rs. 27558/ha) followed by urea @ 1% (Rs.27542/ha) while foliar spray of urea @ 1% recorded highest B:C ratio (2.38) followed by urea @ 2% (2.14) (Table 187).

Table 187: Toria yield and economics as influenced by foliar sprays

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Main plot						
Foliar spray during dry spell	948	2489	16650	21519	1.29	12.03
Foliar spray after relieving of stress/dry spell	885	2407	15500	20271	1.31	11.22
CD at 5%	144	-	-	-	-	-
Sub plot						
Urea @ 1%	979	2420	11570	27542	2.38	12.43
Urea @ 2%	1019	2400	12900	27558	2.14	12.93
Water soluble complex fertilizer (19:19:19) @ 0.5%	908	2389	12200	24369	2.00	11.53
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% & borax @ 0.5%	1027	2478	14600	26305	1.80	13.03
$ZnSO_4$ @ 0.5% & borax @ 0.5%	994	2350	13900	25597	1.84	12.62
Water spray	783	2310	11500	20536	1.79	9.94
Control (no spray of any material/water)	704	2302	11500	17751	1.54	8.94
CD at 5%	64	-	-	-	-	-

Toria under foliar spray of urea @ 1%

Toria under control (no spray)

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. 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 2018-19

During 2018, in Chamua Narayanpur village, the onset of monsoon was delayed by 4 days (11 June). A rainfall of 1835.3 mm was received which was deficit by 143.3 mm compared to normal (1978.6 mm). During south-west monsoon (*kharif*), a rainfall of 1383.2 mm was received against a normal rainfall of 1280.1 mm. The rainfall during *rabi* was 222.1mm which was excess by 61.0 mm compared to normal rainfall of 161.1 mm (Fig.49).

Normal onset of monsoon	1st week of June
Onset of monsoon during 2018	11 June
Normal annual rainfall	1978.6 mm
Annual rainfall during 2018-19	1835.3 mm
Normal crop seasonal rainfall	1280.1 mm and 161.0 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2018-19	1383.2 mm and 222.1 mm during *kharif* and *rabi*, respectively

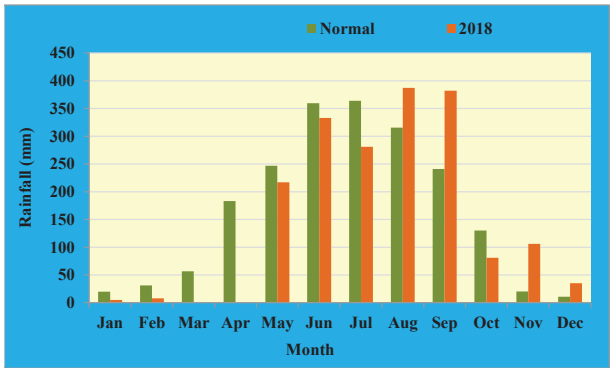


Fig.49: Normal and actual (2018) monthly rainfall at Chamua village

Dry spells during crop growing season (2018-19)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
10	3-12 October	*Sali* rice	Tillering, PI (*SDC),
21	14 October - 03 November	*Sali* rice, potato, toria	*Sali* rice: maturity (SDC), tillering and PI (MDC), tillering (LDC)
30	18 November -17 December	*Sali* rice, potato, toria	Maturity (MDC, LDC)
25	05-29 January, 2019	Potato, toria	Tuber formation, siliqua formation

* Short duration cultivar (SDC), Medium duration cultivar (MDC), Long Duration Cultivar (LDC); PI: Panicle initiation

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	Crop	RTCP implemented
Delayed onset of monsoon	Upland	Rice	Sowing of rice in nursery using harvested rainwater
Mid season drought	Upland	Rice, potato	Irrigation with harvested rainwater
	Medium land	Rice, potato	

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2018, onset monsoon was delayed by 4 days (11th June). Among high yielding rice varieties, Dishang (short duration) in upland and TTB-404 (medium duration) in medium land situation gave 44.3 and 50.7% higher grain yield (4520 and 5110 kg/ha), respectively over traditional cultivars (long duration) (2520 kg/ha), with higher net returns and B:C ratio (Table 188).

Table 188: Performance of improved rice varieties as compared to local cultivars

Farming situation/ soil type	Variety (duration)	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland	Dishang (100-110 days)	4520	3.1	27700	1.58
Medium land	TTB-404 (140-145 days)	5110	3.3	36100	2.41
	Mashuri (130 days)	2520	1.6	10200	0.68

Performance of short (Dishang) and medium duration (TTB-404) rice varieties

Situation: Early season drought

A dry spell of 21 days from 14 October to 03 November affected vegetative growth in potato and toria under upland condition. One life saving irrigation of 1 cm depth with the water lifting pump from farm pond in early vegetative stage (20-25 DAS) gave (56.3%) higher yield of potato (22532 kg/ha) as compared to no irrigation (9853 kg/ha) (Table 189).

Table 189: Effect of supplemental irrigation on crop yield and economics

Farming situation/ soil type	Intervention	Tuber yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland	Supplemental irrigation in potato (Kufri Pokhraj)	22532	138.91	65660	1.40
	Farmers' practice (no supplemental irrigation)	9853	75.54	16765	0.38
	Supplemental irrigation in potato (Local)	9500	58.57	79500	1.26
	Farmers' practice (no supplemental irrigation)	7548	46.54	52720	0.87

Supplemental irrigation in potato (left) and potato without irrigation (right)

Situation: Mid season drought

The crops experienced three mid season dry spells of 8 days (12-19 August), 10 days (3-12 October) and 21 days (14 October-3 November). One supplemental irrigation of 2 cm depth with the water lifting pump from farm pond increased the yield of rice (4520 kg/ha) by 33.3% with higher net returns (Rs. 27700/ha) and B:C ratio (1.58) over no supplemental irrigation (3015 kg/ha) (Table 190).

Table 190: Effect of supplemental irrigation on yield and economics of upland rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland	Supplemental irrigation in rice	4520	3.11	27700	1.58
	Farmers' practice (no supplemental irrigation)	3015	2.07	15150	1.01

Rice with supplemental irrigation

Rice with no supplemental irrigation

Preparedness

Rainwater management

Organic mulching during April-May before emergence of turmeric with rice straw, stalk of rapeseed, water hyacinth etc in turmeric resulted in 35.4% increase in yield of turmeric (34063 kg/ha) with higher net returns (Rs.781062/ha) and B:C ratio (11.1) as compared to no mulching (25150 kg/ha) (Table 191).

Table 191: Effect of organic mulching for *in-situ* moisture conservation on yield and economics of turmeric

Farming situation/ soil type	Intervention	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Upland	Organic mulching in turmeric	34063	70500	781062	11.1	18.0
	Farmers' practice (without mulching)	25150	68000	560755	8.3	13.3

Cropping systems

Double cropping of rice-potato gave higher net returns (Rs. 50927/ha) and B:C ratio (0.96) as compared to farmers' practice of growing only rice (Rs. 17326/ha) under uplands while rice-toria system recorded net returns of Rs. 31731/ha and B:C ratio of 1.13 under medium land situation (Table 192).

Table 192: Yield and economics of rice-potato double cropping system

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Rice	Potato/ toria			
Upland	Rice-potato	3125	9085	53000	50927	0.96
	Farmers' practice (sole rice)	3583	--	18500	17326	0.94
Medium land	Rice-toria	4233	580	28000	31731	1.13

At Chamua village, 7 low-cost polyhouses were established for demonstrating cultivation of high value off-season/ seasonal vegetables and raising nursery for vegetable seedlings in advance for cultivation during *rabi* season. Due to heavy rainfall till mid of October, it was difficult to raise seedlings of tomato, brinjal, chilli etc, which caused delay in planting of *rabi* vegetables. Thus, low-cost polyhouses were useful for advancing vegetable growing period which helps in better utilization of residual soil moisture due to early establishment of vegetables and increase in yield (3.10 and 2.15 kg/m^2) and net returns (Rs.8800-32300/yr).

Cultivation of high value crops under low-cost polyhouses

Potential of organic crop production as a climate change adaptation and mitigation strategy in rainfed agriculture

Organic agriculture is one of the fastest growing sectors of agricultural production, and is reported to have both climate change adaptation and mitigation potential particularly in rainfed agriculture. A field experiment was conducted during *kharif* 2018 at Gunegal Research Farm (GRF) of ICAR-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_20/ha for sunflower).

In general, the seed yield of pigeonpea was less across different treatments due to terminal drought (no rainfall after 25th October). The seed yield of sunflower was 17.8 and 18.9% higher in the plots under integrated management (1138 kg/ha) than that under inorganic and organic management, respectively. However, plots under organic management gave marginally higher seed yield of greengram (791 kg/ha) compared to integrated (765 kg/ha) and inorganic management (744 kg/ha). Similarly, pigeonpea seed yield was similar in the plots under three production systems (400-443 kg/ha) (Fig.50).

During the last 7 years, pigeonpea recorded significantly higher pigeonpea equivalent yield (PEY) in 2013 (1898 kg/ha) whereas, sunflower produced higher PEY in 2014 (641 kg/ha), 2016 (721 kg/ha) and 2017 (969 kg/ha), and greengram in 2015 (573 kg/ha). Among the production systems, crops under integrated management produced significantly higher PEY in 2012 (1553 kg/ha) but was at par with organic production system during next 6 years. On average, integrated management being on par with organic management recorded significantly higher PEY (886 kg/ha) compared to inorganic management (792 kg/ha).

Greengram under organic management

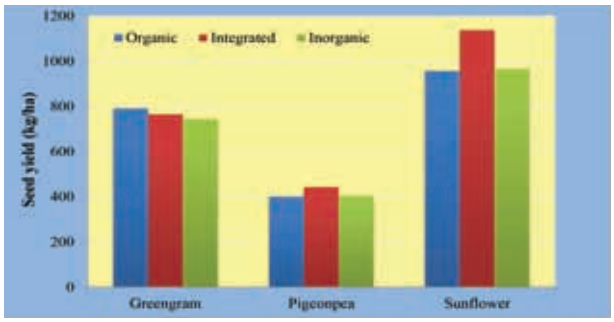


Fig.50: Performance of crops under different production systems

Different production systems had no significant on soil pH and available Mn. However, plots under organic management recorded significantly higher soil organic C (0.66%), compared to inorganic and integrated production systems. Plots under organic management being on par with integrated production system also recorded significantly higher available K (242.3 kg/ha), Cu (2.01 ppm), Fe (13.4 ppm) and Zn (0.69 ppm) compared to inorganic production system. However, integrated production system recorded significantly higher available P (26.9 kg/ha) compared to other production systems. The plots under organic management had higher dehydrogenase activity (5.69 µg TPF/g soil/h) and microbial biomass carbon (302 µg/g soil) compared to other production systems. The incidence of insect-pests on greengram and sunflower was below economic threshold level. The incidence of pod borer complex on pigeonpea was less in organic production system (33%) compared to inorganic (42%) and integrated production system (57%).

In general, the cost of cultivation under organic management was higher by Rs. 2610/ ha in pigeonpea & greengram and by Rs. 9790/ ha in sunflower compared to that under integrated production system. Therefore, a price premium of at least 5% for organic greengram, 25% for organic pigeonpea and 40% for organic sunflower may be required to offset the higher cost of cultivation and low yields under organic production system compared with integrated production system.

3. NICRA - Other Activities

3.1 Village Institutions

3.1.1 Village Climate Risk Management Committee (VCRMC)

VCRMCs established in each NICRA village are actively involved in various activities of the project. During 2018-19 in NICRA villages, the VCRMCs participated in identification of beneficiaries, and 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	Decision taken/outcome of meeting
Vannedoddi village, Ananthapuramu district, Andhra Pradesh (Ananthapuramu)	03.07.2018	*In-situ* moisture conservation through deep ploughing with chisel plough in groundnut
Chikkaputtayanapalya village, Bengaluru Rural district, Karnataka (Bengaluru)	22.07.2018	Opening of ridges and furrows between paired rows of pigeonpea in pulse based cropping systems
	25.08.2018	Weeding and intercultivation in fingermillet
		Opening of moisture conservation furrow between paired rows of pigeonpea
	30.09.2018	Advised farmers to take up plant protection measures in pigeonpea
	04.11.2018	
Nignoti & Bisakhedi villages, Indore district, Madhya Pradesh (Indore)	11.05.2018	Site selection for water harvest tank finalized
	14.05.2018	Soil testing suggested
Babhulgaon & Ujalamba villages, Parbhani district, Maharashtra (Parbhani)	10.06.2018	Timely sowing should be followed. Early and drought tolerant varieties to be sown
	20.07.2018	Hoeing and weeding to be carried out to cope with dry spell Opening of furrow after every 4 rows in soybean and 2 rows in pigeonpea and cotton (30 days after sowing)
	04.08.2018	Straw mulching and spraying of KNO_3
	05.09.2019	Supplemental irrigation to cotton and pigeonpea, if required from open well/ farm pond
Budhadani village, Kandhamal district, Odisha (Phulbhani)	08.06.2018	Selection of beneficiaries and demonstrations
	25.08.2018	Pest and disease management
Chamua village, Lakhimpur district, Assam (Biswanath Chariali)	09.03.2018	Discussion on annual accounts/ revenue generation from CHC
	02.06.2018	Discussion on implementation of NICRA activities in newly adopted villages
	18.07.2018	Renovation of polyhouse
	01.11.2018	Renovation of farm ponds
Patameghpar (old village) & Dangarvada (New village), Jamnagar district, Gujarat (Rajkot)	07.06.2018	Farmers advised to avoid the sowing of long duration varieties of *Bt* cotton and groundnut
Warkhed village, Akola district, Maharashtra (Akola)	03.07.2018	Opening of furrows by tying a rope to hoe in soybean and cotton for *in-situ* moisture conservation
	20.07.2018	
	10.08.2018	Suggested farmers for foliar spray of 19:19:19 @ 0.5% at pod initiation stage in soybean
	11.09.2018	Foliar spray of KCl @ 2% at the time of boll development in cotton
	14.12.2018	Protective irrigation in chickpea

NICRA village	VCRMC meeting	Decision taken/outcome of meeting
Khaner, Madana (new village), Amba district, Jammu & Kashmir (Rakh Dhiansar)	04.09.2018	Sowing of *rabi* crops on receding moisture. Sowing of wheat with seed cum fertilizer drill
Naiwan, Achalpur & Bhawanipur villages, Hoshiarpur district, Punjab (Ballowal Saunkhri)	15.02.2019	Revise the rate of custom hiring centre
	19.03.2019	Provide supplemental irrigations from harvested rainwater in village Nainwan
Dharmathampatti village, Thoothukkudi district, Tamil Nadu (Kovilpatti)	28.10.2018	Recommended suitable pest management for control of fall army worm
Tahkapal & Jhatarae villages, Bastar district, Chhattishgarh (Jagdalpur)	07.08.2018	Harvesting of rainwater in farm ponds
	13.10.2018	Supplemental irrigation in rice and niger
Kalimati/Dholiya villages, Banaskantha district, Gujarat (SK Nagar)	28.06.2018	Planning of interventions for different crops and selection of farmers
	05.07.2018	Distribution of inputs
Tedha village, Mirzapur district, Uttar Pradesh (Varanasi)	05.07.2018	If the germination affected, maintain plant population through gap filling
	22.07.2018	Interculture and foliar spray
	12.10.2018	Suggested plant protection measures in pigeonpea, planning for mustard cultivation
Danti village (new), Mirzapur district, Uttar Pradesh (Varanasi)	15.10.2018	VCRMC committee formed
	31.10.2018	*Rabi* planning for chickpea, lentil & pea, suggested new varieties, use of harvested rainwater as pre-sowing irrigation
Hardoiya village, Faizabad district, Uttar Pradesh (Faizabad)	05.06.2018	Planning for *Kharif* season crops
	07.07.2018	Short duration varieties of rice may be sown
	11.08.2018	Control of weeds by hoeing
	12.09.2018	Foliar spray of 2% urea in rice, pigeonpea and maize
	15.10.2018	Sowing of mustard, chickpea, lentil linseed, barley, pea etc. to be taken up

3.1.2 Custom Hiring Centre (CHC)

Custom Hiring Centre (CHC) was established in each NICRA village and need based implements were made available to farmers for hiring as per the rates approved by custom hiring management committee (CHMC). The money earned through hiring was incurred for CHC maintenance and for repair of the implements. Implements availability for various agricultural operations on custom hiring during 2018-19 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)
Vannedoddi village, Ananthapuramu district, Andhra Pradesh (Ananthapuramu)	Chisel plough	Preparatory cultivation	2.0	5	-
	Bullock drawn Ananta Planter	Sowing	6.0	3	14.2%
	Tractor drawn Ananta Planter	Sowing	3.0	3	35%
Chikkaputtayanapalya & Hosapalya villages, Bengaluru Rural district, Karnataka (Bengaluru)	Modified seed drill	Sowing	35.0	-	160
Babhulgaon & Ujalamba villages, Parbhani district, Maharashtra (Parbhani)	Seed cum ferti drill	Sowing and fertilizer application	3.2	50%	400
	Stubble collector	Stubble collection	4.8	75%	600

NICRA Village	Implement used	Farm operation	Area covered (ha)	Labour saving (hr/ha)	Cost saving (Rs/ha)
Budhadani village, Kandhamal district, Odisha (Phulbani)	Power tiller	Land preparation	2.5	25%	15%
	Reaper	Harvesting	2.0	60%	35%
	Winnower	Threshing	2.0	60%	40%
	Water pump	Irrigation	1.0	40%	30%
	Sprayer	Plant protection	1.5	60%	40%
Patameghpar (old village) & Dangarvada (New village), Jamnagar district, Gujarat (Rajkot)	Cultivator	Ploughing	37.0	-	1250
	Reversible M.B. plough	Primary and deep tillage	23.0	-	950
	Rotavator	Tillage and pulverization	42.5	-	1530
	Mobile chopper	Chopping of cotton stalk	21.0	-	1500
Raura & Patuna villages, Rewa district, Madhya Pradesh (Rewa)	Raised bed planter	Sowing	40.0	18	675
	Harrow	Field preparation	77.0	26	975
	Rotavator	Field preparation	74.0	14	525
	Seed drill	Sowing	158.0	27	1010
	Cultivator	Land preparation	40.0	26	975
Warkhed village, Akola district, Maharashtra (Akola)	Multipurpose thresher	Threshing	26.8	11	1170
	Rotavator	Land preparation	6.2	5	900
Khaner (old village) & Madana (new village), Samba district, Jammu & Kashmir (Rakh Dhiansar)	Seed cum fertilizer drill	Sowing of crop	1.3	5	3000
	Maize planter	Sowing of crop	1.2	5	3000
	Maize sheller	Shelling of cobs	2.5	50	3500
	Knapsack sprayer	Weed management	2.5	21	7500
Naiwan, Achalpur & Bhawanipur villages, Hoshiarpur district, Punjab (Ballowal Saunkhri)	Rotavator	Field preparation	1.6	40%	6295
	Bund maker	Field preparation	3.0	60%	
	Maize planter	Sowing of maize	2.8	48%	
	Oilseed drill	Sowing of oilseed crops	4.0	40%	
	Wheat seed drill	Sowing of wheat	16.0	54%	
Kavalagi & Honnutagi villages, Vijayapura district, Karnataka (Vijayapura)	Bullock drawn compartment bund farmer	Compartment bunding	3.6	3	800
	Tractor drawn compartment bund farmer	Compartment bunding	29.2	4	1000
	Power sprayer	Plant protection	8.4	2	150
	Cycle operated fertilizer drill	Fertilizer application	0.5	4	500
	Tractor drawn seed cum fertilizer drill	Sowing and fertilizer application	4.4	8	1000
Dharmathampatti village, Thoothukkudi district, Tamil Nadu (Kovilpatti)	Rotavator	Land preparation	2.0	1	3000

NICRA Village	Implement used	Farm operation	Area covered (ha)	Labour saving (hr/ha)	Cost saving (Rs/ha)
Tahkapal & Jhatarae villages, Bastar district, Chhattishgarh (Jagdalpur)	Cultivator	Ploughing	5.0	15	4500
	Seed cum fertilizer drill	Sowing	3.0	8	2000
	Rotavator	Land preparation	2.2	6	1800
	Trolley	Transport	2.4	5	1000
Tedha village, Mirzapur district Uttar Pradesh (Varanasi)	Mould board plough	Summer tillage	12.0	-	30%
	Ridger seeder	Sowing	10.0	-	50%
	Multi crop seed drill	Sowing	12.0	-	50%
	Zero till drill	Sowing	15.0	-	-
	Hand operated ridger	Manual sowing under ridger furrow	11.0	-	-
	Hand operated maize sheller	Shelling	55.0	-	-
	Dryland weeder	Weeding	48.0	-	-
Kadesarakalan village, Lalitpur district, Uttar Pradesh (Jhansi)	Leveler	Leveling	0.5	3	1200
	Rotavator	Ploughing	1.0	1	700
	Bullock drawn seed drill	Sowing	1.0	12	600
	Sprayer	Spraying	4.5	4	100
	Wheel hoe	Weeding	2.2	96	2000
Hanauta village (new), Lalitpur district, Uttar Pradesh (Jhansi)	Leveler	Leveling	0.4	3	800
	Rotavator	Ploughing	1.0	2	600
	Bullock drawn seed drill	Sowing	1.0	-	-
	Sprayer	Spraying	2.5	2	50
	Wheel hoe	Weeding	1.6	9	1500

Field preparation with Rotavator

Deep ploughing with MB Plough

Nagla Duleh khan village, Agra district, Uttar Pradesh

Ploughing with tractor drawn implement

Drum seeding of rice

Tahkapal village, Bastar district, Chhattisgarh

3.1.3 Village Seed Bank

Participatory village level seed production of short duration, drought and flood tolerant varieties of different field crops was demonstrated in several villages. 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 (3500 kg) and pigeonpea (900 kg). In Budhadani village, Phulbani district, farmers produced seed of rice varieties Sahabhagi, Khandagiri and Naveen. Similarly, farmers produced seed of recent varieties of groundnut, sesame, wheat, chickpea and fenugreek in Patameghpar and Dangarvada villages, Jamnagar district; rice, blackgram, pigeonpea, sorghum and horsegram in Tahakapal village, Bastar district; rice, rapeseed and potato in Chamua village, Lakhimpur district; and fingermillet, groundnut, pigeonpea, fieldbean and cowpea in Chickkaputtayana Palya village, Bengaluru Rural district. The total seed of different crops produced/maintained in AICRPDA-NICRA villages was 21720 kg.

Seed availability in NICRA villages

NICRA village	Crop	Variety/hybrid	Quantity (kg)
Chikkaputtayanapalya village, Bengaluru Rural (Bengaluru)	Fingermillet	MR.1	1000
		GPU.28	80
		GPU.48	50
	Groundnut	GKVK.5	300
	Pigeonpea	BRG.5	100
	Fieldbean	HA.4	50
	Cowpea	IT.38956.1	50
Chamua village, Lakhimpur (Biswanath Chariali)	Rice	TTB.404	300
		Ranjit	500
		Mahsuri	600
		TTB.303.2.23	450
		Swarna sub.1	200
		Ranjit sub.1	100
		Nania	150
		Sokuwa	50
		Bora	50
		Joha	50
	Rapeseed	TS.38	700
		TS.36	500
	Potato	Local	1000
		Kufri Pokhraj	6000
Tahakapal village, Bastar (Jagdalpur)	Rice	-	216
	Blackgram	-	62
	Pigeonpea	-	25
	Sorghum	-	35
	Fingermillet	-	133
	Kodomillet	-	151
	Horsegram	-	31
	Little millet	-	49
	Niger	-	13

NICRA village	Crop	Variety/hybrid	Quantity (kg)
Kalimati/Dholiya village Banaskantha (SK Nagar)	Maize	GM 2	340
	Greengram	GM 4	310
	Blackgram	GU 1	180
	Cluster bean	GG 2	130
	Sorghum (fodder)	CSV 21	2500
Gangu village, Banaskantha (SK Nagar)	Maize	GM 2	300
	Greengram	GM 4	270
	Blackgram	GU 1	150
	Clusterbean	GG 2	100
	Sorghum (fodder)	CSV 21	2000
Hardoiya village, Faizabad (Faizabad)	Pigeonpea	NDA-2	80
		NDA-1	60
	Maize	Naveen	60
	Chickpea	PUSA-362	80
		Udai	20
	Lentil	HUL-57	80
	Mustard	NDA-1	35
		Varuna	25
	Linseed	Garima	30
	Rice	NDR-97	145
Kadesarakalan village, Lalitpur (Jhansi)	Wheat	-	100
	Chickpea	-	100
	Blackgram	-	300
	Sesame	-	150
Hanauta village (new), Lalitpur (Jhansi)	Wheat	-	1000
	Blackgram	-	200
	Sesame	-	50
Total			**21720**

Seeds production of indigenous rice varieties at Chamua village, Lakhimpur district, Assam

Fieldpea seed production

Participatory seed production of rice

Tahkapal and Jhartarae villages, Bastar district, Chhattishgarh

3.1.4 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 4 ha in 20 farmers' fields for realizing better fodder supply to milch animals in the cluster. At Tahakpal village, Bastar district farmers produced seed of *Stylosanthes* (56.0 kg), hybrid Napier bajra (9.0 kg), berseem (38.0 kg) and fodder sorghum (45.0 kg). At Chamua village Lakhimpur district, 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 are being grown in the fodder bank. Cultivation of mixed fodder (sorghum + pearlmillet + cowpea) was demonstrated in 5 ha in Khaner and Madana villages, Samba district. In Kadesara kala village, Lalitpur district, about 10 tons of hybrid napier slips were sold to farmers of different villages. Further about 1.0 ton each of silage and urea treated straw was produced during the year.

Fodder cultivation by farmers at Chamua village, Lakhimpur district, Assam

3.2 Training/ Field days etc., organized

3.2.1 Trainings

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
Agra	One day pre-seasonal training on *kharif* crop production	72	18.06.2018
	Contingency crop/cultivars planning	45	12.07.2018
	Climate resilient agriculture	52	18.02.2019
Akola	Management of surface runoff for ground water development	152	14.02.2019
	Farm mechanization	08	05.03.2019
	Weed management	12	16.03.2019
	Rainwater conservation techniques	23	04.04.2019
Ananthapuramu	Sub-soiling in drylands	20	03.07.2018
	Improved management practices for dryland crops	25	03.07.2018
	Importance of foliar spray of KNO_3 to mitigate drought	20	25.09.2018
Arjia	*Krishak Kalyan Sivir*	158	02.04.2018
	Kharif pre-seasonal training	26	26.06.2018

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
Ballowal Saunkhri	Cultivation practices of *kharif* crops	50	21.06.2018
	Contingency crop management practices for *kharif* crops	40	26.09.2018
	Training for farm women on ash gourd processing for Paitha making	14	29.11.2018
	Soil health management	65	05.12.2018
Bengaluru	*Kharif* planning meeting cum training	40	20.07.2018
Biswanath Chariali	Scientific crop production for climate resilient agriculture	50	15.06.2018
	Awareness on book keeping of women self help groups	100	15.06.2018
Chianki	Scientific cultivation of *kharif* crops	345	04.07.2018
	Kharif crops management	35	27.08.2018
	Rabi crop production	325	09.11.2018
Hisar	Agro-practices of *kharif* crops	24	20.06.2018
	Weed management in *kharif* crops	38	23.07.2018
	In-situ moisture conservation with wheel hand hoe	27	10.08.2018
	Role of weather under dryland conditions	35	12.10.2018
	Agro-practices of mustard and chickpea	29	16.10.2018
	Intercultural operations in *rabi* crops	27	31.12.2018
	Insect pest and disease management	22	08.02.2019
	Precautions during harvesting of *rabi* crops and agro-techniques for higher yields of *kharif* crops	24	06.03.2019
Indore	Summer ploughing, residues management, *kharif* crops production	25	11.05.2018
	Nutrient management in crops	25	25.07.2018
	Management of *rabi* crops	30	02.11.2018
	Irrigation scheduling	15	02.11.2018
Jagdalpur	Cultivation of rice under rainfed situation	56	15.07.2018
	Vegetable cultivation in *baadi* system	26	11.08.2018
	Insect management in *kharif* crops	49	21.08.2018
	Disease management in field crops	56	22.09.2018
	Field preparation for *rabi* crop production	35	06.10.2018
	Vegetable crop production technology	50	23.11.2018
	Post-harvest technology	52	17.12.2018
Jhansi	Foddar production for livelihood improvement in Bundelkhand region	32	21.04.2018
	Kharif pre-seasonal training	62	06.07.2018
	NB hybrid production techniques	20	15.01.2018
Kovilpatti	High density planting system of dryland cotton	25	12.09.2018
Parbhani	*Kharif* farmers rally	54	17.05.2018
	Kharif crop management	54	22.06.2018
	Crop management	70	25.07.2018
	Rabi farmers rally	54	17.09.2018
	Rabi crop management	49	12.10.2018
Phulbani	Poultry rearing	100	22.12.2018

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
Rajkot	Crop contingency planning	67	08.06.2018
	INM in *kharif* crops	46	25.06.2018
	IPDM in *kharif* crops	38	26.06.2018
	In-situ and *ex-situ* rainwater management	77	24.07.2018
	Critical growth stage of irrigation and MIS	46	24.09.2018
	Importance of soil and water testing	140	25.09.2018
	Planning for *rabi* crops	53	08.12.2018
Rakh Dhiansar	Pre *kharif* training	14	03.05.2018
	Pre-*rabi* training and farmers' scientist interaction meeting	30	13.11.2018
Rewa	*Rabi* crops and cropping systems suitable for the region	35	22.09.2018
	Importance of plant protection in *rabi* crops	25	02.01.2019
Solapur	Management of *kharif* crops	63	04.08.2018
	Animal vaccination and animal health	250	23.08.2018
	Soil health management	100	05.12.2018
	Safflower cultivation	50	10.12.2018
	Management of r*abi* crops	55	23.01.2019
SK Nagar	Method of sowing of different crops	141	19.07.2018
	Foliar and soil application of fertilizers in field crops	250	25.08.2018
	Soil application of fertilizers in different crops	185	01.08.2018
	Total	**4485**	

Training on crop management at Patameghpar (old village) & Dangarvada (New village), Jamnagar district, Gujarat

Training on management of *kharif* crops

Animal vaccination and health camp

Narotewadi & Banegoan villages, Solapur district, Maharashtra

3.2.2 Field Days

AICRPDA centre	Intervention	NICRA village	Date	Beneficiaries (No.)
Ananthapuramu	Foliar spray of KNO_3 to mitigate midseason drought in groundnut and *in-situ* moisture conservation through conservation furrows in castor	Vannedoddi	19.10.2018	30
Arjia	Community pasture land	Tara Ka Khera	05.10.2018	54
	Maize + blackgram (2:2) intercropping system	Tara ka Khera	26.10.2018	46
Ballowal Saunkhri	Contingency crop management practices for *kharif* crops	Naiwan	26.09.2018	30
	Toria as contingent crop	Naiwan	05.12.2018	30
	Management of yellow rust in wheat and training of mushroom cultivation	Naiwan	10.01.2019	41
Bengaluru	Groundnut based cropping system	Chikaputtayanapalya	10.09.2018	70
Hisar	Field day on pearlmillet	Balawas and Nalwa	11.09.2018	38
	Field day on mustard	Balawas and Nalwa	18.03.2019	32
Jagdalpur	Seed production	Tahkapal	13.07.2018	35
Jhansi	*Rabi* crop production	Kadesara kala	18.02.2018	35
Parbhani	BBF technology for soybean	Babhulgaon and Ujalamba	27.06.2018	10
	High density cotton planting using inclined plate planter	Babhulgaon and Ujalamba	29.06.2018	20
	Crop stage advisory	Babhulgaon Ujalamba	10.07.2018 11.07.2018	54
	Foliar spray of KNO_3 for dry spell management	Babhulgaon Ujalaamba	02.08.2018 06.08.2018	54
Phulbani	Bullock drawn and tractor drawn seed cum fertilizer drill	Budhadani	05.07.2018	50
Rajkot	IPDM in groundnut and cotton	Patameghpar	26.06.2018	38
	Moisture conservation practices	Patameghpar	24.07.2018	77
Rakh Dhiansar	Field day on maize	Khaner	4.09.2018	30
Solapur	Management *kharif* crops	Banegaon	04/08/18	25
	Management of *rabi* crops	Banegaon	25/10/2018	60
Total				**859**

Demonstration on bullock drawn seed cum fertilizer drill Demonstration on tractor drawn seed cum fertilizer drill Budhadani village, Phulbani district, Odisha

Exposure visit of farmers to AICRPDA centre

Exposure visit of farmers to Dryland technology park

Exposure visit of farmers to small millet processing unit

Jhartare & Tahkapal, Bastar district, Chattishgarh

3.3 Agro-Advisories

Centre	Agro-advisories	Frequency
Akola	Weekly bulletin	Weekly
Ananthapuramu	Black board and SMS	Twice in a week
Bengaluru	Black board in NICRA village	Twice in a week
Biswanath Chariali	SMS through farmers portal, black board	As required
Chianki	Meeting in NICRA village	As required
Faizabad	Newspaper, Radio	Daily
Hisar	Weekly bulletins	Weekly
Jagdalpur	Meeting in NICRA village	As required
Kovilpatti	Weekly bulletins	Weekly
Parbhani	Weekly bulletins	Weekly
Phulbani	SMS	As required
Rajkot	SMS	Twice in a week
Rakh Dhiansar	Bi-weekly bulletin	Bi-weekly
Rewa	Meeting in NICRA village	As required
SK Nagar	Meeting in NICRA village	As required
Varanasi	SMS, Phone calls, Newspaper	Twice in a week
Vijayapura	Meeting in NICRA village	Weekly

Agro-advisories through black board and SMS in Chamua village, Lakhimpur district, Assam

Agro-advisory through SMS in Patameghpar village, Jamnagar district, Gujarat

3.4 Soil Health Cards

Distribution of soil health cards in NICRA villages during 2018-19

Centre	NICRA Village	Soil health cards issued (No. of farmers)
Akola	Warkhed and Kajleshwar	108
Anantapuramu	Vannedoddi	49
Arjia	Kochariya and Lapsiya	50
Bengaluru	Chikkamaranahalli	25
Biswanath Chariali	Chauma	15
Jagdalpur	Tahkapal & Jhatarae	84
Kovilpatti	Dharmathampatti	24
Parbhani	Babhulgaon	50
Phulbani	Budhadani	38
Rajkot	Pata meghapar	28
Rakh Dhiansar	Khaner and Madana	46
Rewa	Patauna	11
Rewa	Raura	30
SK Nagar	Kalimati, Dholiya and Gangu	170
Total		**728**

3.5 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 stakeholders. During 2018-19, 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 2 states (Karnataka and Tamil Nadu) for operationalization of district agriculture contingency plans and contributed in developing action plans.

4. Publications

a) Research papers

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Ramachandrappa BK, Thimmegowda MN, Krishnamurthy R, SrikanthBabu PN, Savitha MS, Srinivasarao Ch, Gopinath KA and Ravindra Chary G. 2018. Usefulness and impact of agromet advisory services in eastern dry zone of Karnataka. Indian Journal of Dryland Agricultural Research & Development 33(1): 32-36.

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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
ANGRAU	Acharya NG Ranga Agricultural University
ARS	Agriculture Research Station
AU	Agriculture University
BAU	Bihar Agricultural University
BBF	Broad Bed & Furrow
B:C ratio	Benefit:Cost Ratio
BHU	Banaras Hindu University
CAU	Central Agricultural University
CAZRI	Central Arid Zone Research Institute
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CD	Critical Difference
CEY	Chickpea Equivalent Yield
CEY	Cotton Equivalent Yield
CEY	Castor Equivalent Yield
CHC	Custom Hiring Center
CHMC	Custom Hiring Management Committee
CRIDA	Central Research Institute for Dryland Agriculture
DAS	Days After Sowing
DFRS	Dryland Farming Research Station
Dr. PDKV	Dr Panjabrao Deshmukh Krishi Vidyapeeth
FEY	Fingermillet Equivalent Yield
FP	Farmers' Practice
FYM	Farmyard Manure
GEY	Groundnut Equivalent Yield
GRF	Gunegal Research Farm
ha	Hectare
HW	Hand Weeding
ICAR	Indian Council of Agricultural Research
IFS	Integrated Farming System
IGAU	Indira Gandhi Agricultural University
IGFRI	Indian Grassland and Fodder Research Institute
IISWC	Indian Institute of Soil and Water Conservation
INM	Integrated Nutrient Management
IP	Improved Practice
JAU	Junagadh Agricultural University
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya
kg	Kilogram
LDC	Long Duration Cultivar
LER	Land Equivalent Ratio
LMU	Land Management Units
MCEY	Main Crop Equivalent Yield
MDC	Medium Duration Cultivar
MGEY	Maize Grain Equivalent Yield
MJ	Mega Joule
mm	Millimeter
MPKV	Mahatma Phule Krishi Vidyapeeth
MPUAT	Maharana Pratap University of Agriculture and Technology
NDUAT	Narendra Dev University of Agriculture and Technology
NICRA	National Innovations in Climate Resilient Agriculture
NRM	Natural Resource Management
OC	Organic Carbon
OUAT	Orissa University of Agriculture & Technology
PAU	Punjab Agricultural University
PEY	Pearlmillet Equivalent Yield
PI	Panicle Initiation

PPFM	Pink Pigmented Facultative Methylotrophs
PST	Paddy Straw
RBSC	Raja Balwant Singh College
RDF	Recommended Dose of Fertilizer
RDN	Recommended Dose of Nitrogen
RFS	Ridge Furrow System
Rs.	Rupees
RTCP	Real Time Contingency Planning
RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
RWC	Relative Water Content
RWUE	Rainwater Use Efficiency
SDAU	Sardarkrushinagar Dantiwada Agricultural University
SDC	Short Duration Cultivar
SI	Supplemental Irrigation
SK Nagar	Sardarkrushi Nagar
SKUAS&T	Sher-e-Kashmir University of Agricultural Science & Technology
SMW	Standard Meteorological Week
SW	South-West
SWC	Soil & Water Conservation
SWM	South- West Monsoon
TNAU	Tamil Nadu Agricultural University
UAS_B	University of Agricultural Sciences, Bengaluru
UAS_D	University of Agricultural Sciences, Dharwad
UAS_R	University of Agricultural Sciences, Raichur
VC	Vermicompost
VCRMC	Village climate risk management committee
VNMKV	Vasantrao Naik Marathwada Krishi Vidyapeeth
WHH	Wheel hand hoe
WUE	Water Use Efficiency

Notes

Notes

Best farmers from NICRA villages felicitated during the XXVI Biennial Workshop of AICRPDA

Bengaluru Centre, UAS, Bengaluru, Karnataka, 16-19 January, 2019

Shri K. Peddaiah
from Vannedoddi village, Ananthapuramu district, Andhra Pradesh

Shri Mahantesh Chandrashekhar Koulagi
from Hegadihal village, Vijayapura district, Karnataka

Shri Rupram Saikia
from Chamua village, Lakhimpur district, Assam

Shri Manjit Singh
from Bhawanipur village, Hoshiarpur district, Punjab

Shri S. Ramamoorthi
from Dharmathampatti village, Thoothukudi district, Tamil Nadu

Shri Thimmappa Gowda
from Chikkahosapalya village, Bengaluru Rural district, Karnataka

Shri Sachin Digambar Kondankar
from Warkhed village, Akola district, Maharashtra

Shri Satyanarayan Pareek
from Sunderpura village, Bhilwara district, Rajasthan

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना

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